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INTEGRATING AI IN ARCHITECTURAL DESIGN THINKING: AN OPPORTUNITY AND CHALLENGES STUDY IN INDONESIA ARCHITECTURAL EDUCATION

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Abstract

The presence of AI has been integrated into many aspects of life, including education and even architecture. AI has offered revolutionary alternatives for analyzing, optimizing, and visualizing an architectural design that can enrich learning experiences for students in architecture studios. Nevertheless, there is still a little research done regarding the potential and threat that AI could conceive, especially in Indonesia. The purpose of this study is to explore the use of AI in architectural education through different stages of the design process. A literature review regarding the use of AI is done to determine the variety of AI used in architecture. A questionnaire is then distributed to lecturers and students that have already used digital architecture. This research could illustrate the role that AI plays in an architectural design studio.

***Keywords**: Artificial intelligence; architecture; design thinking; exploration; digital architecture.*

INTRODUCTION

Architecture education first belongs to an elite group of people within some masons that encompass design and construction technology altogether. It was when the Académie Royale d'Achitecture, which later evolved into the Ecole des Beaux Arts, was established in France that architecture education focused on design, yet was still enclosed to a few heavily selected students (Wong, n.d.). This system lasted from the middle ages to around the 1930s, when the Bauhaus School of Architecture introduced the German curriculum. Nevertheless, the process of learning under the mentorship of a professional, which has been called studio in modern architecture education, still continues to become the core of architecture education worldwide. The purpose of this studio system is to spend time processing the design and to mirror the actual architectural practice in an architectural bureau.

Since then, the development of technology has, at many times, outrun the model of education in the studio, where the system in architectural education is relatively the same, with changes in curriculum and focus, while the development of technology in materiality and construction keeps advancing. Not only the physical space of the studio needs to be redeveloped as it was used by cross-generational students (Wijaya & Dharmatanna, 2024), the technological advancements must be well adapted to education to minimize the gap between practice and theory (Haleem, Javaid, Qadri, & Suman, 2022).

One thing that the education system can cope with in professional practice is technology in software use. The curriculum in architecture education has used and included computer-aided architectural design (CAAD) since 1963 (Weisberg, 2023). Since then, architectural software has developed to help architects visualize their designs and ideas more conveniently. Through the development, the software is not used only for drafting purposes but also for optimizing the design as well as presenting the design in realistic 3D visualization. Further improvements in architectural software are trying to integrate the design with the construction phase by enabling the ability to develop 2D drafting and 3D modeling simultaneously by using Building Information Modeling (BIM) that can update real-time changes in the design. BIM also integrates the architectural design with the different professionals, such as structural engineers and mechanical-electrical engineers, which helps the design coordination between stakeholders with different backgrounds. (Tang, Chen, Tang, Wu, & Trofimova, 2017).

Many studies have been conducted regarding the use of AI in general higher education (Keles & Aydin, 2021), (Cao, Aziz, & Arshard, 2023), (Jeffrey, 2020). Special consideration of AI use in Architecture has been studied for its potential in certain aspects (Fareed, Bou

Nassif, & Nofal, 2024), (Zhang, Fort, & Giménez Mateu, 2023), but the combination use in the holistic design process has not yet been discussed much, especially in the context of Indonesian architectural education.

The start of Architecture education in Indonesia traces back to 1950, when the Department of Civil Engineering at the University of Indonesia (UI) was established, to replace the Technische Hoge School Bandung in Dutch colonial era. As per today, Indonesia has around 120 Universities that teach Architecture, both private and public universities (Dewanto, Lestari, & Prasetya, 2023). Indonesia also has the Association of Architecture Higher Education (APTARI). However, according to the Indonesian Architects Association (IAI), less than 30% of the graduates pursue their career as professional architects. This score marks the importance of staying abreast of architectural developments to groom future architects who take pride in their profession and can compete globally.

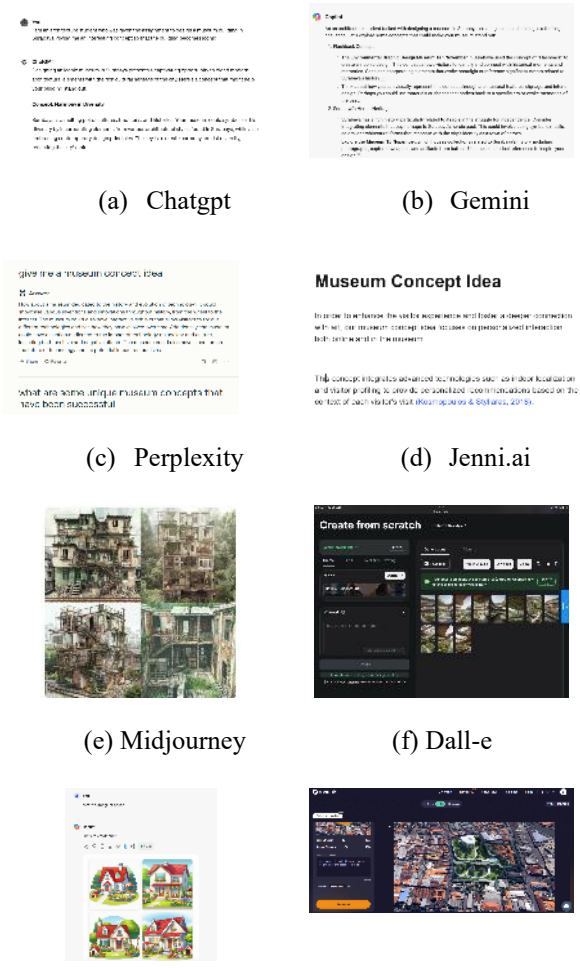
Even though the technology is evolving, the design process in architecture still can be classified into several basic repetitive stages. Previous research has classified the design process to four stages, namely (1) Programming, (2) Design Development, (3) Schematic Design and (4) Construction Documents (Soliman, 2017). These stages can be followed with the real construction phase, but this research focuses only on the design stages in architectural education that needs to keep up with the advancement of systems and technologies, especially in Indonesian architectural education context.

LITERATURE REVIEW

The presence of Artificial Intelligence has reached the architectural field. Artificial intelligence itself is defined as a system that has the capability to process external input and give appropriate response or result through flexible adaptation (Kaplan & Haenlein, 2018). The use of artificial intelligence to assist Architectural design can be classified into a few stages, such as data collection and processing, creating design options, building performance analysis, energy performance analysis, architectural representation and also construction (Ceylan, 2021). More specifically, from education perspectives, previous researches also utilized AI in mode specific function, such as, most appropriate in a studio with creativity form finding as the main goal (Sadek & Mohamed, 2023), to study the similarities of Architectural styles (Heri Pramono, Sri Winiarti, Prasasto Satwiko, & Sugesti Retno Yanti, n.d.)

Programming and Generating Ideas

The student's main activity at this stage is to gather accurate information about the project they are going to design. There are basically two ways that AI can help students learn at this stage. The first is by giving written data information regarding the project standards, definition, important considerations, and even steps suggestions to design correctly, as displayed in figure 1a, 1b, 1c and 1d. The second type of AI will provide images from our prompt. These generated images could serve as a method of initial form generator, to brainstorm design initial form, gather ideas and explore. Figure 1e, 1f and 1g display the result of AI that is commonly used in the initial design form inspiration finding. In both of the AIs, the input data is a prompt that directs the result of the process, any type of text, question, information, or code that tells the AI what kind of response we are seeking.



(a) Chatgpt (b) Gemini

(c) Perplexity (d) Jenni.ai

(e) Midjourney (f) Dall-e

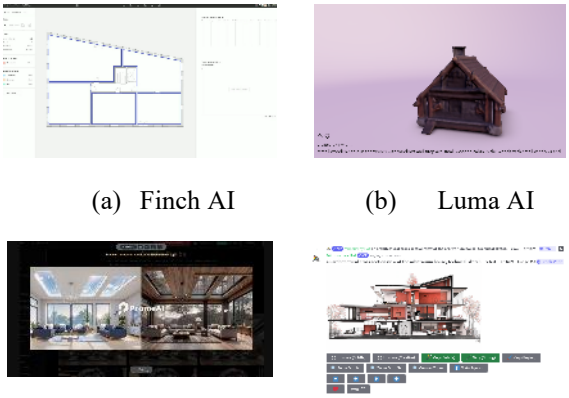
(g) Ms bing: Copilot (h) rendaircorp.com

Figure 1. Types of AI used in initial design stage

Schematic Design

The initial phase of schematic design typically commences with preliminary sketches, aiding in problem-solving and visually communicating the conceptual design to establish an architectural concept

and propose a solution (Hurst, 2000). In schematic design, there are a lot of aspects that can be assisted by AI. One of which is by integrating our preliminary 3D file into the AI plugin so that the AI can help to calculate the optimized room division based on the input traits, as shown in figure 2a. In figure 2b, 2c and 2e, we can see the result of an optimized image that is generated from input sketches and additional prompts.



(a) Finch AI (b) Luma AI

(c) Prime AI (d) Midjourney

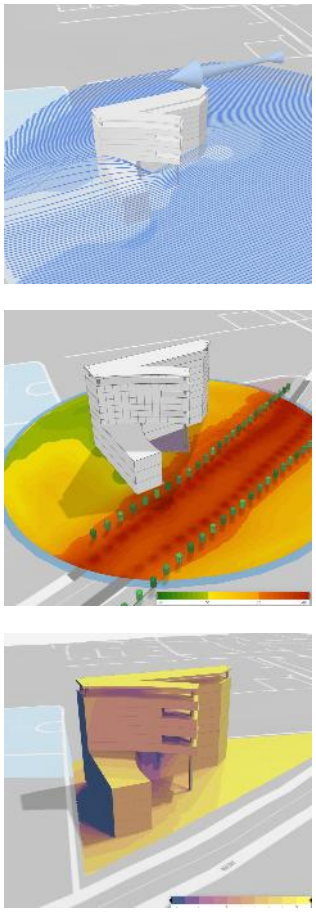
Figure 2. Types of AI used in schematic design

Design Development

The design development stage targets the optimisation of the design, by creating alternatives and analysis to sharpen the design concept and intention. Here, one of the AIs used to transform the building massing by using an environmental database is Forma by Autodesk, which is capable of simulating the interaction between the designed massing and the environmental elements, such as wind, noise, and the performance of the building envelope, for example, how long a certain side of the building is going to be exposed to the sunlight. Knowing these simulated data, the architect developed the design better based on reliable analysis. The result of the AI simulation to enhance the building design can be seen in figure 3.

Construction Documents

The preparation of construction documents includes the rendering and visualization documentation, which is a crucial phase in the attempts to communicate design to other stakeholders such as the owner, building contractor, as well as construction workers. AI in visual presentation allows students to visualize their ideas realistically for a larger audience. AI can also help students to save time, improve visual quality, and conduct further design exploration which in turn is very beneficial to the assignment.



(a) Wind Simulation

(b) Noise Analysis

(c) Building Envelope

Figure 3. Types of AI used in design development

The rendering quality produced by using AI is very dependent on the prompt included. The more detailed a prompt is being input, the better the rendering results. The quality of the rendering depends on the prompt and could be an advantage for students who do not have qualified laptop specifications to run an advanced rendering using installed software. Even so, there are several AI rendering websites that require a fee to access. Nevertheless, careful attention should be considered to prevent future disputes because of the unrealistic expectations created by the renderings (Abdul-Malak & Hamie, 2019). The commonly used AI in this phase can be found in figure 4 below.

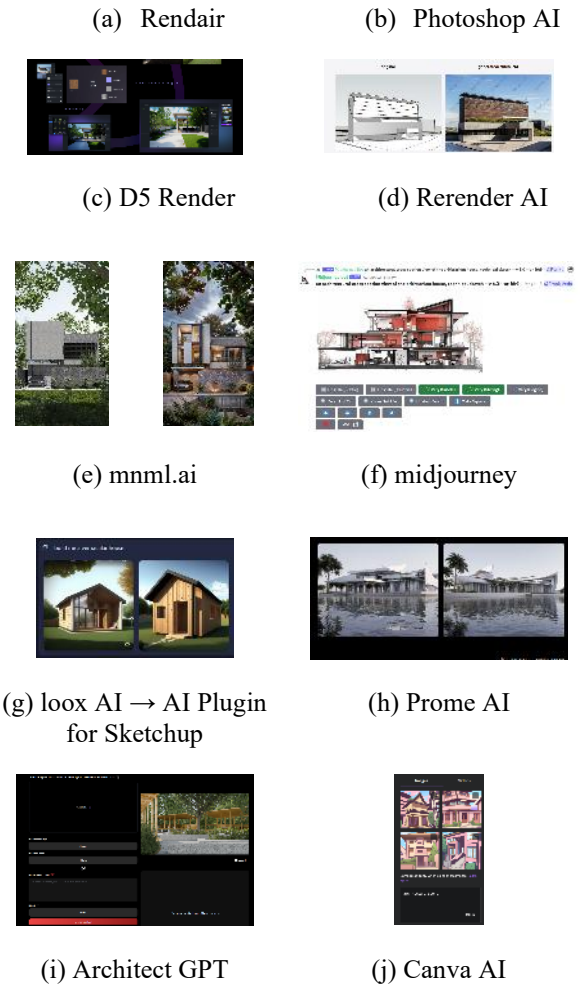


Figure 4. Types of AI used when preparing construction documents

Considering the increasing number of AI that could be utilized for architectural design, this paper attempts to picture the use of AI from the perspectives of architectural students and educators and to analyze the potential of future opportunity and threads.

METHOD

This research begins with a literature study regarding the use of AI in architectural education, and also the design phases of architectural education which are commonly practiced in Indonesian Architecture Studio. Then, a questionnaire model is adapted from the Royal Institute of British Architects (RIBA) Artificial Intelligence Report 2024 ("RIBA AI Report 2024," n.d.), to collect responses from respondents. The questionnaires adapted the design stages mentioned and combine them into nine more specific phases in architectural design, namely: (1) Initial design phase: Initial exploration, programming and zoning; (2) Creating design alternatives; (3) digital 3D model making and 3D massing transformation; (4) building performance simulation; (5) aerial environment design performance simulation; (6) Concept description, specification and design narratives writing; (7) Building standard, rules and regulation exploration; (8) Design rendering visualization and animation; and (9) Presentation layouting, to understand the flexibility of AI tools.

The questionnaire is divided by the respondent's background: educator and student. From this branching question, both educator and student must answer questions regarding the frequency of AI use in the design process. Students and educators will obtain slightly different questions, as the lecturers may answer questions from the perspective of their students, such as: " .. Please answer depending on your experience, or your observation of students, regarding the use of AI in .. stage ..". Both of the parties are then asked to indicate their preference for AI use in each design stage.

In the next section of the questionnaire, both parties are asked to give their opinion regarding the use of AI in Architectural education, especially on the issues, such as: (1) Design Initiation; (2) Complex Design Alternatives; (3) Making 3D Modeling; (4) Building Simulation; (5) Surrounding Environment Simulation; (6) Narrating Concepts and Descriptions; (7) Building Standard Exploration; (8) Rendering and Visualization, and (9) Layouting and Presenting. For each of the answers, they are objected to giving the reason for the answer. Lastly, they have to rate at two questions, regarding their opinion of the AI used in Architectural education in terms of overall practice, and also in terms of creativity.

RESULT AND DISCUSSION

Respondents Profile

There are 166 respondents in this research, including students from the Architecture Department who have already used digital presentation and tools, and also lecturers. Out of the 166 respondents, there are 3 invalid student respondents that were not taken into consideration in the data analysis. Both parties, students and lecturers, come from universities all around the big cities in Indonesia, including the students and educators from the graduate architecture department. The result is that 50% of the respondents are students who have already used AI in their projects, while only 15% of the student respondents have never used it. The students who never use AI prefer to use manual methods like sketches in their design stages. All of the lecturers claim to have already used AI for the teaching and learning process in Studio.

The overall usage of AI in architectural

education can be seen in figure 6, where most of the students and lecturers use AI seldomly, as the total of respondents who answered 'seldom' is nearly twice as much as the respondents who answered 'many times'. 4% of the students answered that they use AI in the overall design stages every time. 20% of the students responded that they almost never use AI, as did 8% of the lecturers.

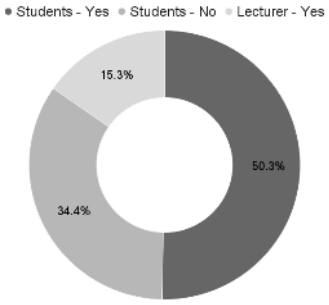


Fig 5. Respondents's profile

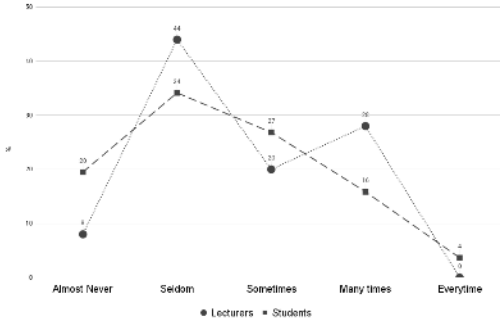


Fig 6. Overall use of AI

The intensity of AI usage

The questionnaire demands that students and educators answer based on the intensity of AI usage in each of the design stages. Students almost never use AI in building and environmental simulation (75%), as well as in layouting and presentation (77.5%). Besides, 66.25% of the students also never use AI in generating 3D modeling. AI is commonly used in the rendering and visualization phase, where 7.5% of students always use AI features to maximize their presentations, followed by the design initiation phase (3.75%). 3.5% of the students also always use AI to narrate their concepts and descriptions, searching for building standards, rules, and regulations. From the graphics in Figure 7, we can also conclude that, in total, AI is used mostly in design initiation (programming and brainstorming), narrating concepts and descriptions, and also searching for buildings' standards. These three stages affect the design but are not related to the actual drawing for architectural products. Students also use AI in the design alternatives, also rendering and visualization phase with 'many times' and 'sometimes' intensity.

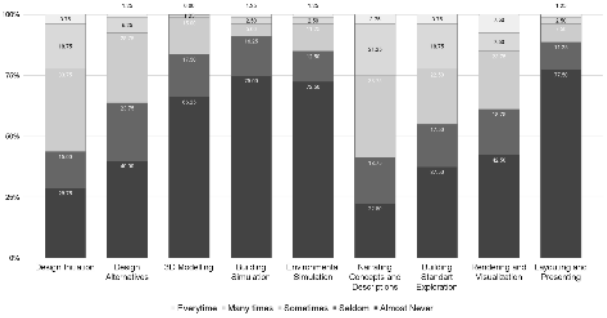


Fig 7. Student's use of AI in design phases

Proportionally, from the lecturer's point of view, the AI is found to be used more frequently in design initiation (40%), narrating concepts (40%) and rendering phase (52%) with the cumulative percentage from the answer 'every time' and 'many times'. The AI is least used in 3d modeling (56%) and simulation phases (48% building and 52% environment), by adding the amount of respondents that answered 'almost never' and 'seldom'. The response from the lecturers can be seen in figure 8.

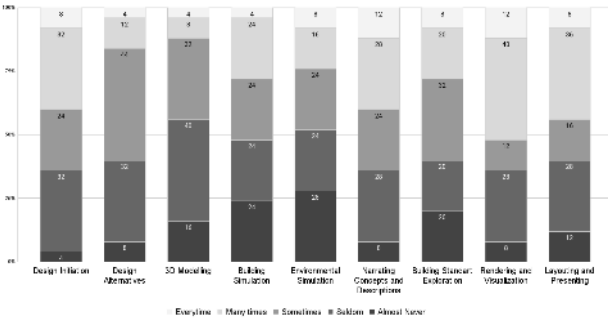


Fig 8. Lecturer's use of AI in design phases

Varieties of AI: Student vs Lecturers

The probability of AI use in each design stage may be different, in student's and lecturer's perspectives. Therefore, we asked the respondents to validate their use of AI in each design stage more specifically. The result from the student's point of view is shown in figure 9 below. Some students answered by mentioning software that is not AI-based and therefore classified as invalid.

As mentioned before, the students are using AI mostly for gathering data, narrating concepts and doing explorations such as building standard comparison, and also rendering and visualizing their design ideas. The answers from respondents were then accumulated, and summarized in Table 1.

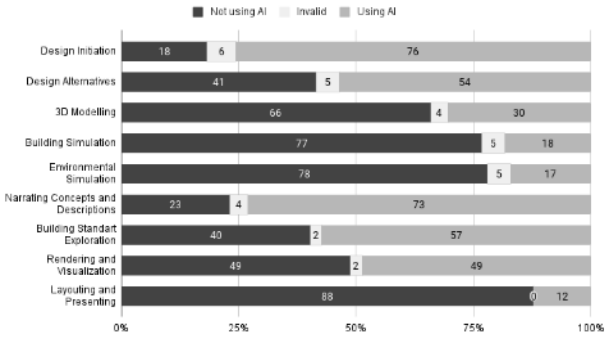


Fig 9. The use of AI from Student's point of view

The AI mentioned below the line signifies the less mentioned AI. We found that Chat GPT is often mentioned in many design stages, such as Design Initiation and Narrating Concepts and Descriptions, and also Building Standard Exploration with high accumulative mention compared to the other AI. Chat GPT is also surprisingly used in the Design Alternatives and Building Simulation stage. For more clarity in this finding, we did an interview with the respondents, and they state that the use of AI in the Design Alternatives stage is to provide them with more concrete design feedback to develop their design and to validate their alternatives. In the simulation stage, such AI is used to find the parameters needed for the simulation, and the suggested steps to do the simulation. More variations of the AI used are shown in the rendering and visualization stages, where the number of students that used the AI is high, with the various mentioned.

Table 1. The variations of AI used by the students

Design Stage	**AI Name (Number of Respondents)**
Design Initiation	**Chat GPT (38)** - MS Bing (8) - Gemini (9) - Co Pilot (3) - DAL-E (3) - LOOX (5) - Sketchup Diffusion (2) - Midjourney (5) - Kiskom (2) - Rerender AI (2) --- Forma - Gen Kraft AI - Adobe Psd AI - Varys AI - Prompt - canva ai - Perplexity - adobe AI - openAI
Design Alternatives	*Chat GPT (9)* - Ms Bing (7) - LOOKx (6) - Sketchup Diffusion (2) - Midjourney (7) - DLI (4) - Gemini (3) --- Forma - Gen Kraft - Adobe Psd AI - mnml.ai - evel lev veras - rerender - open ai - viskom - fotor - luma ai
3D Modelling	MS Bing (6) - LOOKx (6) - Chat GPT (3) - Rerender AI(2) - Midjourney (3) --- Gen Kraft - Adobe Psd AI - mnml.ai - Vizcom - DAL E - evolve - jeni AI
Building Simulation	Forma (4) - *Chat GPT (6)* - MS Bing (2) --- Rerender AI - Adobe Psd AI - Gemini - Finch.ai
Environmental Simulation	*Chat GPT (6)* - Bing (4) - Gemini (2) - Forma (2) - Lookx (2) --- AdobeAI - mnml.ai - evolve - Finch - Forma
Narrating Concepts and Descriptions	**Chat GPT (44)** - Bing (7) - Gemini (11) - Co Pilot (2) - Adobe AI (2) - Perplexity AI (2) --- Text correct - photohsop AI - mmlm.ai - open ai
Building Standards Exploration	**Chat GPT (16)** - Bing (2) - Gemini (6) - Perplexity AI (2) --- Adobe AI - architect gpt - open ai
Rendering and Visualization	LOOKx (7) - Bing (5) - Vizcom (4) - Midjourney (4) - Prompt.ai (3) - twinmotion (3) - Chat GPT (2) - mnml.ai (2) - Render AI (2) - Dall E (2) - D5 (2) --- Evolvelab - Genkraft - Copilot - Gemini - Adobe AI - Architect Render AI - skp diffus - archsynta - photosop - rerender ai - Getimg.ai
Layouting and Presenting	Adobe AI (2) - Chat GPT (3) --- Bing - Behance - Canva ai - Text correct - Midjourney

All of the AI mentioned by the students is also mentioned by the lecturers. There are also some lecturers that use more advanced AI with the premium membership to use more optimized AI features. In contrast, there are also 16% of the lecturers who know the use of AI in their

student works, but can not specify which AI is used in which design stage. This phenomenon needs attention, as the lecturers should assure that the competencies of Architecture are transferred to the students via the process in the design studio, and the inspiration and creativity for problem solving come from the students' initiatives.

Opinion regarding the use of AI in Architectural Education

In addition to the intensity of AI usage in certain design stages, the respondents are also asked to share their perspectives regarding the use of AI. The guide for the assessed parameter is the RIBA questionnaire. There are some results that goes similarly between the students and lecturers, such as:

- The thread for architect profession → At majority, the students and lecturers disagree with the statement (72.5% disagreement from students and 68% from lecturers)
- Improved Efficiency → Around 90% of the students and lecturers are agree that AI could assist the architectural design
- Enhancing sustainability → Most of the students (70%) and lecturers (75%) agree that the use of AI will support energy efficiency in designing buildings, so that will enhance sustainability

Nevertheless, there are two points that resulted in an almost evenly divided response between agree and disagree.

- The risk of imitation → This was caused by the fear of accumulated data learned by the AI that will create a rather general design, versus a group of people that still believe in the power of strong, unique prompts that will lead to unique design.
- Enhanced Accuracy → The answers are divided between a group of respondents that question the accuracy of AI itself, as they think that AI is still under development, versus individuals that trust the performance of machine that is more error free than human, as the machine will always collect database information and keep growing to minimize the error margin.

Lastly, there is a difference in answer between the lecturers and students, regarding the needs of AI assistance, due to the increasing complexity of the building. Only 78,75% of the students agree that they will need AI for designing more complex buildings, yet all of the responses from the lecturer fully agree with the statement. The reason for the disagreement from the students is that they feel like the AI will result in a design that goes against what they have in mind, so they feel like in more complex architectural design, the human approach still outperforms the AI. The result of this opinion can be found in figure 10.

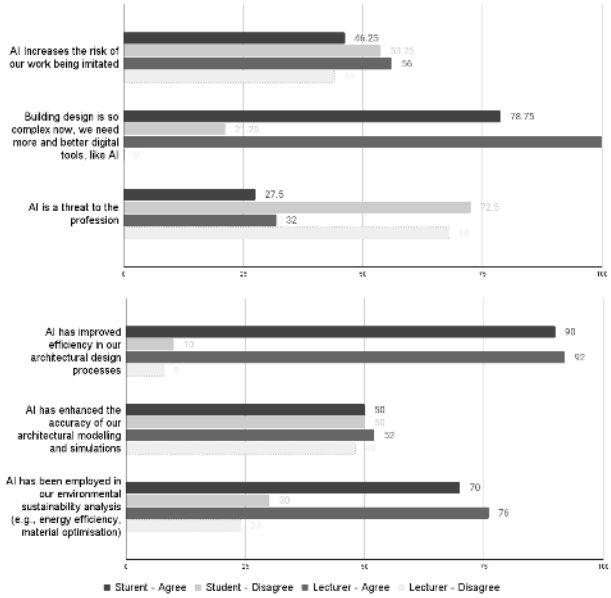


Fig 10. Opinion from students and lecturers regarding the use of AI

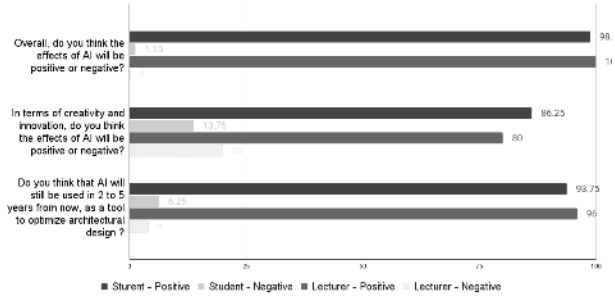


Fig 11. Positive and negative opinion regarding the use of AI

In terms of overall performance, both students and lecturers agree that the use of AI has mostly a positive impact on architectural education. The degree of agreement decreases when being questioned regarding the creativity and innovation aspects, yet it still has more than 80% positive answers. Lastly, both students and lecturers are confident that AI will still be used in the future, and keep improving. This result can be seen in Figure 11.

The questionnaire also gave open ended questions for the respondents to describe their reasoning and further opinions that will explain their previous ratings and answers, as well as the reason why they feel positive or negative impact of using AI in architectural education. The most used keywords found in the answers of open ended questions are then accumulated and summarized as advantages and disadvantages of AI as below.

AI is an alternative that provides many benefits and advantages. Using technology wisely can certainly be used as a reference for a design. Architect's ideas are still

a main source to insert prompts appropriately so that it will enable the production of optimized design ideas using AI. The following are the main benefits and advantages of using AI in rendering.

1. Time efficiency → Ability to read prompts and generate visual quality can save time on rendering so that architectural students can focus on brainstorming to optimize design creativity.
2. Presentation quality's improvement → Easy to visualize and will certainly clarify the intention of the design
3. As an inspirational source → To be a reference tool which produces out of the box formations as a source of reference that can be developed.
4. BIM İntegration → Collaboration with BIM and AI will certainly help the design process to optimize the design form.
5. Improvement of Accuracy → In the case of reading analysis or site conditions such as autodesk forma integrated with the BIM system and reliable data surely can optimize the design response because AI can read site data accurately.

With the advantages, there are also weaknesses when relying heavily on the use of AI such as:

1. Decreasing creativity → when we imitate 100 percent of the results of AI without making modifications. This condition will decrease the level of creativity of students.
2. Decreasing the role of the sensory in design → Buildings are usually very characteristic of the personality of the architect or designer, and when they have a sense of dependence on AI, the character of the building no longer characterizes the designer.
3. Becoming Lazy → Only needing to create a prompt in the design process to realize something instantly makes students have a lazy personality.
4. Different User Power → Some AI sites cost money and the price difference results in different levels of quality.
5. Lack of detail innovation → Some AI working drawings did not produce as much detail as students expected, so students needed to look for the information again in other sources.

CONCLUSION

The most common uses of AI in Indonesian Architectural design studios are gathering data, narrating concepts and doing explorations such as building standard comparisons, and also rendering and visualizing their design ideas. Students view AI as an alternative to solve their design problem, by gathering initial information, for actual architectural design work like renderings and visualization. More than 80% of them also see AI from the positive perspective, including in terms of creativity and innovation. The same result comes from the lecturer's perspective. AI can be a part of a student's creativity, as they utilize AI in a creative way, like Chat GPT to validate their design alternatives.

Despite the findings, lecturers must also update their knowledge of AI, so that they can direct the dynamics of the student's learning process, to assure the competency of Architectural design thinking is passing through the architectural studio process, and is not highly dependent on AI. AI can enrich and accelerate the design process. It was found that the use of AI created new opportunities for students to develop unlimited creativity, provide more efficient solutions, and be innovative in responding to complex challenges in design tasks. Nevertheless, students certainly should not rely heavily on the use of AI. Architecture students as future architects have a key role in managing and applying AI wisely. Fortunately, it is also found in this study that students can act objectively and answer that the heavy use of AI can make them more lazy to do exploration. Research regarding the limitations, potential and ethical implications of using AI in the context of architecture could be explored more in the future. Human-AI collaboration will be key to realizing a shared vision of a sustainable and competitive environment in the future.

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