ACCELERATING FUTURE SCENARIO DEVELOPMENT FOR CONCEPT DESIGN WITH TEXT-BASED GENAI (CHATGPT)

LINUS TAN[1] and THOM LUKE[2]
[1] *Swinburne University of Technology*
[2] *RMIT University*
[1] *linustan@swin.edu.au, 0000-0002-5705-0493*
[2] *thom.luke@rmit.edu.au, 0009-0003-6317-5879*

Abstract. This case study describes the integration of Generative Artificial Intelligence (GenAI) into a design workflow that envisions future scenarios for concept development. While image-based GenAI tools like MidJourney and Stable Diffusion have garnered attention from designers for their ability to visualise ideas rapidly, integrating textual GenAI, like ChatGPT-3.5, in design workflows has been less explored. This case study investigates how future thinking techniques can be digitized and accelerated using ChatGPT-3.5 to create a textual GenAI-embedded design workflow. Next, we test the workflow with postgraduate design students to speculate future scenarios, substantiate scenarios with existing circumstantial evidence, and develop a concept design based on the scenario. The outcomes highlight that GenAI suggested social changes from a range of disciplines, and designers still need to search for the source to clarify and evidence the changes manually. The case study concludes by describing the benefits of using textual GenAI in design workflows, and future research needed to strengthen the use of textual GenAI as a tool for design concept development.

Keywords. Future scenario, Futures thinking, Horizon Scanning, Signal, Futures Wheel, Generative AI, ChatGPT, Concept design

1. Introduction

Speculating scenarios for architecture design helps to deliver a vision of the future that responds to emerging trends, technological advancements, and environmental challenges. These speculations also can suggest how architecture are crucial catalysts of those visions. Not only can we find examples of these from the past, such as Peter Cook's Plug-in City (1965) and Superstudio's The Continuous Movement (1970), but similar speculative architectural projects still emerge today, such as Liam Young's Planet City (2021) and Lateral Office's State of Disassembly (2017). These examples, while diverse, share a common theme: the provocative proposals offer novel spatial experiences and, more importantly, spark discourses about the relationship between societal and architectural development.

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Design researchers have also integrated future thinking and scenarios as briefs and inspirations to guide their design processes. These mixed approaches include Critical Design (Dunne, 2008), Speculative Design (Dunne & Raby, 2013; Mitrović et al., 2021), and Design Fiction (Bleecker, 2009; Bleecker et al., 2023). In these design approaches, the goal is not to produce practical, implementable solutions but to provoke thought, spark conversations, and inspire new perspectives on the future. These methods encourage designers to step beyond the constraints of the present and consider the long-term consequences of design choices in an environment of societal change. By engaging with speculative scenarios, designers can offer unique insights into the potential impacts of emerging technologies, social changes, and cultural shifts, ultimately contributing to a more informed and imaginative approach to design.

This case study builds on such approaches by introducing architectural design to a design workflow using textual Generative Artificial Intelligence (GenAI) to generate future scenarios that creatively provoke architectural and design discourse. The significance of this work lies in demonstrating how textual GenAI augments the ideation phase of the architectural design process and how it helps architectural designers consider future thinking in their own approach.

2. Background

2.1. FUTURE SCENARIOS

Future scenarios offer individuals insights into potential future directions and opportunities. These described visions of the future help us expand our understanding of what might lie ahead. To speculate future scenarios, designers often gather data on current trends in technology, society, and culture and extrapolate how these trends might evolve. This is different to simply imagining future environments, which does not always include examining existing societal behaviours and trends. For example, imagining a floating city, without considering if current societal demands or behaviours indicate a development towards living on water. Below we expand on two of its components, Futures Thinking and Scenarios.

Futures Thinking is a broad concept that emerged from strategic planning, foresight, and futurism. This approach provides designers a structured way to think about the future (Evans & Sommerville, 2007; Jonas, 2001; Raymond, 2003). It encompasses future-oriented techniques that not only help individuals build practical foresight skills but at its conceptual level, seeks to challenge our perceived notions of the future. As Inayatullah (2008, p. 6) pointed out, "it is not so much predicting [the future] correctly... but about enhancing our confidence to create futures that we desire. Futures methods thus decolonize the world we think we may want."

Scenarios, in the field of future studies, are narrative representations of a possible future development, spotlighting key moments that do not exist currently (Meinert, 2014). Speculative scenarios, particularly those in film and science fiction, "represent highly implausible and impractical situations and technologies… with a sheen of plausibility" (Kirby, 2010, p. 46). Examples include Peter Cook's Plug-in City (1965) and Liam Young's Planet City (2021). On the other hand, future scenarios offer a more grounded perspective on the possibilities ahead. According to Sardesai et al., (2021, p.

62), such future scenarios "portray causal relationships that explain how, from the vantage point of the present, a particular future in a certain story setting has been derived." By grounding future scenarios with existing observations, it enables designers to explore the potential consequences of current societal actions and trajectories of its collective endeavour.

2.2. GENAI TECHNOLOGY IN ARCHITECTURAL DESIGN

Architectural designers and researchers have begun to integrate GenAI into their architectural design development, to generate design concepts (As et al., 2018), develop architectural forms (del Campo et al., 2019), develop spatial compositions (Dzieduszyński, 2022), introduce glitches and defamiliarisation to spark new approaches to design (del Campo & Manninger, 2022), and use food imagery to inspire architectural designs (Koh, 2023), to name a few. Many architectural design projects that use GenAI, such as these examples, often use visual GenAI. These image-based GenAI, like MidJourney and Stable Diffusion, have received significant attention in the design industry, and have the potential to reshape how designers conceptualise spatial designs. These text-to-image GenAI tools often rely on deep learning models to almost generate realistic images instantly from a few keyword descriptions, accelerating the designer's ability to visualise their ideas.

3. Research Objective

The novelty of our research is integrating textual GenAI, as opposed to visual GenAI, into the design process. While AI-powered text expanders have shown their potential in various domains, like creative writing and content generation, they have not received equal attention in the architectural community as a design tool. This case study documents our exploration of future scenario development using textual GenAI to spark discussions about future environments through the three objectives:

- Explore how textual GenAI can accelerate future design scenario development. We use GenAI to digitise future design techniques into a digital workflow.
- Evaluate the impact of using our GenAI-augmented digital workflow in generating design narratives that convey the future user experience as architectural proposals.
- Explore architecture-related future scenarios of using our GenAI-augmented digital workflow.

3.1. RESEARCH APPROACH

In some forms of architectural design, the design process is seen as a dynamic and interconnected series of tasks (e.g. Generative Architecture). This design process references Alexander's (1968, p. 605) *Systems Generating Systems* perspective, which posits, "a generating system… is a kit of parts, with rules about the way these parts may be combined." We use his "kit-of-parts" perspective to develop our design workflow, then test it with designers to see its effectiveness in their concept design process. While Tan (2024) has implemented a textual GenAI workflow to help designers extract installation concepts from historical stories, our GenAI workflow focuses on value-

adding future thinking approaches to architectural design process.

To develop our digital workflow, we connect different priming and prompting tasks in GenAI to form a system that serves as the framework for generating future narrative (we describe this development in the section below). In Grasshopper, a popular generative design modelling software, components are linked up into a Grasshopper definition that can produce a 3D model based on a few inputs. In our research, priming and prompting are like Grasshopper components, and our workflow is the Grasshopper definition that enables designers to come up with a future scenario based on a set of inputs. The value to designers in adopting design workflows is for them to assess their overall creative design process and pinpoint aspects where they might substitute digital technologies to augment their creativity (see e.g. Yousif & Vermisso, 2022). Here, the prospect of elevating their creativity is using our digitised future thinking process.

To implement our workflow, we rely on Yang et al.'s (2018) two approaches to teach students about designing with AI. The first way is to teach them the technical details of how the AI technology works so they understand the capabilities prior to design. The second way is to let students learn-by-doing. Our research combined both approaches; we first demonstrated the workflow by generating an example scenario to postgraduate design students, then tasked them to experiment, evaluate and iterate the workflow. These designers are not future designers, and most are novices at using GenAI. The research lasted four weeks. In these four weeks, we instructed students to experiment with the workflow, identify issues, and suggest improvements through their revised workflow. We then evaluated our digital workflow with theirs to provide a synthesised textual GenAI model for designers. After demonstrating their refined digital workflow and early scenario, the postgraduate design students spent six weeks to refine and visualise their scenarios.

4. Results

4.1. THE GENAI DIGITAL WORKFLOW

In this phase, we used textual GenAI to digitise and accelerate future design techniques. Specifically, we used ChatGPT-3.5 and digitised 1) Horizon Scanning for Signals, and 2) Futures Wheel of Consequences. We then stacked these digitised techniques to form a GenAI-embedded design workflow for scenario development (see Figure 1), similar to linking Grasshopper components to create a Grasshopper definition for designers to generate a design.

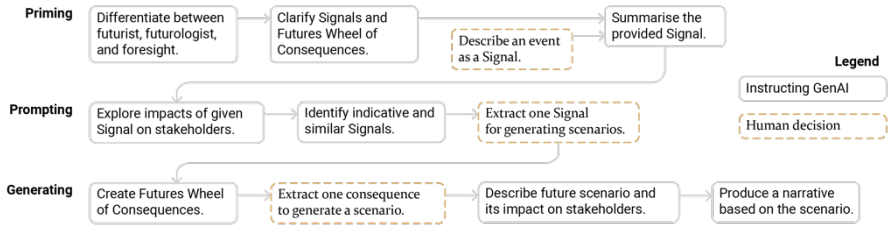

Figure 1 Textual GenAI digital workflow for developing future scenario

4.1.1. Future design techniques

We describe only Horizon Scanning for Signals and Futures Wheel of Consequences in the array of futures thinking techniques as they were chosen for our digital workflow. Reviewing all the future design techniques is outside the scope of this paper. Additionally, Evans & Sommerville (2007) summarised and contextualised a list of futures thinking techniques for design education, whereas Palmer & Ward (2010) demonstrated futures thinking integration with architectural pedagogy.

Horizon Scanning is searching for information from various sources that may indicate changes in the environment (Cuhls, 2020). This information is better known as "signals" and the collection of changes can suggest trends, which may help individuals anticipate potential futures (Rossel, 2012; Saul, 2006; Voros, 2003). We postulated that ChatGPT-3.5, pre-trained on a large corpus of internet sources, may accelerate Horizon Scanning by rapidly providing a range of signals from different disciplines to help designers indicate a changing trend. Futures Wheel of Consequences organises thinking and questioning about the future (Glenn, 2009) through a structured mind mapping process. We employed ChatGPT-3.5's language pattern recognition capabilities to analyse our Signals input (from Horizon Scanning), imagine different possibilities, and describe them as unique scenarios.

4.1.2. Generative AI ChatGPT-3.5

Textual GenAI, or Conversational GenAI, are large language models (LLMs) that leverage advanced natural language processing techniques and machine learning algorithms to simulate human-like conversations. It interprets and generates text-based responses to user's input, mimicking interactive dialogues with the user on a wide range of topics and tasks. Common LLMs include OpenAI's ChatGPT, Microsoft's Bing Chat (powered by ChatGPT), Google's Gemini, Anthropic's Claude 2, and Meta's Llama 2. We chose ChatGPT as it has the highest accuracy and lowest hallucination rate compared to other LLMs (Hughes et al., 2023/2023) based on Vectara's Hallucination Evaluation Model (Hughes, 2023). We chose ChatGPT-3.5 over ChatGPT-4 as it was free and available to public and thus more accessible to designers.

Since ChatGPT-3.5 recognises language patterns and relies on contextual information to respond, we primed ChatGPT-3.5 to enhance the accuracy and relevance of its responses. Additionally, priming enabled us to verify that ChatGPT-3.5 is outputting contextually relevant information. We primed ChatGPT-3.5 by asking it to differentiate similar keywords prior to prompting with those keywords. In our workflow, we asked ChatGPT-3.5 to differentiate between futurist, futurologist, and foresight practitioner, then prompted ChatGPT-3.5 to provide responses like a futurist to start our digital workflow.

4.2. GENAI DIGITAL WORKFLOW EVALUATION

Figure 2 shows samples of the students' workflows at the end of the four-week hands-on experimentation, whereas Figure 3 shows our revised workflow.

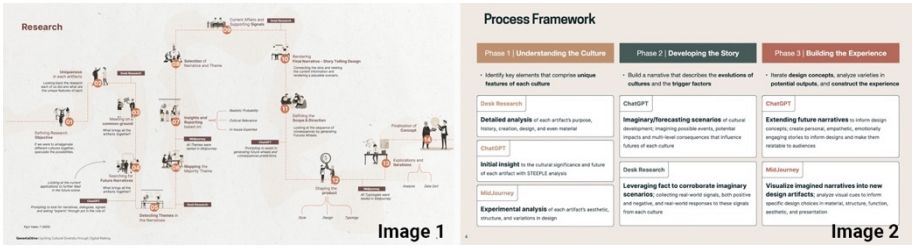

Figure 2 Iterated digital workflows (Mohanasunder et al., 2023; Yadav et al., 2023)

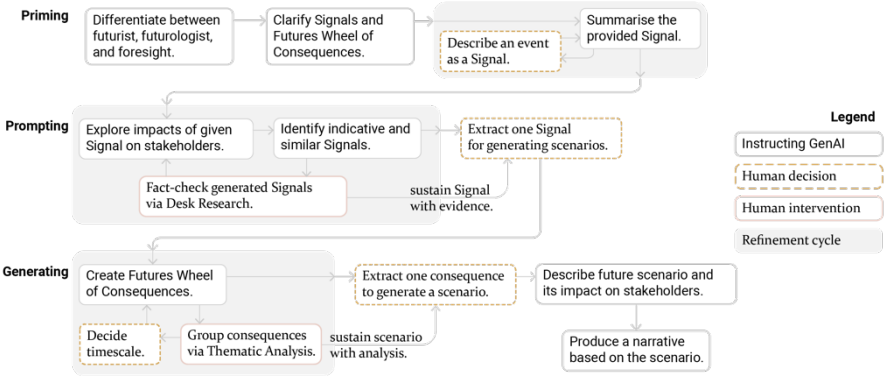

Figure 3 Revised digital workflow

In our revised workflow, we implemented three refinement cycles. This is for designers to verify the outputs provided by ChatGPT-3.5 and sharpen their inputs to produce more nuanced outcomes. During priming, we noticed that ChatGPT-3.5 did not always summarise the given Signal accurately and so it is important to refine the Signal before proceeding on to prompting. While ChatGPT-3.5 provided suitable responses for developing scenarios, the dialogue between ChatGPT-3.5 and the users played a significant role in steering the concept direction. During Horizon Scanning for Signals (i.e. the prompting episodes), ChatGPT-3.5 suggested likely but not specific evidence of Signals, and unsurprisingly, manual fact-checking on the internet to verify its evidence was required. However, this web-based evidence enabled the designers to justify their selection of a Signal for scenario development. Additionally, the value of using ChatGPT-3.5 was its ability to identify potential Signals from disciplines outside design, which increased the breath of where the Signals were found. The final refinement cycle was for Futures Wheel of Consequences. Adding a timescale to the scaffold the prompting influenced how divergent the resulting Futures Wheel of Consequences were from the original Signal. The shorter the timescale, the smaller the deviation the consequences were from the Signal. Below, we chose two generated scenarios, based on maximum variability within the range of design outcomes, to expand on how the scenarios developed into an architectural and a place-making design outcome.

4.3. SCENARIO OUTCOMES FOR CONCEPT DESIGN

Figure 4 shows two different scenarios developed by our workflow. Image 1 shows a scenario, 40 years into the future, about the consequences of using AI-augmented design algorithms on vernacular architecture in Riyadh, Saudi Arabia. Image 2 shows a scenario, 20 years into the future, about protecting culture through public artefacts that generate energy in India. We describe both scenarios below.

Figure 4 Scenario developments (Mohanasunder et al., 2023; Yadav et al., 2023)

In Scenario 1 (i.e. Figure 4 Image 1), the Signal begins with Saudi Arabia strengthening their ties with India (in 2023). The speculation is that some Indians re-locate to Saudi Arabia by 2025, cultural integration gradually occurs by 2030, and so did cultural misrepresentations by 2035. Both demographics attempt to design architecture that represents both cultures by 2050. GenAI's datasets become tainted by 2055, due to existing cultural misrepresentations, and thus future architecture in Riyadh, Saudi Arabia diverges to either be culturally accurate or misrepresented by 2060. Figure 5 Image 1 shows a comparison of the culturally accurate and inaccurate design elements, Image 2 shows how the culturally accurate design appears in architecture, and Image 3 shows how culture in architectural design may be misrepresented.

Figure 5 Scenario 1 as concept design development (Yadav et al., 2023)

In Scenario 2 (i.e. Figure 4 Image 2), the Signal begins with local communities in Native America looking to generate sustainable energy in 2023. The future thinking is that these communities will implement energy creation devices such as solar panels, wind turbines, and piezoelectric floor panels by 2026. Their ability to generate electricity while simultaneously integrating cultural design inspired other nations like India to adopt their technology by 2030, which then began to integrate their cultural

stories for learning in the piezoelectric floor tiles by 2035. This becomes an initiative for public cultural learning by 2040. Figure 6 shows how this 2040 scenario may look (Image 1), how it may be used by the community (Image 2) and a prototype of the piezoelectric floor tile (Image 3).

Figure 6 Scenario 2 as concept design development (Mohanasunder et al., 2023)

5. Discussion

This research uses textual GenAI to develop and test a digital workflow for designers to create future scenarios for concept development. Scenarios like Peter Cook's Plug-in City (1965) and Liam Young's Planet City (2021) are visually provocative. While our GenAI workflow guides designers to produce concepts that are less evocative than the speculative examples we gave, it differs from mere speculations for, based on Kirby's (2010) description, our outcomes represent plausible and practical situations and technologies to an extent. Revisiting both concepts described above, the technologies and design appear attainable within their proposed timeframes. This can be attributed to how we intentionally integrated futures thinking approaches into our textual GenAI digital workflow. This is evidenced through the scenarios' timeframes, which sought to visualise imagined relationships that lead from the present to their future. Apart from introducing futures thinking to architectural concept development, our case study also contributes to the increasing works on GenAI in architectural design. The novelty of our study is using textual GenAI and not visual GenAI to develop concepts for the built environment.

A key limitation of this study is the lack of a distinct architectural concept corpora to train ChatGPT-3.5. While ChatGPT-3.5's internet-derived training data provided the breadth for suggesting Signals in other fields during Horizon Scanning, being able to restrict ChatGPT-3.5's training data to architectural concept corpora for the Futures Wheel stage may yield scenarios that are architectural-specific. Despite this limitation, our research demonstrated the potential of using textual GenAI in architectural concept development, opening up new avenues for innovative design approaches.

To further understand the value of this introduced concept technique, future research can conduct a comparative study between the difference between manual concept design development and this digital workflow. Another future research would be to integrate visual GenAI within our proposed workflow. Augmenting each generated scenario with a GenAI image may influence which scenario designers choose for development. This image creation approach may also influence designers to select more speculative scenarios than future scenarios.

6. Conclusion

GenAI can potentially shape how architects develop concepts, and our case study shows how it can help designers develop future concepts of the built environment. While many recent research focus on the image-based GenAI in exploring architectural concepts, we instead demonstrated how textual GenAI can help designers use future thinking techniques to imagine future built environments. Our case study shows how we replicated futures thinking techniques in textual GenAI to create a digital workflow. Then, we tested the workflow with postgraduate design students to generate future scenarios of the built environment.

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