INVESTIGATING THE ACCEPTANCE AND IMPACT OF CUSTOMISED GEN AI CHATBOT ON SYSTEMS THINKING AMONG POLYTECHNIC STUDENTS

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Teaching systems thinking can be challenging due to its complexity. Students tend to perceive systems as isolated parts rather than dynamic and interconnected. To address this, a customised Gen AI chatbot is proposed as a learning scaffold that offers personalised coaching and feedback on systems thinking. It is integrated with GPT3.5 and enables the researchers to code specific prompts to scaffold systems thinking. This study aims to investigate students' perceptions of their learning experiences with the chatbot, as well as examine whether students developed systems thinking competencies following the interaction with the chatbot. The study employed a mixed method convergent parallel design. Participants were 52 first-year polytechnic students undertaking a critical thinking and problem-solving skills module. Students' post-survey responses and chat logs were collected for analysis. The survey included items adapted from the Technology Acceptance Model (TAM): Perceived usefulness, perceived ease of use, and behavioural intention. Descriptive analysis of the quantitative survey items suggests that while students recognise the value of the chatbot, particularly in enhancing assignment quality, barriers to regular usage may need to be addressed. Thematic analysis of the open-ended responses revealed that while students commended the chatbot for its constructive feedback, promotion of critical thinking, and practical relevance to the assignment, they also identified technical limitations, its demanding interaction style, and a lack of contextualisation and nuanced understanding as areas for improvement. Additionally, to investigate the extent to which the chatbot facilitated the development of systems thinking competencies, an analysis of students' chat logs, categorised into three pre-defined areas aligned with the assignment rubric, was done. It revealed that while students were able to identify factors and stakeholders in a complex system, their ability to analyse inter-relationships and evaluate solutions remained underdeveloped. The results of the study provided insights for educators when integrating customised Gen AI chatbot to facilitate systems thinking lessons. Study limitations and implications are further discussed in the paper.

Keywords: *generative artificial intelligence, customised chatbot, systems thinking*

Introduction

Systems thinking involves understanding underlying drivers, interactions, and conditions that influence decisions, and helps students to build skills in reframing problems and expanding their perspectives to anticipate unintended consequences (Voulvoulis et al., 2022). The Structure-Behaviour-Function (SBF) framework provides a conceptual structure for organising ideas about complex systems (Jordan et al., 2013) and guides the scaffolding and assessment of systems thinking in this study. However, mastering systems thinking is challenging due to its complexity and interdisciplinary nature. Students often struggle to see systems as dynamic and interconnected, instead perceiving them as isolated parts (Assaraf & Orion, 2005). This highlights the need for innovative instructional strategies that actively engage students in deep reasoning and iterative problem-solving to make systems thinking more accessible and effective.

Generative AI (Gen AI) offers a promising tool for enhancing systems thinking education by providing an interactive, scalable, and personalised learning environment. Unlike traditional AI chatbots with scripted responses, large language models like GPT-3.5 enable open-ended conversations and can be customised to ask guiding questions rather than simply providing answers. Chang et al. (2023) argue that educational AI chatbots should act as facilitators rather than mere information sources. Research suggests that conversational agents help students develop systems thinking skills (Nguyen, 2023) by allowing them to grasp complex systems at their own pace, complementing classroom instruction. However, the role of Gen AI in fostering higher order thinking for systems thinking remains unclear. There is a need to explore how students can engage with complex problems through structured chatbot interactions, moving beyond reliance on AI for answers and toward understanding interconnections and designing solutions.

Despite Gen AI's potential in education, its effectiveness depends on student acceptance and engagement. The Technology Acceptance Model (TAM) provides a framework for understanding how users come to accept and use new technology. TAM identifies two primary factors influencing user acceptance: perceived usefulness and perceived ease of use. Perceived usefulness refers to the degree to which an individual believes that using a particular system would enhance their performance, while perceived ease of use is the degree to which an individual believes that using a system will be free of effort (Davis, 1989). In the context of this study, students' willingness to engage with the chatbot may be influenced by whether they see it as useful in enhancing their learning experience and intuitive in its interactions. Understanding these factors is key to designing AI-driven learning tools that are both pedagogically effective and widely adopted (Al-Abdullatif, 2023).

Objectives

This study examines the acceptance and impact of a customised Gen AI chatbot on systems thinking among polytechnic students. The research questions are:

(1) What are the reported levels of perceived usefulness (PU), perceived ease of use (PEU), and behavioural intention to use (BI) the customised Gen AI chatbot among students?

(2) What are the themes arising from the positive and negative experiences reported by students using the customised Gen AI chatbot?

(3) To what extent do students demonstrate systems thinking competencies when interacting with a Gen AI chatbot?

Methods

This study employed a mixed-methods convergent parallel design using convenience sampling. Participants (N=52) were first-year polytechnic students enrolled in a Critical Thinking and Problem-Solving Skills module across two classes facilitated by the respective researchers. Figure 1 outlines the study procedure. Data collection took place from Lessons 4 to 6, which focused on systems thinking. Data was collected from two sources: (1) survey responses from students and (2) chat logs from student interactions with the chatbot. At the start of Lesson 4, students were introduced to a problem statement related to sustainability in the fashion industry. They were also introduced to the chatbot and briefed on its use. Across the three lessons, students engaged with the chatbot independently as a learning scaffold while completing a written assignment to address the problem statement. In addition to the chatbot, students had access to e-learning materials, an assignment rubric, and support from the class facilitator.

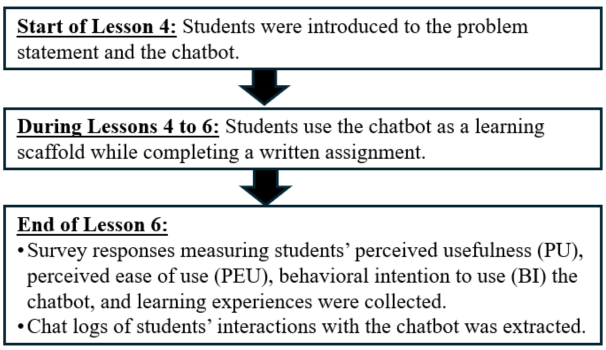

Figure 1: Outline of study procedure

The chatbot was built using a Gen AI model integrated with GPT-3.5. It was designed with researcher-coded prompts, structured questioning and feedback mechanisms to guide students in analysing the complex problem of sustainability in the fashion industry.

The coded questions in the chatbot were categorised into three areas: Factors and stakeholders, their inter-relationships, and solutions. Students were prompted by the chatbot to (1) identify the factors and stakeholders of the problem, (2) examine the inter-relationships among these factors, and (3) propose solutions to mitigate the problem's negative impacts. These steps were adapted from the SBF framework in systems thinking (Jordan et al., 2013), where identifying factors and stakeholders corresponds to exploring the structure, examining inter-relationships mirrors analysing behaviour, and proposing solutions draws from considering the function. This scaffolded approach aims to progressively develop students' thinking skills. These categories also served as the rubric for the assignment. Figure 2 shows a screenshot of the chatbot interface.

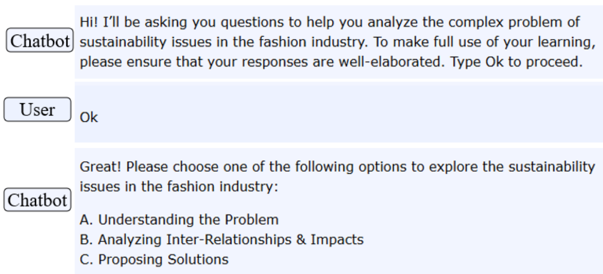

Figure 2: Screenshot of chatbot interface

At the end of Lesson 6, students completed an online survey on their perceptions and learning experiences with the chatbot. The survey included validated items adapted from the Technology Acceptance Model (TAM) (Davis, 1989). It comprised 9 statements: 4 on perceived usefulness (PU), 4 on perceived ease of use (PEU), and 1 on behavioural intention to use (BI) the chatbot. Students rated each statement on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). Two open-ended questions collected feedback on students' positive and negative experiences. Descriptive statistics were used for quantitative analysis, and qualitative feedback was analysed by two researchers using thematic analysis.

The chat logs of all students (N = 52) were extracted after Lesson 6 and analysed by the two researchers who systematically categorised the text into three pre-defined categories aligned with the assignment rubric: factors and stakeholders, their inter-relationships, and solutions, to assess systems thinking competencies across different levels of proficiency.

Results and Discussion

RQ1: What are the reported levels of perceived usefulness (PU), perceived ease of use (PEU), and behavioural intention to use (BI) the customised Gen AI chatbot among students?

The descriptive statistics of the quantitative items in the survey are shown in Table 1. The means for all items exceeded the mid-point of 3.00, indicating favourable student responses. The standard deviation values ranged from 0.70 to 1.02, indicating a narrow spread of item scores around the mean. The skewness (from -0.03 to -0.98) and kurtosis (from -0.89 to 2.14) were within the suggested cut-offs of absolute values less than 3 and 10 respectively (Kline, 2005), indicating univariate normality.

Overall, the PU dimensions have the highest mean score for all the items, followed by the PEU dimensions and the BI dimension. The survey item with the highest rating was "Using the chatbot enhances the quality of my responses in the assignment" (Mean = 4.19, SD = 0.77), suggesting that students find the chatbot's contribution to assignment quality particularly useful.

On the other hand, the item with the lowest rating was "I find the chatbot flexible to interact with" (Mean = 3.69, SD = 1.02). In fact, this item has a high SD (1.02), which might suggest that students have mixed opinions about the chatbot's flexibility (discussed later under RQ2).

The mean score for BI (3.75) suggests that students are moderately inclined to use the chatbot more often. This suggests that while students see value in the chatbot, there might be barriers to regular usage that need to be addressed.

Table 1: Descriptive statistics of survey items

Con-struct	Item	Mean	*SD*	Skew-ness	Kurto-sis
Perceived usefulness (PU)					
PU1	Using the chatbot enable me to accomplish my assignment tasks more quickly.	4.00	0.74	-0.30	-0.26
PU2	Using the chatbot enhances the quality of my responses in the assignment.	4.19	0.77	-0.62	-0.15
PU3	Using the chatbot make it easier to do my assignment.	3.96	0.79	-0.42	-0.14
PU4	I find the chatbot useful.	3.98	0.70	0.03	-0.89
Perceived ease of use (PEU)					
PEU1	Learning to use the chatbot is easy for me.	3.96	0.82	-0.60	0.17
PEU2	I find the chatbot to be flexible to interact with.	3.69	1.02	-0.72	0.34
PEU3	My interaction with the chatbot is clear and understandable	3.98	0.73	-0.29	-0.15
PEU4	I find the chatbot easy to use.	4.06	0.83	-0.98	2.14
Behavioural intention to use (BI)					
BI	I would like to use tools like the chatbot more than I already do.	3.75	0.88	-0.01	-0.88

RQ2: What are the themes arising from the positive and negative experiences reported by students using the customised Gen AI chatbot?

Qualitative responses to the two open-ended survey questions on students' chatbot experiences were coded and categorised. The first researcher conducted initial coding, and emergent themes were refined through discussions with the second researcher until consensus was reached. The analysis identified recurring themes that highlight the chatbot's strengths and limitations in supporting students' learning (see Table 2).

The theme "Constructive feedback for improvement" (P1) emerged as the highest frequency under positive experiences. Students value the chatbot's ability to identify flaws and offer constructive suggestions, as it helps refine their thinking and enhances their learning. In contrast, the theme "Technical limitations" (N1) had the highest frequency under negative experiences. Technical limitations, such as user interface issues and slow response time, likely caused frustration in the students. These performance issues can reduce the chatbot's perceived effectiveness and make it harder for students to focus on content and critical thinking. Addressing these issues could enhance student engagement and improve the overall learning experience.

Table 2: Themes and sample responses from open-ended survey questions

Themes [Frequency]	Sample responses
P1: Constructive feedback for improvement [27]	*"It points out flaws in my argument and include viewpoints that I would've never thought of."* *"Responses are detailed and not generic. It reads my questions and responds accordingly".*
P2: Promotes critical thinking [12]	*"Gives us questions to help us think actively"* *"Encourages me to explain my answers often."*
P3: Practical and learning support [7]	*"It is tailored towards what we have to solve for the given problem statement."* *"Helped me understand the topic better… which improved my assignment."*
N1: Technical limitations [15]	*"It takes a while to respond."* *"The chat box does not expand which would help me better see what I was writing before."*
N2: Overly demanding [14]	*"It is constantly demanding for improvement to the answers that you gave. Would be better if it is more lenient."* *"You have to answer the chatbot's questions first before getting the answers from it."*
N3: Lack of context and facilitator insight [6]	*"It doesn't give enough info in Singapore context."* *"It doesn't understand my input as good as my (human) facilitator."*

RQ3: To what extent do students demonstrate systems thinking competencies when interacting with a Gen AI chatbot?

Students' chat logs were analysed. The two researchers independently rated each student's interaction with the chatbot in three systems thinking competencies: (1) Investigation of factors and/or stakeholders contributing to the complex problems, (2) Analysis of inter-relationships among factors and/or stakeholders, and (3) Evaluating solutions that address the complex problem. The ratings were based on the level of competency demonstrated in students' final outputs for each category, ranging from high to low. After completing the initial ratings, the researchers aligned their assessments to ensure consistency. These categories correspond to the question categories in the chatbot, which align with the students' assignment rubric. See Table 3 for the summary.

(1) **Investigation of factors and/or stakeholders contributing to the complex problem:** 31% of students provided a comprehensive analysis with detailed explanations, while 54% demonstrated moderate analysis or elaboration. The remaining 15% demonstrated limited analysis or elaboration.
(2) **Analysis of inter-relationships among factors and/or stakeholders:** 17% of students critically analysed how different factors and stakeholders influenced one another and the broader system. 27% of students made a moderate attempt to analyse the inter-relationships, while a significant portion 56% of students made little or no attempt to analyse the inter-relationships.
(3) **Evaluation of solutions to address the complex problem:** 15% of students considered a range of solutions and critically evaluated the solutions' implications while 21% gathered basic solutions without considering their impacts. The remaining 64% did not propose or evaluate solutions to address the complex problem.

Table 3: Categories, levels of competency and frequency from chat logs

Categories	Levels of competency in students' outputs	Frequency & Percentage
Investigation of Factors and/or stakeholders that contribute to the complex problem	[High] Identify a broad range of factors and/or stakeholders that contribute to the complex problem with elaborate explanations	16 (31%)
	[Moderate] Identify some factors and/or stakeholders without deep exploration of their roles or impacts	28 (54%)
	[Low] Limited or no attempt to identify or understand factors and/or stakeholders	8 (15%)
Analysis of inter-relationships among factors and/or stakeholders	[High] Critically examine how factors and/or stakeholders may influence others and the broader system	9 (17%)
	[Moderate] Identify basic relationships among factors and/or stakeholders without exploring deeper systemic connections	14 (27%)
	[Low] Limited or no attempt to analyse the inter-relationships among factors and/or stakeholders	29 (56%)
Evaluation of Solutions to address the complex problem	[High] Consider a range of solutions and critically evaluate each solution's implications	8 (15%)
	[Moderate] Gather basic ideas or a limited range of solutions without in-depth evaluation or consideration of broader impacts	11 (21%)
	[Low] Limited or no attempt to explore or evaluate any solutions to address the complex problem	33 (64%)

The findings indicate that while students could identify factors and stakeholders in a complex problem, their abilities to analyse interrelationships and evaluate solutions remain underdeveloped.

One possible explanation is cognitive fatigue: students may have engaged initially but found tasks like analysing relationships and evaluating solutions to be more demanding, leading to reduced effort or disengagement. These tasks require more abstract reasoning, which could explain struggles in later stages. This suggests that while the chatbot supported initial exploration, additional scaffolding may be needed to sustain engagement and deepen reasoning.

In addition, from the findings of RQ1 and RQ2, mixed opinions on the chatbot's flexibility suggest that its technical limitations, demanding interaction style and lack of contextualisation, may have further hindered student engagement and the ability to analyse complex relationships or evaluate solutions effectively. Addressing these issues could enhance engagement and cognitive processing. Strategies such as breaking tasks into smaller steps, using scaffolded questioning, and providing progressive hints could also help mitigate cognitive fatigue and improve the learning experience.

Implications for Practice

The findings suggest that while customised Gen AI chatbots can support students in recognising system thinking components, additional instructional strategies are needed to enhance students' ability to analyse relationships and evaluate solutions in systems thinking.

The following are implications of the findings for educators, instructional designers, and students.

(a) **Educators**: Chatbot interactions should be complemented with collaborative discussions and peer interactions for them to refine their ideas and gain alternative perspectives. Systems thinking benefits from social construction of knowledge. Embedding chatbot interactions within structured peer discussions can help students recognise deeper interconnections and evaluate solutions more critically.
(b) **Instructional designers**: Chatbots should be customised with progressive questioning strategies that gradually increase in complexity. Rather than presenting complex, open-ended prompts upfront, chatbots should guide students through a scaffolded sequence, for example, starting with simple identification tasks before progressing to deeper analysis of interconnections and systemic consequences. This approach ensures that students build foundational understanding before engaging in higher-order thinking.
(c) **Students**: It is crucial to develop awareness of the chatbot's affordances and limitations to maximise its learning potential effectively. While chatbots can provide structured prompts and generate ideas, they do not replace critical thinking or real-world contextual understanding. Encouraging students to reflect on chatbot-generated insights, cross-check information, and engage in deeper inquiry beyond the chatbot's initial responses will enable them to take ownership of their learning and apply systems thinking more meaningfully.

Limitations of Study and Future Research

The small sample size of the study limits the generalisability of the results to the population. Future research could include larger and more diverse samples. Additionally, the variability in the levels of competency in students' outputs suggests that while some students benefited from iterative questioning, others engaged superficially. Further studies could explore factors influencing engagement, such as different questioning strategies and interactive features.

Conclusions

This study investigated students' acceptance of the customised Gen AI chatbot, and how it impacted students' systems thinking and learning experiences. While students reported positive perceptions of the chatbot's usefulness and ease of use, analysis of chat logs revealed variability in their competency levels. These findings suggest that, while the chatbot supports initial exploration, additional strategies are needed to deepen students' reasoning and engagement. Educators and instructional designers can leverage the chatbot's affordances by integrating scaffolding techniques, such as providing progressive questioning and guidance, to help students build deeper understanding and systems thinking skills.

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