Elevating Postgrad Learning: A New Chatbot Instructional Model

Ivy Chia, Singapore University of Social Sciences, Singapore
June Tay, Singapore University of Social Sciences, Singapore
Ma Nang Laik, Singapore University of Social Sciences, Singapore

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Abstract

This exploratory study examined the usability and pedagogical potential of STEP-AI, a text-based chatbot designed to scaffold student learning. Initial findings reveal consistently positive ratings for the chatbot in terms of accessibility, communication clarity, and educational support. STEP-AI also demonstrated alignment with key educational principles. These include structured progression, tailored feedback, active engagement and progressed learning. However, areas such as privacy communication and contextual adaptability are areas which could be strengthened for improvement. Limitations of the study include a small sample size, use of a pilot version, and the absence of multimedia features. As development continues, future research should include broader testing with diverse learners across authentic educational settings to evaluate STEP-AI's effectiveness, scalability, and relevance to evolving educational needs.

Keywords: GenAI, chatbot, instructional design, heuristic evaluation, user testing

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Introduction

Recent advances in generative AI (GenAI) have expanded the role of chatbots in educational contexts, particularly in supporting learner engagement, guided thinking, and personalized learning pathways (Baidoo-Anu & Ansah, 2023; Ilieva et al., 2023). By offering immediate, judgment-free interactions, chatbots can function as accessible learning companions, especially for students who may lack confidence or hesitate to seek support through conventional academic services (Hirose et al., 2021; Kerly et al., 2006). This continuous availability allows learners to ask questions and receive clarification at their own pace, thereby fostering sustained, self-directed learning.

Chatbots have been explored across a range of domains, including cognitive behavioural therapy (Oh et al., 2020), mental health support (Eshghie & Eshghie, 2023; Joshi, 2023), healthcare education (Sallam, 2023), and psychiatric assistance (Cheng et al., 2023). While these applications demonstrate the versatility of conversational agents, their integration into higher education—particularly in the context of applied learning—remains underdeveloped. This project seeks to extend chatbot use into this area by exploring how conversational AI can be designed to support structured and pedagogically grounded learning experiences in tertiary education settings. Existing educational chatbots, including those based on models such as ChatGPT, present several limitations that constrain their effectiveness in academic contexts. These challenges include:

- Reliance on Non-curated Sources: Many chatbots generate responses based on large, unfiltered datasets from the internet, which may contain inaccuracies or reflect biased information.
- Overly Generalized Knowledge: Responses often lack subject-specific depth and are not aligned with curriculum requirements.
- Insufficient Pedagogical Design: Most available chatbots are not developed with explicit reference to educational theory, limiting their capacity to support structured learning processes.

The STEP-AI Framework

A central aim of our project then was to design the chatbot not simply as a tool for delivering answers, but as a virtual tutor capable of supporting deeper learning through dialogue with student learning. To support these goals, we developed a chatbot knowns as STEP-AI. Its design was based on instructional design principles that support conversational learning. These principles include:

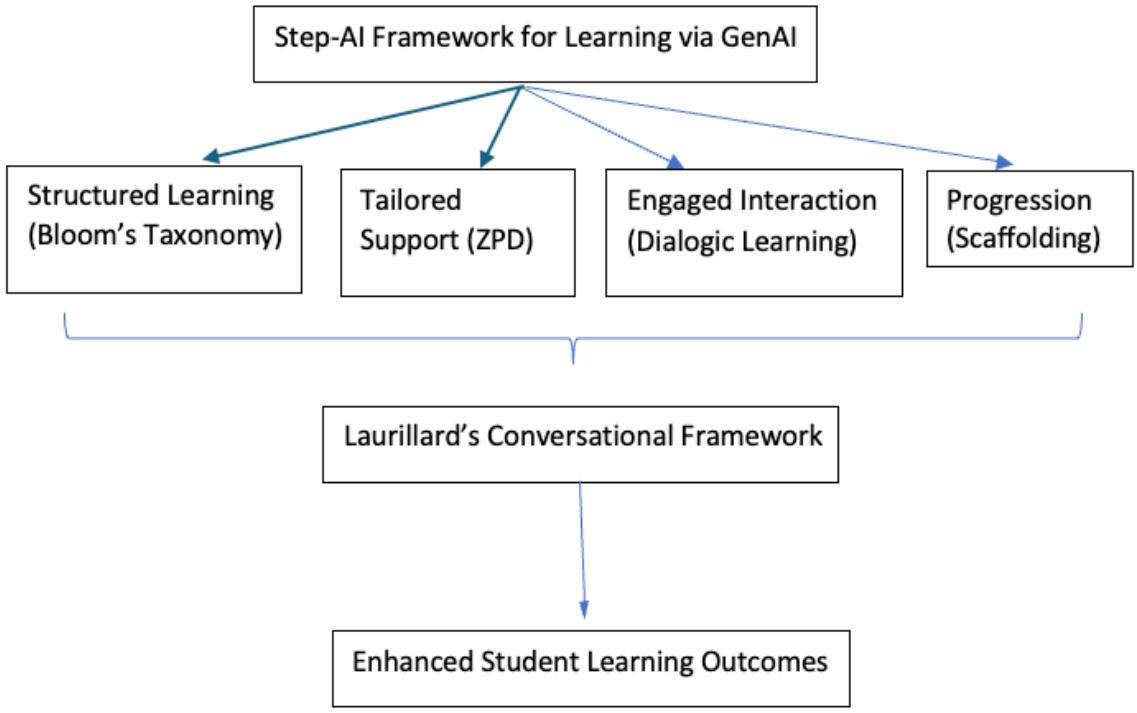
- Structured Learning: Chatbot introduces foundational concepts before guiding learners toward more complex thinking, following the hierarchical structure of Bloom's Taxonomy.
- Tailored Support: Chatbot aligns learning interaction and support with learners' ability, guided by Vygotsky's Zone of Proximal Development.
- Engaged Interaction: Chatbot promotes knowledge construction through meaningful dialogue and activities.
- Progression: Chatbot facilitates gradual, step-by-step learning through effective scaffolding.

We term this integrated approach the STEP–AI Framework—Structured, Tailored, Engaged Progression for Learning —highlighting the key scaffolding pedagogical principles that prime the chatbot for effective teaching and learning. Our design aligns closely with Laurillard's

(2002) conversational framework. Laurillard emphasizes that interactive dialogue, iterative feedback, and adaptive learning processes are essential for facilitating meaningful learning experiences. This includes:

- Two-Way Dialogue: Chatbots' conversational capabilities make them ideally suited to facilitate the iterative teacher–student dialogue central to Laurillard's framework, encouraging students to question, explore, and co-construct knowledge.
- Iterative Feedback and Adaptation: Incorporating capabilities of cycles of feedback, reflection, and adaptation, chatbots can support by providing instant feedback, suggesting improvements, and tailoring responses based on user input.
- Practical Applications: Emphasizes bridging theoretical concepts with practical application, which a chatbot can facilitate through case-based scenarios and contextualized feedback.

Figure 1
STEP-AI Framework



Within this STEP-AI chatbot, we integrated case studies and domain-specific content for contextualised learning; these carefully curated to reflect authentic learning contexts. The incorporated learning materials and content allows for foundational knowledge building, complex problem-solving and critical analysis—ensuring that the chatbot is well-equipped to support a diverse spectrum of needs. Machine learning techniques are then applied, enabling the chatbot to process, interpret, and respond to student queries with contextual relevance and pedagogical appropriateness

Heuristic Evaluation and User Testing

To address technical and pedagogical robustness, our study adopts a two-stage evaluation process: heuristic evaluation and user experience survey. Expert reviewers conducted a heuristic evaluation to pinpoint how well the chatbot functions and where user experience could be improved. User testing, on the other hand, relies students' hands-on interaction with

the chatbot. We collected users' self-reported perceptions of their experience in learning, and these are are aligned with key STEP-AI pedagogical constructs: structured learning, tailored support, and engaged interaction. Through integrating these two complementary evaluation methods, the study aims to provide a more comprehensive assessment of the chatbot's technical robustness and its capacity to facilitate meaningful learning experiences.

Heuristic evaluation, originally developed by Nielsen, is a widely used usability method that applies standard heuristics to identify design issues in user interfaces (Nielsen, 1994). The process typically involves multiple evaluators independently interacting with a system to detect usability problems, assign severity ratings, and suggest improvements. Among the most frequently cited frameworks are Nielsen's 10 usability heuristics (Nielsen, 1994a), which address broad interface design principles applicable across a wide range of systems.

While traditionally applied to websites and software applications, heuristic evaluation is increasingly relevant for conversational AI systems, such as ChatGPT, due to the complexity and variability of language-based interactions. In this study, we adopted the heuristic framework proposed by Höhn and Bongard-Blanchy (2021), which is specifically tailored to conversational interfaces. This model was selected for its ability to account for the dynamic, dialogic nature of chatbot interactions.

To evaluate both usability and pedagogical effectiveness, we extended the framework to include key learning design principles embedded in the STEP-AI model—namely, structured progression, personalized scaffolding, and interactive engagement. These were integrated into criteria 13 to 15 in the evaluation matrix (see Appendix 1).

For this study, we invited five subject matter experts to carry out a heuristic evaluation of the chatbot. As noted by Nielsen (1994a), three to five independent evaluators are typically sufficient to identify approximately 75% of usability issues in a given design. The experts tested the application across multiple platforms—including Internet Explorer, Chrome, and Firefox—and on various devices such as laptops, tablets, and smartphones. Table 2 outlines the evaluated heuristics and sub-heuristics, along with sample guiding questions and the grading scale used during the evaluation. Issues found were rectified in the Chatbot.

Table 1

Examples of Chatbot Heuristic Problems

Heuristic	Sub-Heuristic	Problems
1. Visibility of system status	1.1 Presence of information	Lack of clear indication that the chatbot is processing (e.g. no typing indicator).
	1.2 Immediate feedback	Bot responses are delayed or not acknowledged; users feel stuck.
	1.3 Compel user action	Users unsure how to proceed; no clear next steps after a response
2. User control and freedom	2.1 Undo/redo	Users cannot undo or correct a previous input.
	2.2 Permanent menu	No easy way to return to main options or start over.
	2.3 Navigation options	Users can't skip sections or jump to specific features.
	2.4 Repair initiations	Chatbot fails to understand when users try to correct a misunderstanding.

User Testing

Seven student volunteers were recruited in this chatbot for a user experience survey, from the broader cohort of tertiary students. Previous studies suggest that a sample of four to five user testers can uncover approximately 85% of usability issues (Virzi, 1992), supporting the use of a smaller sample for initial testing, using the User Experience Questionnaire (UEQ) adapting key dimensions from the UEQ (Borsci et al., 2021),[1] and integrating learning design elements such as structured learning, tailored support, engaged interaction and progression (see page 2) grounded in Bloom's Taxonomy, Zone of Proximal Development (ZPD), and scaffolding principles (see Appendix 2). This combination enables us to assess both the chatbot's usability and its educational effectiveness, which informed the development of a Likert-scale questionnaire (see Appendix 3). This user testing questionnaire was then administered to evaluate user perceptions of the chatbot's performance across multiple dimensions, including accessibility, functional quality, conversation clarity, privacy and security, response time, pedagogical features (STEP-AI components), and overall satisfaction. Twenty-four items were rated on a 5-point scale (1 = Strongly Disagree to 5 = Strongly Agree). See Appendix 3. The summarised results are presented below.

Table 2

Result Summary

	Factor	Mean (Average)	SD (Average)	Key Observations
1.	Perceived Accessibility (Item 1-2)	4.2	0.6	High accessibility with easily detectable and findable chatbot.
2.	Perceived Quality of Functions (Item 3-9)	4.1	0.65	Good communication clarity, but context handling could be strengthened further.
3.	Perceived Quality of Conversation and Information Provided (Item 10-13)	4.1	0.6	Accurate and appropriate amount of information were given.
4.	Perceived Privacy and Security (Item 14)	3.9	0.8	Concerns about privacy communication.
5.	Time Response (Item 15)	4.2	0.6	Wait time was short.
6.	Structured Learning (Bloom's Taxonomy) (Item 16-17)	4.3	0.5	Strong progression from simple recall to higher-order thinking skills.
7.	Tailored Support (ZPD) (Item 18-19)	4.2	0.55	Effective scaffolding and adaptive prompts supported learning.
8.	Engaged Interaction (Item 20-21)	4.3	0.55	Active learning and reflection encouraged through interactive dialogues.
9.	Progression (Item 22-23)	4.2	0.6	Step-by-step learning progression effectively scaffolded learning experiences.
10.	Overall Satisfaction (Item 24)	4.5	0.4	High overall satisfaction and consistent positive experience.

[1] The scale was designed to check the quality of a chatbots based on the principles of interactive quality found within chatbot literature in the field. It has an estimated reliability between 0.76 and 0.87 distributed over 15 items.

The chatbot was generally rated relatively high across most areas, indicating relatively good usability and engagement. More specifically, users expressed strong satisfaction with the chatbot overall (Overall Satisfaction, Mean = 4.5, SD = 0.4), indicating that the platform met expectations and provided some positive experience. The chatbot's clarity of communication (Perceived Quality of Functions, Mean = 4.1, SD = 0.65) and the quality of information provided (Perceived Quality of Conversation and Information Provided, Mean = 4.1, SD = 0.6) were also highlighted as key strengths. Users found the chatbot accessible, with reasonably higher ratings for its detectability and ease of discovery (Perceived Accessibility, Mean = 4.2, SD = 0.6).

We also observed some reasonably strong alignment with established learning principles. Structured learning (Mean = 4.3, SD = 0.5) reflected the chatbot's effective progression from basic recall to higher-order thinking, aligning with Bloom's taxonomy. Tailored support (Mean = 4.2, SD = 0.55) suggested the chatbot successfully adapted to learners' needs and readiness through effective scaffolding. he pedagogical component of the questionnaire, consisting of four dimensions based on learning theories (Bloom's Taxonomy, ZPD, engagement, and progression), showed generally positive responses (M = 4.2 to 4.3, SD = 0.5–0.6). The pedagogical component showed a Cronbach's alpha of 0.70, indicating preliminary internal consistency for this exploratory study. However, given the small number of respondents, this value may not be stable and should be interpreted with caution. Further reliability testing with a larger sample is recommended. Given the early-stage status of the instrument, this serves as a diagnostic tool to guide refinement rather than a strict measure of psychometric adequacy.

Some areas emerged as areas to be strengthened. For example, the lower rating on perceived privacy and security (Mean = 3.9, SD = 0.8) suggested a need for clearer communication about data use and privacy policies. On the whole, the chatbot generally performed effectively, with particular strengths observed in facilitating step-by-step concept development, offering responsive support aligned with learner ability, and promoting active engagement through interactive dialogue. Additional testing with a larger, more diverse student participant base, along with higher order tasks and interactive media, will be needed to validate the chatbot's effectiveness across different contexts and learner needs.

Limitations of the Study

Our study has a few limitations. Firstly, the small sample size, although aligned with standard heuristic evaluation practices (Virzi, 1992), limits the generalizability of the findings across all users. Secondly, the evaluation focused on a pilot version of the chatbot, which may not fully reflect the performance or usability of a more mature system. Future studies could expand testing with higher order tasks, with dynamic scaffolding in different learning scenarios, and in authentic educational settings to ensure its relevance and effectiveness. Also, the study focused solely on text-based interactions and did not include multimedia features.

Recommendations and Next Steps

This study was largely exploratory and preliminary in nature, focusing on the development of the chatbot and gathering early user feedback. Future development could address the weak areas, such as enhancing privacy communication by integrating clearer messaging about data use and security. Future studies could build on exploratory findings and expand testing to include larger, more diverse participant samples. Going forward, the testing could also incorporate diverse learning scenarios, and evaluating the chatbot in authentic educational

settings to ensure its relevance and effectiveness. Collecting further data, such as performance metrics can guide further refinement of our Chatbot's design.

Conclusion

To conclude, the integration of questioning techniques into ChatGPT for scaffolding learning, supported by educational theories, showed some potential. The initial user testing with the very small number of students indicated that they are generally satisfied with the quality of the interactions. The favourable outcomes suggest a potential for use and supports broader expansion of topics with further testing. The project represents a modest effort on our part to explore and experiment with chatbot, which we hope will benefit our students in the long run.

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Appendices

Appendix 1

Heuristics for Chatbot Conversational Interface (Höhn & Bongard- Blanchy 2021) – for Expert Evaluation

Heuristics	Sub Heuristics
1. Visibility of system status	1.1 Presence of information about the chatbot's state in the entire process 1.2 Immediate feedback (did the last user action work?) 1.3 Compel user action (what does the chatbot think the user will do next?)
2. Match between system and the real world	2.1 Chatbot uses the language familiar to the target users 2.2 Visual components (emojis, GIFs, icons) are linked to real- world objects 2.3 If metaphors are used, they are understandable for the user
3. User control and freedom	3.1 Chatbot supports undo/redo of actions 3.2 Chatbot offers a permanent menu 3.3 Chatbot provides navigation options 3.4 Chatbot understands repair initiations
4. Consistency and standards	4.1 Chatbot uses the domain model from the user perspective 4.2 Chatbot has a personality, consistency in language and style
5. Error prevention	5.1 Chatbot prevents unconscious slips by meaningful constraints 5.2 Chatbot prevents unconscious slips by spelling error detection 5.3 Chatbot requests confirmation before actions with significant implications 5.4 Chatbot explains consequences of the user actions
6. Recognition rather than recall	6.1 Chatbot makes the options clear through descriptive visual elements and explicit instructions 6.2 Chatbot shows summary of the collected information before transactions 6.3 Chatbot offers a permanent menu and help option
7. Flexibility and efficiency of use	7.1 Chatbot understands not only special instructions but also synonyms 7.2 Chatbot can deal with different formulations 7.3 Chatbot offers multiple ways to achieve the same goal
8. Aesthetic and minimalist design	8.1 Chatbot dialogues are concise, only contain relevant information 8.2 Chatbot uses visual information in a personality-consistent manner to support the user, not just random decoration
9. Help users recognize, diagnose, and recover from Errors	9.1 Chatbot clearly indicates that an error has occurred 9.2 Chatbot uses plain language to explain the error 9.3 Chatbot explains the actions needed for recovery 9.4 Chatbot offers shortcuts to fix errors quickly
10. Help and documentation	10.1 Chatbot provides a clear description of its capabilities 10.2 Chatbot offers keyword search 10.3 Chatbot focuses its help on the user task 10.4 Chatbot explains concrete steps to be carried out for a task
11. Context understanding	11.1 Chatbot understands the context within one turn 11.2 Chatbot understands the context within a small number of turns (usually 2-3 user-bot turn pairs) 11.3 Chatbot understands the context of a multi-turn conversation
12. Interaction management capabilities	12.1 Chatbot understands conversation openings and closings (e.g., 'hello') 12.2 Chatbot understands sequence closings (e.g., 'ok' and 'thank you') 12.3 Chatbot understands repair initiations and replies with repairs 12.4 Chatbot initiates repair to handle potential user errors
13. Progressive Learning	13.1 Chatbot questions in a way for knowledge to build on each other, increasing in complexity and depth according to Bloom's hierarchical structure. 13.2 Chatbot includes engaging questions that promote various cognitive skills from recalling facts to creating new ideas 13.1 Chatbot engagement allows for clear progression from simpler to more complex thinking
14. Personalised Scaffolding	14.1 Chatbot personalises content based on learners' input or profile 14.2 Chatbot provides hints, prompts, feedback, and other forms of support to guide learners through challenging tasks. 14.3 Chatbot adjusts the level of support based on the learner's prior knowledge, skill level, or progress.
15. Interactive Engagement	15.1 Chatbot require learners to interact with the content rather than passively consume it. 15.2 Chatbot's adapts its responses based on the learner's input to guide progress and personalize the experience. 15.3 Chatbot engage through dialogue, questions, simulations, or scenario- based tasks.

Appendix 2

Items and Factors in the Chatbot Experience (adapted from Borsci et al., 2021)

Item	Factors	Statements
1.	Perceived Accessibility	The chatbot function was easily detectable.
2.		It was easy to find the chatbot.
3.	Perceived Quality of Functions	Communicating with the chatbot was clear.
4.		I was immediately made aware of what information the chatbot can provide.
5.		The interaction with the chatbot felt like an ongoing conversation.
6.		The chatbot was able to keep track of context.
7.		The chatbot could make references to the website or service when appropriate.
8.		The chatbot could handle situations where the conversation line was not clear.
9.		The chatbot's responses were easy to understand.
10.	Perceived Quality of Conversation and Information Provided	I feel the chatbot understands what I want and helps me achieve my goal.
11.		The chatbot gives me the appropriate amount of information.
12.		The chatbot only gives me the information I need.
13.		I feel the chatbot's responses were accurate.
14.	Perceived Privacy and Security	I believe the chatbot informs me of any possible privacy issues.
15.	Time Response	My waiting time for a response from the chatbot was short.
16.	Structured Learning	The chatbot's questions progressed from simple recall to more challenging tasks.
17.		The chatbot included opportunities to apply, analyze, and evaluate information.
18.	Tailored Support	The chatbot adjusted its guidance based on my progress and understanding.
19.		The chatbot provided hints or prompts when I was unsure.
20.	Engaged Interaction	The chatbot encouraged me to reflect on my answers.
21.		The chatbot asked follow-up questions that deepened my understanding.
22.	Progression	The chatbot broke learning into small, manageable steps.
23.		The chatbot provided a sense of progression from simpler to more complex ideas.
24.	Overall Satisfaction	Overall, I am satisfied with my experience using the chatbot.

Appendix 3

Chatbot Usability Questionnaire (Adapted from Borsci et al., 2021)

Item	Statement	1	2	3	4	5
1	The chatbot function was easily detectable.	○	○	○	○	○
2	It was easy to find the chatbot.	○	○	○	○	○
3	Communicating with the chatbot was clear.	○	○	○	○	○
4	I was immediately made aware of what information the chatbot can provide.	○	○	○	○	○
5	The interaction with the chatbot felt like an ongoing conversation.	○	○	○	○	○
6	The chatbot was able to keep track of context.	○	○	○	○	○
7	The chatbot could make references to the website or service when appropriate.	○	○	○	○	○
8	The chatbot could handle situations where the conversation line was not clear.	○	○	○	○	○
9	The chatbot's responses were easy to understand.	○	○	○	○	○
10	I feel the chatbot understands what I want and helps me achieve my goal.	○	○	○	○	○
11	The chatbot gives me the appropriate amount of information.	○	○	○	○	○
12	The chatbot only gives me the information I need.	○	○	○	○	○
13	I feel the chatbot's responses were accurate.	○	○	○	○	○
14	I believe the chatbot informs me of any possible privacy issues.	○	○	○	○	○
15	My waiting time for a response from the chatbot was short.	○	○	○	○	○
16	The chatbot's questions progressed from simple recall to more challenging tasks.	○	○	○	○	○
17	The chatbot included opportunities to apply, analyze, and evaluate information.	○	○	○	○	○
18	The chatbot adjusted its guidance based on my progress and understanding.	○	○	○	○	○
19	The chatbot provided hints or prompts when I was unsure.	○	○	○	○	○
20	The chatbot encouraged me to reflect on my answers.	○	○	○	○	○
21	The chatbot asked follow-up questions that deepened my understanding.	○	○	○	○	○
22	The chatbot broke learning into small, manageable steps.	○	○	○	○	○
23	The chatbot provided a sense of progression from simpler to more complex ideas.	○	○	○	○	○
24	Overall, I am satisfied with my experience using the chatbot.	○	○	○	○	○

Comments: _____