

AI-powered Chatbot for Cultural Learning: The Case of Kompang

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Abstract—The kompang is a traditional single-headed frame drum that holds significant cultural value within the Malay Archipelago. However, modernization and the proliferation of digital entertainment technologies have contributed to a decline in both its popularity and the number of skilled practitioners. Contributing factors include limited access to qualified instructors, fragmented scheduling and coordination of training sessions, and the absence of interactive learning platforms. This study presents Pak Bung, an intelligent chatbot system designed to promote cultural preservation and public engagement with kompang music through adaptive digital learning. The chatbot Leverages Large Language Models (LLMs), cloud-based knowledge retrieval, and interactive dialogue systems to deliver personalized educational content across seven curated topics. Features include multimodal tutorials, gamified quizzes, multimedia demonstrations, and real-time scheduling for consultations with human experts. A chatbot usability testing was conducted to assess usability, engagement, and perceived usefulness for learning, with results indicating that Pak Bung can successfully support user engagement, accessibility, and perceived learning support in cultural knowledge exploration. The system aligns with Sustainable Development Goal 4 (Quality Education) by integrating AI-driven pedagogical interaction into the preservation of traditional musical knowledge.

Keywords—kompang, chatbot, education technology, cultural heritage preservation, interactive learning

I. INTRODUCTION

The kompang, generally translated to mean “to hit” or “to beat”, is a traditional percussion instrument among the Malay communities in Malaysia. This single-headed frame drum consists of two major components: the wooden frame carved into a circular shape (*baluh*), and the animal skin head (*muka*) stretched over and nailed to the frame using brass tacks [1]. Either sitting with legs crossed, standing, or moving in procession, the kompang ensemble normally performs in a group of three strokes, including *pembolong*, *penyilang*, and *peningkah* [2].

A kompang player holds the drum in the bend of the left arm, striking it with their right hand while holding the rim with their left hand. Essentially, the kompang produces two timbres: ‘pak’ and ‘bung’. The ‘pak’ sound is produced when the middle part of the kompang is struck with the palm while the fingers are open. The ‘bung’ sound, on the other hand, is produced when the edge of the kompang surface is struck with the fingers while all the fingers are closed [3].

Kompang playing is one of the results of the adaptation and syncretism of the Islamic culture by the Malay people as kompang still preserves some of its original elements but has gradually changed to blend into the local culture. Although kompang remains deeply embedded in Malay cultural practices and has adapted to contemporary settings, the survival of kompang is far from guaranteed, underscoring the importance of preservation. Societal changes driven by modernization and globalization, alongside the widespread appeal of Western musical genres and instruments, have gradually diverted public attention from traditional music [4].

Kompang today lacks experts who possess both a rich theoretical background and strong experiences of music performance, thus leading to a dilution of the intricacies and depth of kompang’s art form. This presents challenges in coordinating kompang performances and rehearsals, as it usually involves a group of players with comprehensive knowledge of kompang and their musical roles. Compared with internationally recognized instruments like the guitar and violin, kompang also faces barriers to global recognition due to limited structured learning materials, interactive platforms, and formal representation in global music education.

To overcome these challenges, this study proposes a chatbot called “Pak Bung” that serves as an engaging, interactive, and effective platform for kompang preservation and education. The chatbot is developed on the Dialogflow chatbot framework, with the integration of VertexAI’s large-language model and Google Calendar API. Pak Bung chatbot remained publicly available for real-world usage and evaluation over ten months, from May 2024 to February 2025. The primary objective of this research is to design and develop a multi-turn vertical chatbot that helps the general public to understand more about the culture and basic knowledge of kompang.

The development of the Pak Bung chatbot aims to support the Sustainable Development Goals (SDGs) set by the United Nations for 2030, specifically SDGs 4 and 11. Unlike most general generative Artificial Intelligence (AI) chatbots which have limited knowledge about kompang, the proposed vertical kompang aligns with SDG 4: Quality Education by integrating cultural knowledge into digital education, promoting inclusive and lifelong learning opportunities. In addition, SDG 11: Sustainable Cities and Communities is achieved as Pak Bung chatbot contributes to safeguarding

intangible cultural heritage and supporting cultural sustainability in younger generations.

The remainder of this paper is organized into literature reviews in Section II, materials and methods in Section III, evaluation results in Section IV, and conclusions as well as future works in Section V.

II. LITERATURE REVIEW

A. The Kompang in Malay Musical Heritage

The kompang is one of the most prominent traditional percussion instruments in the Malay Archipelago. Historically, the kompang has been linked to Islamic influences brought to the Malay Peninsula through trade and religious expansion during the Malacca Sultanate. Over time, it became embedded in Malay cultural expressions, particularly in religious processions, weddings, and royal ceremonies.

As a community-based instrument, kompang ensembles emphasize collective performance rather than individual virtuosity. The rhythmic patterns are organized into layers: *pembolong* provides the base rhythm, *penyilang* adds the counter rhythm, and *peningkah*, played by the leader, guides the group [5]. The instrument's cultural value lies not only in its musicality but also in its role as a tool for social cohesion, where communal participation reinforces shared identity [6].

B. Symbolic and Spiritual Meanings of Kompang

Beyond musical performance, the kompang carries symbolic and spiritual connotations. According to Nor [7], kompang performances were traditionally used to accompany religious recitations such as *berzanji* and *marhaban*, which narrate the life of the Prophet Muhammad. The rhythmic beats symbolized unity, discipline, and devotion, reflecting the integration of Islamic spirituality into local artistic practices.

In contemporary cultural studies, the kompang is seen as an emblem of Malay identity. Its sounds are often associated with collective joy and harmony, making it a key feature at weddings and national celebrations [5]. The Ministry of Culture, Arts, and Heritage in Malaysia has categorized the kompang as part of the nation's intangible cultural heritage, emphasizing its enduring cultural symbolism.

C. Educational Value and Modern Adaptations

The kompang has increasingly been incorporated into formal and informal educational systems. In Malaysian schools, kompang ensembles are common in co-curricular activities, serving as a means of teaching discipline, teamwork, and cultural heritage [1]. However, many music teachers lack in-depth training in traditional instruments, leading to superficial teaching methods and a loss of stylistic authenticity.

Recent technological adaptations attempt to address these issues. Digital tools, such as multimedia tutorials and interactive applications, have been developed to teach kompang rhythms and techniques [8]. The Pak Bung chatbot, as proposed in this study, aligns with such innovations, presenting kompang learning in an accessible, interactive format to preserve and modernize the tradition.

D. Decline of Traditional Musical Practices

Despite its central role in Malay traditions, kompang preservation faces challenges due to modernization, globalization, and declining numbers of trained experts. Despite revisions and improvements in the music curriculum in public schools, kompang is often underrepresented in schools, where instruction is often delivered by teachers with only short-term exposure to traditional music pedagogy [1]. This has weakened the transmission of stylistic authenticity and reduced its visibility among younger generations. UNESCO [9] classifies such practices as intangible cultural heritage, highlighting their need for safeguarding.

Emerging scholarships also emphasize the potential of technology to preserve musical traditions. Platforms such as chatbots, gamified apps, and multimedia tutorials present opportunities for revitalizing cultural learning [10]. By embedding cultural identity in AI-driven systems, such tools extend the reach of heritage knowledge and provide interactive, learner-centered pathways for sustainability.

E. Kompang as Intangible Cultural Heritage

UNESCO [9] defines intangible cultural heritage as practices, representations, expressions, knowledge, and skills transmitted from generation to generation. The kompang falls within this definition, particularly as it embodies both artistic practice and social function. Efforts to document and digitize kompang practices are consistent with broader initiatives to safeguard intangible heritage in Southeast Asia [11].

Within Malaysia, preservation efforts focus on education, community programs, and state-organized cultural events that highlight the kompang as a national heritage. Traditional Malay performing arts continue to face pressure from modernization, but community efforts and state recognition remain crucial in sustaining these practices.

F. Comparison with Existing Educational Chatbots or Digital Tools

Prior research indicates growing adoption of AI-powered chatbots in education, particularly in language learning, cultural heritage, and self-regulated learning contexts. However, comparatively little attention has been given to music education and the learning of traditional cultural instruments. Existing educational chatbots tend to focus on general academic support or language acquisition, while heritage-oriented systems often emphasize passive information delivery rather than skill development.

Pak Bung addresses this gap by extending established educational chatbot principles to traditional music pedagogy through multimodal and culture-contextualized design. Unlike general-purpose educational chatbots, Pak Bung integrates structured tutorials, interactive skill-based quizzes, and optional expert consultation alongside multimodal cultural content. These features serve as a bridge between AI chatbot technology and cultural music education.

To better position Pak Bung in the landscape of educational and cultural-heritage chatbots, Table 1 shows a comparative overview between Pak Bung and representative existing systems/tools from the literature. The comparison highlights the domain, pedagogical, and technical features, strengths, and limitations relative to Pak Bung.

G. Current Trends and Future Directions

Scholars highlight the need for innovative pedagogical approaches and technological platforms to revitalize traditional instruments [8, 12]. Chatbots, mobile applications,

and virtual reality offer opportunities to integrate heritage with digital learning. Studies on gamified learning environments for music education suggest that such approaches can increase student engagement and retention [10].

Table 1. Comparison of Pak Bung vs selected educational chatbots/ tools in literature.

System/ Tool	Primary Domain and Purpose	Core Features	Strengths	Limitations/ Gaps (Relative to Pak Bung)
EduChat [13]	Broad educational support (various subjects)	LLM-based Q&A, essay assessment, Socratic teaching, and emotional support	Versatile, supports many subjects; personalized tutoring and feedback	Does not include specialized multimodal tutorials or cultural/ arts content; lacks domain-specific structured tutorials or quizzes for music/ culture
EduBot (Curriculum-Driven EduBot) [14]	Language learning via conversational practice (text-based)	Chat-based dialogues generated from curriculum, adaptive conversation, and user proficiency adaptation	Good for language skills, interactive, adaptive to user level	No multimedia content (video/ audio), no music or cultural heritage domain, no structured skill-based tutorial/quizzes for non-linguistic skills
Generic educational chatbots (meta-analysis/ reviews) (e.g., studies summarized in reviews such as [15])	Varied: language learning, content learning, and administrative support	Chat-based tutoring, feedback, task guidance, and adaptive support	Personalized support, accessibility, flexibility, and self-regulated learning support (SpringerLink)	Typically limited to one dimension (knowledge delivery or language), rarely includes multimodal music/cultural content, and is limited in supporting psychomotor or expressive skills
Museum-Venue Chatbots/ Cultural-heritage chatbots (as in museum/ cultural venues) (e.g., museum chatbots described in [16])	Cultural heritage/ museum visitor information	Provide historical/ cultural info, descriptions, and sometimes guided tours	Good for passive learning about heritage/ background, accessible to public	Focus on information transfer only, not skill acquisition, no interactive practice, no quizzes or performance feedback, no structured learning path
Pak Bung (this study)	Traditional music/cultural heritage education (kompang)	Multimodal tutorials (text + video + 3D), structured Easy → Advanced learning path, interactive quizzes, personalized chatbot dialogue, optional human expert consultation scheduling, fallback/error handling, and conversational scaffolding	Combines cultural heritage content with active skill learning and practice; supports knowledge + psychomotor + contextual understanding; accessible asynchronously; culturally contextualized	Addresses many of the gaps above

Google, via Dialogflow, supports several communication channels and languages [11, 12], seamlessly accommodating integrations across systems. Therefore, the Pak Bung chatbot represents a timely response to the urgent need for kompang preservation.

Future directions may include integrating artificial intelligence with sound recognition, enabling automated feedback on performance quality. This would help learners improve accuracy while maintaining cultural authenticity. Furthermore, collaborations between cultural institutions and educational organizations could reinforce shared ownership of the kompang while ensuring its continued relevance for younger generations.

III. MATERIALS AND METHODS

Pak Bung chatbot employs a hybrid intent-based and retrieval-augmented conversational architecture. Dialog management handles structured flows while external knowledge retrieval supports open-ended queries through semantic search and grounding.

Fig. 1 shows the modular architecture for Pak Bung chatbot, beginning from user input to the chatbot's response. This modular framework grants Pak Bung chatbot conversational intelligence with the help of its predefined guidelines, templates, plugins, and API integrations. As Pak Bung chatbot evolves and encounters increased use scenarios, Dialogflow supports several communication channels and languages, seamlessly accommodating growth and reducing the need for disruptive migrations in the long term [17].

Pak Bung chatbot is embedded within a website created using Wix, whereby user requests received on the website are

forwarded to Dialogflow API in the form of detect intent request. It is first handled by Dialogflow's Natural Language Understanding (NLU) component, which interprets and transforms the language to structured input by performing dialogue act classification, intent classification, and form-filling.

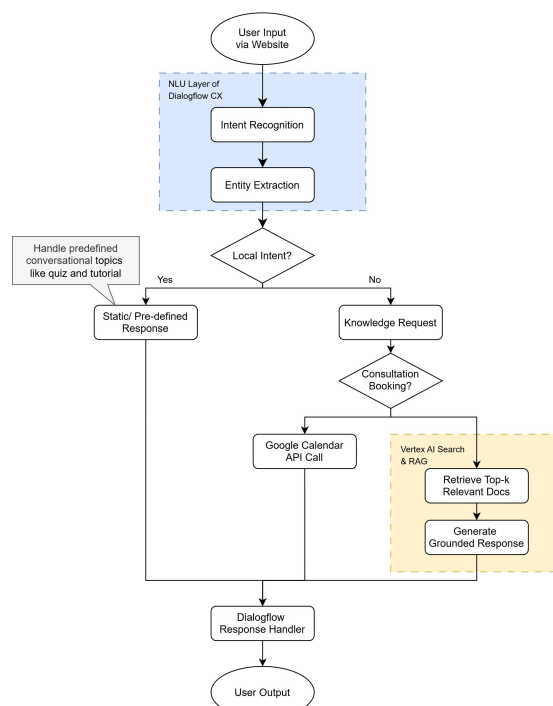


Fig. 1. Architecture of Pak Bung chatbot.

To shape and update the conversation, state handlers, both

routes, and event handlers are evaluated to trigger the chatbot's action and retrieve information from the backend, such as the internal knowledge base and the web. With a webhook created in the fulfillment, a webhook request can also be sent to the webhook service for dynamic response generation, database queries, and external API calls. Next, the Response Generation component will forward a detected intent response based on the webhook response, or a static response if no webhook is called, to the client application.

In Dialogflow, Pak Bung chatbot is constructed with one core CX agent and one supporting Expert System (ES) agent to handle concurrent and multi-turn conversations, while serving as a top-level container for various settings and data (<https://cloud.google.com/dialogflow/cx/docs/basics>).

As the states (page) associated with respective conversational paths (flow) can be defined for intricate and multi-turn dialogs, the visual flow builder and reusable intents allow Pak Bung core CX agent to meet the chatbot's primary requirement to handle kompiang-related queries. On the other hand, the supporting ES agent complements it using the in-line editor enabled for simple codes to perform consultation scheduling and quiz conducting. This is shown in Fig. 2.

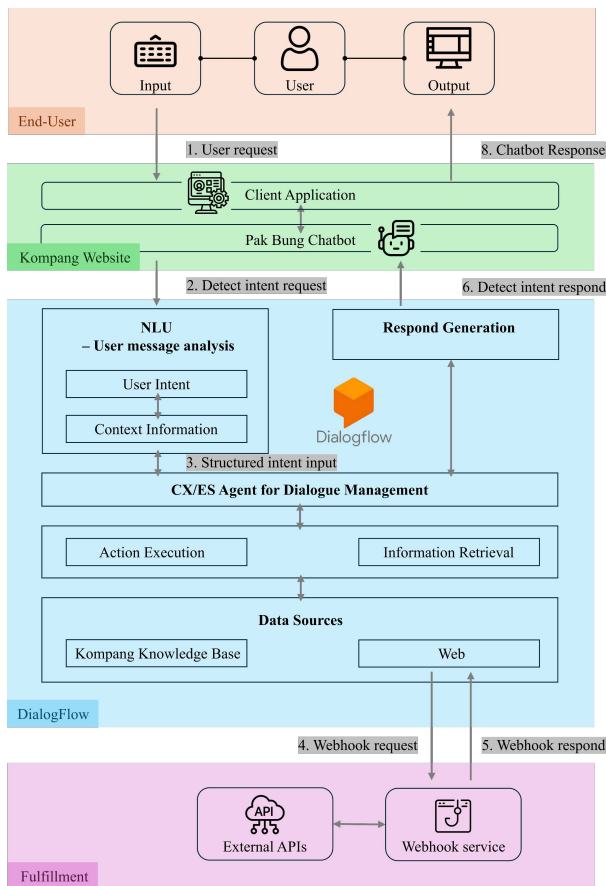


Fig. 2. Pak Bung chatbot framework.

A. General Conversation Flow

Once the user accesses the website, a conversation will be automatically initiated by Pak Bung chatbot by greeting the user based on the current time range. The chatbot will ask for and carry forward user's name throughout the conversation to create a sense of familiarity and connection. Personalized interaction is also enhanced as the conversation flow

continued with a small talk that asks about user experiences on kompiang playing.

Users may navigate through any of the six knowledge topics or follow along the tutorial topic that consists of 2 difficulty levels. To seek clarity and guidance, users can type "Help" or "Function" to view the list of kompiang-related topics and chatbot functionalities, hence facilitating user navigation and chatbot accessibility. A quiz session of 5 multiple-choice questions is also made available for users to identify weaknesses and track their understanding of theoretical concepts.

To elevate users' learning experience, Google Calendar API is integrated into Pak Bung chatbot for users to book an appointment with the kompiang experts. Fig. 3 shows the conversational flow for Pak Bung from getting the user's input to delivering the chatbot's response.

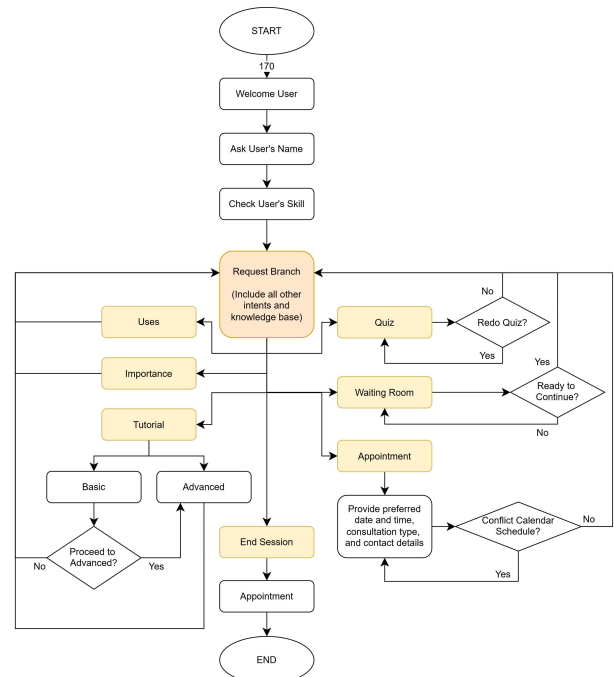


Fig. 3. Conversational flow.

B. Pedagogical Design Framework

To ensure that Pak Bung functions not only as a technical system but also as a pedagogically sound learning environment, its features were designed based on established educational theories. Recent research in digital learning emphasizes that chatbots, multimodal tutorials, and gamified interactions are most effective when grounded in clear instructional principles that support cognitive processing, learner engagement, and knowledge construction.

Accordingly, the instructional components of Pak Bung, such as multimedia tutorials, quizzes, dialogic prompts, and expert consultation scheduling, were guided by contemporary frameworks including constructivist learning, the Cognitive Theory of Multimedia Learning (CTML), gamification design principles, and chatbot-based scaffolding models. These theories informed both the structure of the learning pathways and the design of micro-interactions within the chatbot. Table 2 maps each major feature of the system to its underlying pedagogical rationale, supported by recent literature (2020–2025).

The alignment, as shown in Table 2, ensures that each

feature of Pak Bung is not only technically functional but also pedagogically justified, providing a coherent, theory-driven foundation for supporting meaningful and culturally grounded learning. The mappings are grounded on recent empirical reviews and theoretical updates in multimedia learning, constructivist e-learning, gamification, and chatbot scaffolding [13–18].

The application of these pedagogical principles is reflected in the outcomes of the Chatbot Usability Questionnaire (CUQ) section. Participants consistently reported that the chatbot was clear, engaging, and easy to navigate, which outcomes aligned with the expected effects of constructivist personalization, CTML-based segmentation, and gamified feedback mechanisms.

The strong user ratings for clarity, informativeness, and error handling further indicate that the embedded scaffolding strategies supported comprehension and reduced cognitive breakdowns during interaction. These findings indicate that users perceived the interaction as clear and supportive. However, the CUQ evaluates usability rather than knowledge acquisition. Therefore, the results should be interpreted as evidence of interaction quality and perceived learning facilitation, not direct learning effectiveness.

C. Knowledge Representation

Fig. 4 presents the semantic network underlying Pak Bung, where domain concepts are organized as nodes and relations to support structured reasoning and retrieval. The chatbot operates through multiple topic-specific flows, each managed by state pages representing conversational steps. User utterances are matched to predefined intents, triggering transitions between pages or flows and routing the conversation to the appropriate knowledge context.

When user input does not match any predefined intent, the chatbot uses a knowledge connector to generate responses from a defined knowledge base.



Fig. 4. Knowledge representation.

Table 2. Pak Bung features mapped to pedagogical theories (2020–2025 sources)

Chatbot Feature	Applied Theory (2020–2025 evidence)	Reasons for Alignment
Step-by-step tutorials (Easy → Advanced)	Constructivist/ technology-enhanced constructivism [18]	Short, scaffolded modules activate prior knowledge and let learners construct understanding progressively; tech enables scaffolding and learner control.
Multimedia (images, videos, 3D models embedded in chat)	Cognitive Theory of Multimedia Learning (CTML) [19]	Dual-channel presentation (visual + verbal) and segmentation reduce cognitive load and improve retention; embedding media in chat reduces extraneous navigation.
Segmented navigation (“Next”/ “Exit”)	CTML — segmentation & learner control [19]	Segmentation supports processing in manageable chunks and gives learner pacing control, reducing overload.
Quiz (5 MCQs) with instant feedback & replay	Gamification & formative assessment [20, 21]	Immediate feedback, scoring, and replayability increase motivation and provide formative correction; consistent with recent gamification reviews.
Personalized greeting & remembering username	Learner-centred personalization/ Constructivist relevance [18]	Personalization raises perceived relevance and engagement, supporting active knowledge construction.
Dialogic prompts, clarifications & fallback handling	Conversational scaffolding/ chatbots as scaffold tools [15, 22].	Prompts and branching dialogue act as scaffolds (hints, prompts, clarifying questions) that guide learners and maintain continuity of learning.
Consultation scheduling with human experts	Situated learning/ community of practice (applied via hybrid tech) as supported in chatbot reviews 2023–2024.	Enabling real expert interaction situates learning in authentic practice and extends learning beyond the bot.
Generative paraphrased LLM responses (low-temp)	Dialogic learning & adaptive explanation [15].	Varied phrasing helps re-explain concepts and supports comprehension for different learners; must be constrained to reduce hallucination.

This knowledge base contains curated documents provided as question–answer pairs or unstructured text, allowing the chatbot to address a broader range of queries as a fallback mechanism. The knowledge connector applies semantic search and natural language understanding to retrieve contextually relevant information, supported by optimized indexing and document embedding to reduce response latency. This approach improves response coverage and

enhances user satisfaction by maintaining consistent and accurate answers beyond predefined conversational flows.

D. Implementation and Evaluation

As shown in Fig. 5, Pak Bung chatbot is a menu- and button-based chatbot developed to answer questions and offer assistance within the knowledge field of kompang. Its modular interface enables smooth navigation across different

topics.

Deployed on a Wix website, users can perform the core Q&A tasks using the main chatbot agent on the left and conduct quiz sessions or book consultations using the supporting chatbot agent by clicking the buttons on the right.

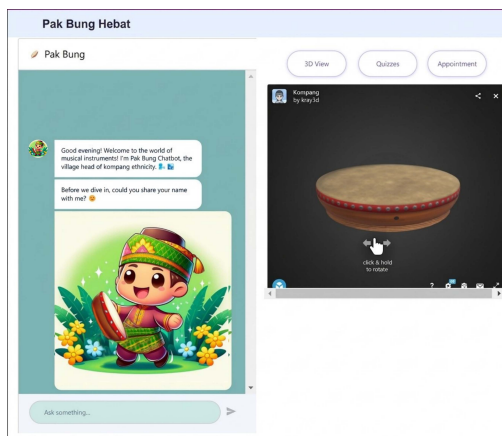


Fig. 5. Overview of the Pak Bung website.

Table 3 shows the excerpts of questions and answers provided on Pak Bung and kompang. The questions can be grouped into four main themes: foundational knowledge of the kompang and its cultural significance; the role of cultural heritage frameworks and sustainability, encompassing UNESCO definitions, SDGs, and the impact of globalization; the purpose, identity, and design of the Pak Bung chatbot, including its objectives, platform, and features; and system evaluation and educational context, covering user reception, usability testing, areas for improvement, and challenges in teaching kompang in formal settings.

Table 3. Excerpt of Q&A on Pak Bung chatbot and kompang

Question	Answer
What does the word kompang generally mean?	It is generally translated to mean “to hit” or “beat”.
What are the two main components of the kompang?	The wooden frame (<i>baluh</i>) and the animal skin head (<i>muka</i>) were stretched and nailed to the frame.
What are the three rhythmic roles in a kompang ensemble?	<i>Pembolong</i> (basic rhythm), <i>Penyilang</i> (counter rhythm), and <i>Peningkah</i> (leader rhythm).
How did the kompang enter Malay culture historically?	It was introduced by Muslim traders from India and the Arab world during the Malacca Sultanate.

In summary, the knowledge base consists of curated cultural concepts grouped into heritage background, performance technique, and system usage categories. The chatbot retrieves answers using semantic matching and structured intents.

Next, to achieve the purpose of promoting and preserving traditional musical culture, the chatbot is designed and implemented based on the three key considerations as follows:

1) User satisfaction

To establish trust and a positive connection with users, the chatbot interaction is humanized by designing a character “Pak Bung”, the village head of kompang ethnicity in the world of musical instruments. The name Pak Bung, which means “Uncle Bung” in English, is named after the two timbres a kompang essentially produces. “Pak” sound is

produced when the middle part of the kompang is struck with open fingers, while the ‘bung’ sound is produced when the edge of the “kompang” surface is struck with closed fingers [2]. Pak Bung is given a friendly and responsible personality, in which he will always answer user queries or offer to help, in an emotionally rich manner.

Personalized interaction is strengthened by tailoring the initial greeting based on the current time range as well as memorizing the user’s name throughout the session. Such a positive user experience is extended through the small talk that asks about experiences of playing kompang. The chatbot is configured to ask for user clarification during the interactions above if the input cannot be recognized and categorized correctly, thus reflecting system robustness in handling invalid inputs. Fig. 6 shows sample interactions with Pak Bung.

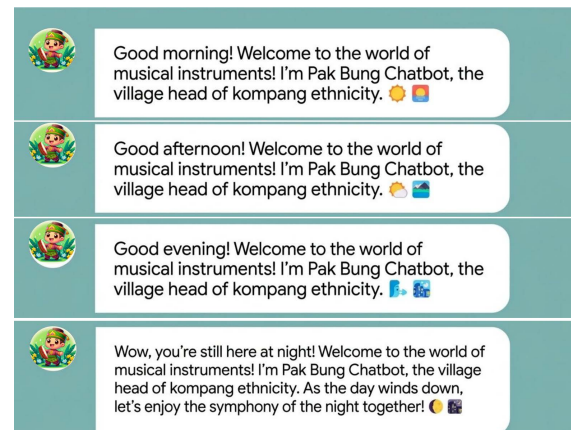


Fig. 6. Greeting message based on current time.

2) Content richness

Pak Bung chatbot is designed to attract users’ attention, accommodate a variety of learning styles, and simplify text-heavy content through the aid of multimedia. This is achieved by delivering content in a blend of images, videos, buttons, 3D model, and text. Images and videos are implemented for users to relate theoretical concepts to practical applications by understanding how kompang is played in real life. User experience can be enhanced as Dialogflow allows videos to be directly played on the chatbot instead of redirecting users to YouTube. This significantly reduces page loading time and eliminates the need for the user to navigate back and forth while chatting with Pak Bung.

Tutorials of two difficulty levels are featured in Pak Bung chatbot so that users of different skill and knowledge levels can learn kompang playing techniques from the instructions, videos, and images prepared. To enhance user’s information digestion, the comprehensive tutorial is split into several parts, where the user can opt to continue (“Next”) or quit (“Exit”) the session throughout the tutorial via button responses as shown in Fig. 7. After completing the easy tutorial, the user is asked to either end the tutorial session or proceed to the advanced tutorial.

In Fig. 8, users may initiate a quiz session to answer the five multiple-choice questions either by clicking the button or typing in the answer. The session is essentially a fulfillment webhook that presents quiz questions sequentially and processes users’ responses by extracting the response and matching the answer. While one mark will be obtained for

every correct answer, users who choose incorrectly do not gain any marks and are told the correct answer. After attempting 5 quizzes, the user's total mark will be announced, and the user can decide whether to repeat the quiz session.

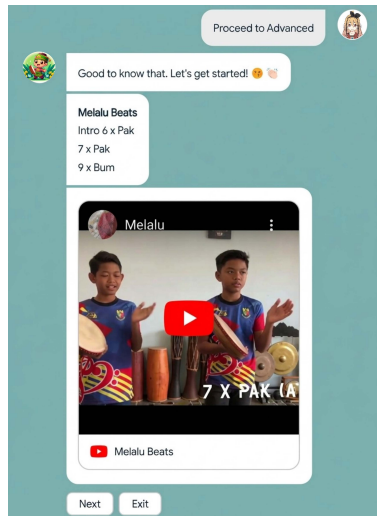


Fig. 7. Kompong tutorial.

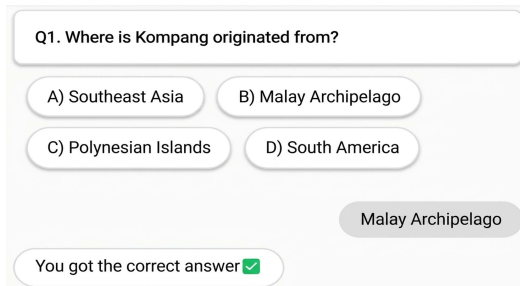


Fig. 8. Example of quiz question.

To enable consultation scheduling, the Pak Bung chatbot is integrated with Google Calendar API and a service account. Users interested in learning beyond the chatbot's scope of kompong knowledge can book an appointment by providing the preferred date and time, consultation type, and contact details. Calendar ID and service account credentials are defined in Dialogflow to access the Google Calendar API. Upon receiving the user request, calendar availability is validated before confirming the consultation and creating a corresponding calendar invite. If a conflicting event exists on the calendar, the user is informed about the denied request and prompted to make another attempt.

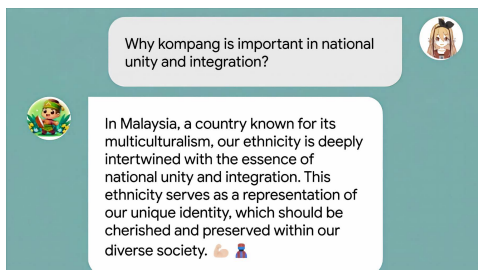


Fig. 9. Generator paraphrased content (example 1).

In Pak Bung chatbot, Google's generative large language models are incorporated to generate dynamic responses based on the predefined agent responses at runtime. With a low temperature setting, the same user input can receive key messages that are expressed in various yet accurate ways, increasing the chatbot's quality and user retention.

Generative responses are constrained using retrieval-augmented generation. The model generates answers only after retrieving the top-k relevant documents from the curated knowledge base. A low temperature (0.2) and top-p filtering are applied to minimize variance. Responses are rejected if the semantic similarity with the retrieved context falls below a defined threshold, preventing unsupported generations. Figs. 9 and 10 show the paraphrased content in two examples.

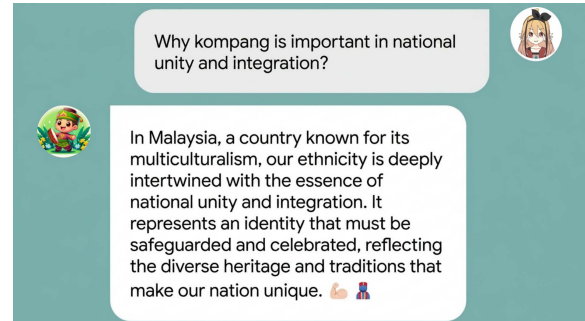


Fig. 10. Generator paraphrased content (example 2).

Knowledge connectors are configured to complement defined intents by allowing Pak Bung chatbot to respond to a wider range of questions by storing additional information about kompong that may not be covered in predefined intents. Unstructured documents such as PDFs, Word documents, or text files are imported into a Google Cloud Storage bucket. These documents are then processed and integrated into Dialogflow as a data store. When a user query does not match any predefined intents or entities, the chatbot can refer to this extensive data store to provide relevant responses, enabling the chatbot to handle a diverse array of user inquiries effectively.

3) Usability

To ensure smooth and effective two-way interaction, Pak Bung chatbot adopts a structured communication path for the initial conversation, from greetings to small talk about kompong experiences. During this stage, users are required to respond to the chatbot's prompts before proceeding to the next section. Moving onwards, users are granted the flexibility to freely explore and navigate through different knowledge topics, even without completing the current explanation.

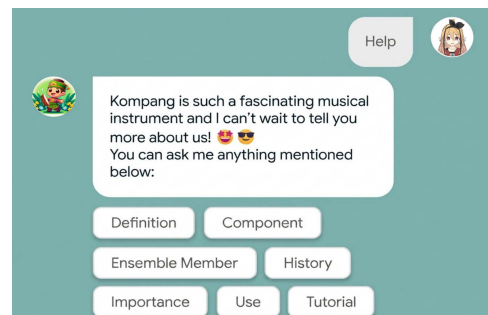


Fig. 11. List of Kompong topics.

Considering the wide range of topics available in Pak Bung chatbot, system clarity and accessibility are emphasized as users can always request a list of kompong-related topics and activities. To improve readability and minimize response error rate, these navigation options are displayed as interactive buttons rather than plain text. In Fig. 11, users can

seek clarity and guidance by typing “Help” or “Function” to view the list of kompang-related topics and chatbot functionalities. Meanwhile, in Fig. 12, users can explore and navigate through different knowledge topics, even without completing the ongoing explanation.

In addition, multiple fallback intents are incorporated to enhance user trust, while ensuring a natural progression of the conversation in various circumstances, as shown in Fig. 13. In the Pak Bung chatbot, fallback intents serve as the safety net, gracefully managing unrecognized inputs and common questions beyond the chatbot’s scope to avoid an abrupt halt.

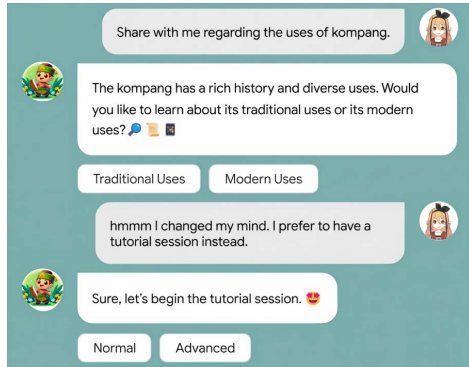


Fig. 12. Flexibility in conversation flow.

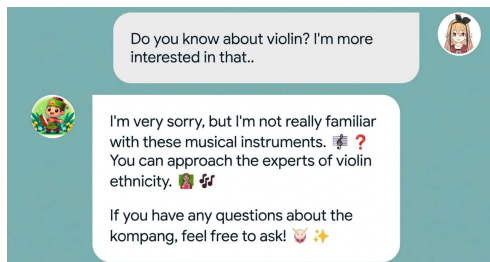


Fig. 13. Error handling.

4) Implementation of Pak Bung Avatar

In developing the Pak Bung chatbot system, an avatar was designed to visually represent the cultural essence of the kompang. A Generative AI tool, Adobe Firefly, was initially employed with the prompt “Malay boy playing drum”. The generated image, as shown in Fig. 14, provided a generic representation but did not reflect the authentic characteristics of the Malaysian kompang. To enhance cultural alignment, the output was further refined using Adobe Illustrator, producing a modified version integrated into Pak Bung.

However, a major limitation was identified. Current generative AI models lack sufficient exposure to Malaysian cultural elements, resulting in avatars that depict incorrect holding styles of the kompang. While several alternative outputs were generated using improved prompts, validation with a kompang expert revealed inconsistencies with the traditional playing posture. To address this, additional analysis was conducted by reviewing live performance recordings and instructional videos to ensure cultural accuracy. Ultimately, the final output in Fig. 14 was validated by the expert as an accurate representation. This approach ensured that the Pak Bung system not only incorporates AI innovation but also preserves the authenticity of Malaysian musical heritage.

The image presents a five-stage workflow illustrating how the Pak Bung avatar was developed using a combination of

Generative AI, manual refinement, and expert cultural validation. It shows the complete pipeline from prompt creation to the final culturally accurate avatar.

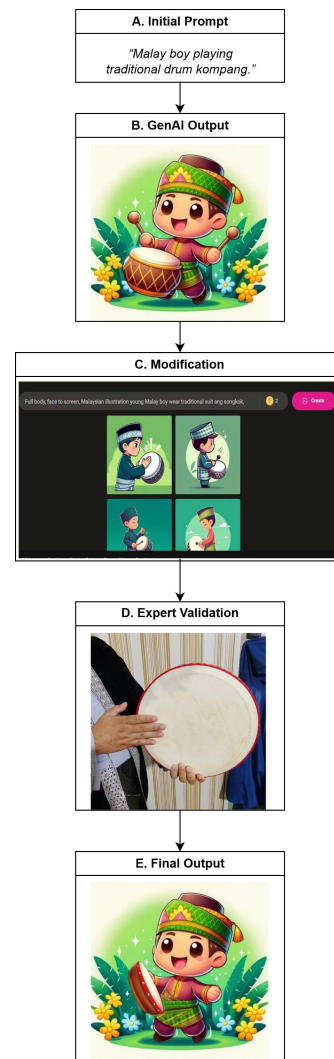


Fig. 14. Avatar generation.

- (1) Initial Prompt: The process begins with a simple text prompt “Malay boy playing traditional drum kompang”. This step represents the starting point of generative creation. At this stage, the objective is to rely on GenAI to generate a culturally relevant character based on a textual description. However, this also highlights a challenge: GenAI models often lack explicit training on Malaysian cultural items, especially niche instruments like the kompang.
- (2) GenAI Output: The first image generated by the AI (Adobe Firefly) presents acute, cartoon-style Malay boy wearing traditional attire, holding and playing a drum. But the problem is that the drum does not accurately resemble a kompang. The holding technique is incorrect (e.g., wrong hand placement, wrong angle). Minor inaccuracies in attire and posture. This demonstrates the cultural knowledge gap present in many GenAI systems.
- (3) Modification (Refinement Stage): In this step, the research team attempts to improve the avatar by regenerating variations and tweaking designs using Illustrator or image editors. Screenshots show multiple versions, where some versions include round frame drums but still with incorrect orientation. Some outputs

show styles closer to Western tambourines. The hand positioning is often wrong (e.g., hitting from the front instead of the side). This step represents human–AI collaboration, where researchers compensate for AI limitations.

- (4) Expert Validation (Cultural Authenticity Check): A Malay kompang expert was consulted to verify the correct way to hold the kompang. The authentic posture. Proper hand placement (left hand supporting the frame, right hand striking the surface). Correct drum dimensions and side thickness. The image shown highlights the correct playing style, with red-circle emphasis on: How the hand strikes the drum. How the drum is held under the arm. This step ensures the final design is culturally accurate and not misleading.
- (5) Final Output: A final avatar is produced after combining AI-generated graphic elements. Human artistic modification. Expert-approved posture and drum design. The final image shows a cheerful Malay boy in traditional attire. Holding the kompang correctly. Displaying accurate drum design (baluh + muka). Correct hand position for ‘pak’ or ‘bung’ sound. This is the validated, culturally authentic avatar used in the Pak Bung chatbot system.

This image summarizes the entire avatar creation pipeline, emphasizing:

- Integration of GenAI tools
- Human artistic intervention
- Cultural expert validation
- Ensuring the authenticity of traditional heritage

It also demonstrates a unique challenge tackled in the research: Current GenAI models cannot automatically generate accurate representations of niche cultural instruments like the kompang.

IV. RESULTS AND DISCUSSION

A. Respondent Demographics

A total of 100 respondents participated in this study. The majority of participants (97%) were students from Asia Pacific University of Technology & Innovation, while the remaining three respondents were kompang players. Given

the chatbot’s focus on promoting kompang music to a broader audience, the inclusion of a substantial proportion of international students (43%) is considered appropriate for evaluating its effectiveness among users with limited prior cultural exposure. It is worth noticing that more than 90% of respondents reported having no prior experience or exposure to kompang. This demographic composition supports the study’s goal to assess the chatbot’s usability and educational value among largely novice users.

The evaluation population is intentionally novice-dominant because the system targets public cultural awareness rather than expert performance training. Nevertheless, only three expert participants were included, which limits conclusions about professional-level instructional validity. Future studies should incorporate structured expert assessment and controlled learning outcome testing. An overview of respondent variation is presented in Fig. 15.

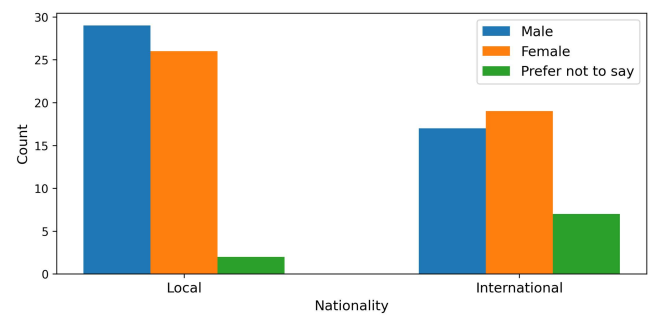


Fig. 15. Grouped bar chart for respondent demographics.

B. Chatbot Usability Questionnaire (CUQ)

Grounded in the chatbot user experience principles provided by the ALMA Chatbot Test tool, CUQ evaluates participants’ levels of agreement with sixteen statements encompassing both positive and negative dimensions of the chatbot usability [23]. Each statement is rated on a five-point Likert scale, from “Strongly Disagree (1)” to “Strongly Agree (5)”. The statements were refined from the questionnaire created by Holmes *et al.* [23] to align with the functional and interaction design requirements of the Pak Bung chatbot. All CUQ items used in this study are presented in Table 4.

Table 4. Chatbot usability questions mapped to the metrics

No.	Question	Metric Mapped
1	Pak Bung chatbot’s personality was engaging and helpful.	Engagement and Helpfulness
2	Pak Bung chatbot’s personality felt disengaging or unhelpful.	
3	Pak Bung chatbot clearly explained its scope and purpose at the start.	Clarity of Scope
4	I was unsure about what Pak Bung chatbot’s scope and purpose were during the interaction.	
5	Pak Bung chatbot provided clear guidance and prompts that assisted and navigated me.	Guidance and Navigation
6	At times, I did not know what to do next because the chatbot offered little or no guidance.	
7	Pak Bung chatbot used a consistent and polite communication style throughout the interaction.	Consistency and Politeness
8	Pak Bung chatbot’s wording or tone occasionally felt inconsistent or inappropriate for the situation.	
9	Pak Bung chatbot provided accurate information even when my input contained mistakes (such as grammatical and spelling errors).	Accuracy
10	Pak Bung chatbot struggled to recognize my messages when they contained minor errors or informal phrasing.	
11	Pak Bung chatbot generated responses that were informative and had appropriate length.	Content Quality
12	Some of the chatbot’s replies felt irrelevant, overly long, or insufficiently detailed.	
13	Pak Bung chatbot handled misunderstandings or unexpected user inputs effectively.	Error Handling and Reliability
14	When communication broke down, the chatbot was unable to handle the issue.	
15	Pak Bung chatbot was easy to use.	Usability
16	Using Pak Bung chatbot felt complicated or required more effort than expected.	

CUQ enables comparison with the widely recognized System Usability Scale (SUS), which has an established

benchmark of 68 out of 100 for acceptable usability of conventional systems [24]. For each participant, raw scores

from the sixteen CUQ items were summed to produce a total out of 160, following the calculation detailed in Eq. (1). These raw scores were then normalized to a 0–100 scale, to permit comparison with SUS.

$$\text{CUQ} = \left(\left(\sum_{n=1}^m 2n - 1 \right) - 5 \right) + \left(25 - \left(\sum_{n=1}^m 2n \right) \right) \times 1.6 \quad (1)$$

where $m = 16$ (number of questions) and $n =$ individual question score per participant.

In this study, university students from the authors' institution were recruited through email invitations and social media postings. The participants interacted with the chatbot at their convenience, then completed the CUQ survey. A CUQ Calculation Tool by Ulster University was employed for the efficient calculation of CUQ scores.

In Fig. 16, a violin plot summarizes the CUQ score distribution for Pak Bung chatbot. Scores ranged from 57.8 to 90.6, with a median value of 75.8 and a mean of 75 ± 6.4 . As the mean exceeds the SUS benchmark of 68, the overall results indicate that users perceived the chatbot as generally usable and effective. This violin plot shows the spread and density of total CUQ scores. The width of the shape reflects how common each score range is, while the internal boxplot shows the median and quartiles. The clustering of scores in the higher range, as shown by the wider central region, reflects favorable overall usability assessments of the chatbot.

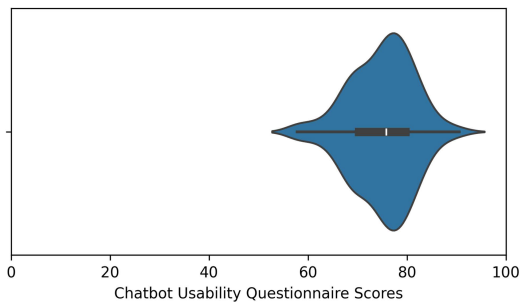


Fig. 16. CUQ score violin plot.

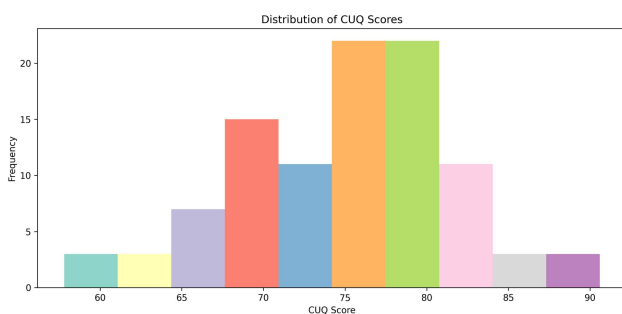


Fig. 17. CUQ score distribution histogram.

This histogram in Fig. 17 illustrates the frequency distribution of CUQ total scores derived from participant responses. Each bar represents a range of scores, and the height shows how many people fell into that range. Most users scored the chatbot between 70 and 80, indicating generally positive usability perceptions, with only a small number of respondents rating the system significantly higher or lower.

Meanwhile, the plot in Fig. 18 shows how users responded to the CUQ, where green (odd-numbered) questions reflect positive statements and red (even-numbered) questions

reflect negative ones. Each box represents the range of scores users gave for a particular question: Taller boxes or wider spreads indicate more variation among users, while higher boxes show overall stronger usability ratings.

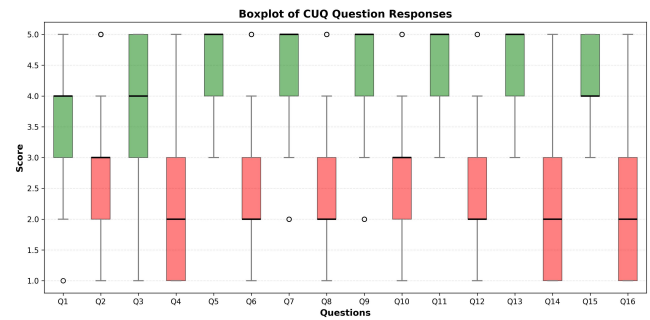


Fig. 18. Boxplot of CUQ question responses.

Finally, Fig. 19 shows how users rated Pak Bung chatbot across the 16 positive (green) and negative (red) phased statements. The height of each bar represents the average score given by participants, and the error lines above the bars show how varied these responses were.

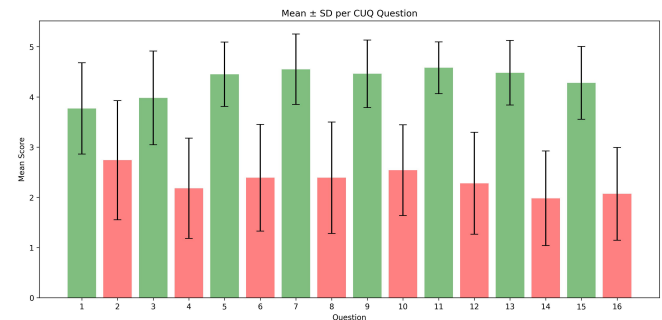


Fig. 19. Mean ± SD per CUQ question.

Through accessible digital resources, the Pak Bung chatbot addresses declining interest in kompiang and provides an inclusive means of transmitting intangible heritage knowledge. Globalization has drawn younger audiences toward Western instruments, but AI innovations demonstrate that traditional practices can coexist with modern technology to remain relevant and impactful.

The development of the Pak Bung chatbot demonstrates how AI can support access to cultural learning resources by combining interactive features: quizzes, tutorials, multimedia resources, and expert consultation scheduling with cultural knowledge. Designed on Google Dialogflow with Vertex AI (<https://cloud.google.com/vertex-ai>), the chatbot personalizes engagement by greeting users, remembering their names, and asking about their prior experiences with kompiang playing.

The platform enables multi-turn intent tracking and contextual state management, which has been widely adopted for education and service-oriented systems [25, 26]. In this study, it is used to implement structured tutorial navigation, quiz handling, and fallback recovery. Retrieval-augmented generation is used to ground responses in curated cultural knowledge, reducing hallucination risk.

V. CONCLUSION

This study contributes to the field of AI-driven cultural education by moving beyond generic conversational agents and demonstrating the design, deployment, and empirical

usability evaluation of a domain-specific cultural chatbot designed for heritage learning contexts. The Pak Bung chatbot integrates Google Dialogflow with Vertex AI to develop a vertical chatbot specifically designed for intangible cultural heritage, addressing a notable gap in generative AI systems that often lack cultural and contextual specificity. By embedding multimedia tutorials, interactive quizzes, and expert consultation scheduling into a single platform, the system provides a holistic digital framework for the teaching and appreciation of *kompang*, a traditional Malay frame drum deeply rooted in communal and spiritual expression [27].

Pak Bung chatbot was publicly deployed and accessible to users from May 2024 to February 2025, during which valuable insights into the chatbot's performance and usability were provided. From a methodological perspective, the study contributes a structured evaluation of cultural chatbot usability using the CUQ, mapped to concrete interaction metrics such as clarity, engagement, accuracy, and error handling. Empirical validation through CUQ with 100 participants offered quantitative evidence with the score exceeding established System Usability Scale (SUS) benchmarks. Moreover, the project advances the discourse on sustainable digital heritage preservation by demonstrating how AI-enabled educational tools can align with global sustainable development objectives. By embedding cultural knowledge within an interactive, user-centered AI system, the study highlights a replicable framework that can be adapted to other traditional instruments and regional art forms.

Beyond its contributions, Pak Bung extends the conventional role of chatbots by incorporating context awareness, multimedia richness, and interactive learning pathways. Nevertheless, several areas for enhancement remain. At present, the chatbot does not retain user data and treats each session as a new interaction. Incorporating a user database could enable personalized recommendations, progress tracking, and improved consultation management, thereby enhancing user retention and tailored learning.

Language accessibility is another key limitation. The current version of the chatbot operates primarily in English to accommodate a wider audience, particularly international students who may have limited exposure to local cultures. However, considering Malaysia's multilingual society and the importance of preserving local linguistic identity, future cultural chatbots can support additional languages such as Malay and Chinese. Incorporating these languages would promote inclusivity and encourage stronger engagement among local users. This initiative would also strengthen the chatbot's role as a cultural learning tool by enhancing its suitability for use in educational settings, including schools that use different languages of instruction, such as vernacular schools. Additionally, implementing voice-input and performance analysis features could allow users to record their *kompang* practice for automated feedback, enriching experiential learning while maintaining the authenticity of traditional performance styles.

In summary, this study establishes a validated, domain-specific chatbot model that effectively facilitates the digital transformation of heritage education. It lays a foundation for future work involving multilingual support, controlled comparative evaluations, and deeper integration of expert-curated knowledge. This thereby contributes both

theoretically and practically to the development of a comprehensive suite of cultural AI tools adaptable to other traditional instruments and regional art forms, advancing both digital innovation and heritage conservation in the era of intelligent learning technologies. While the present study focused on evaluating interaction usability only, it is hoped that a full evaluation of expert-validated musical competency acquisition can be performed in the future.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Vinothini Kasinathan conceptualized the project, designed the research methodology, and prepared the original draft; Samantha Tee Ker Xin designed the system architecture, integrated chatbot framework, conducted background research and documented system features; Aida Mustapha critically reviewed and edited the manuscript; Lim Jia Leong implemented the consultation scheduling feature, managed knowledge base data, and conducted system testing; Tan Wai Ken handled website integration, developed chatbot avatar, and implemented conversation flow; I-Hsien Ting designed the usability evaluation framework and analyzed the quantitative data. All authors approved the final manuscript, ensuring it reflected the collaborative efforts of the entire team.

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