Development of an Erhu Traditional Musical Instrument Education Chatbot Based on Cultural-Historical Activity Theory

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ABSTRACT

Traditional erhu education relies heavily on teacher-led instruction and scattered online materials, which can leave beginners without a clear route through the instrument's history, structure, playing techniques, repertoire, performers, and cultural meaning. This study addresses that access problem by developing and evaluating a menu-guided educational chatbot that answers recurring beginner questions and presents erhu knowledge in a structured, interactive form. Cultural-Historical Activity Theory (CHAT) was used to define the learner, learning object, mediating tool, rules, community, and division of labor, while a semantic network organized relationships among the content concepts. The system was implemented in Typebot with modules for origins and structure, study guidance, repertoire and performers, multimedia content, and quizzes; its architecture, topic network, interface, and decision flow are documented through system diagrams. After using the chatbot, 44 participants completed a modified 16-item Chatbot Usability Questionnaire. The mean CUQ score was 93.4 out of 100 (SD = 6.9), the median was 96.1, and scores ranged from 73.4 to 100. Positive items averaged 4.7-4.8 out of 5, whereas negatively worded items averaged 1.2-1.3, indicating high perceived usability, clarity, and educational value. These findings support the chatbot as an accessible introductory resource, but they do not by themselves demonstrate knowledge gain or sustained interest because no pre-test/post-test or control comparison was conducted. The design offers a transferable framework for other learner groups and cultural instruments, subject to demographic validation, accessibility adaptation, and richer open-ended or voice interaction.

Keywords: Erhu, Chinese traditional musical instrument, educational chatbot, Cultural-Historical Activity Theory (CHAT), semantic network, chatbot usability.

INTRODUCTION

Research Background

It is considered one of the most representative traditional bowed string instruments in China which appeared during the Tang Dynasty and the history of its evolution runs back to the time of more than a thousand years[4]. It has been given the name china violin due to its deep expressive tone. The erhu has also played a significant role in folk music, accompaniment of opera and modern composition with example of the erhu being represented in the music like the Moon Reflected in the Second Spring and Horse Racing being very popular. According to the recent findings, there is a rapid decrease of the younger generation interest in learning traditional instruments and a lot of professional erhu performers are lost and a very poor situation with protecting the intangible cultural heritage[4][6].

As a solution to this problem, this paper suggests the creation of an educational chatbot that would popularize the knowledge about erhu among the general users and in particular young individuals with the help of digital and interactive technologies.

The benefits of chatbots include easy access, low entry barriers, and an individual approach that can be useful to balance the shortcomings of the traditional classroom instruction and show a potential of new use opportunities in the sphere of cultural education[1][2][6].

Problem Statement, Study Aim, and Research Questions

Problem statement. The problem addressed in this study is not a complete absence of erhu information, but the lack of a coherent, beginner-oriented access point that connects basic practical questions with the instrument's cultural and historical setting. Static pages and search results often separate history, structure, playing guidance, repertoire, and maintenance into unrelated sources, while face-to-face instruction may not be immediately available to a curious beginner. A simple FAQ system can improve access, but without an educational structure it may still present isolated facts and fail to support meaningful cultural learning.

Study aim and significance. This study therefore aims to design, implement, and evaluate a Typebot-based educational chatbot that provides consistent answers to typical beginner questions and offers a low-pressure entry point to erhu culture. Its technical contribution is the translation of CHAT and semantic-network concepts into an executable menu, knowledge structure, and conversation flow rather than the creation of a generative artificial-intelligence tutor. Its educational significance lies in showing how cultural context and practical guidance can be presented together in a widely accessible web interface. The chatbot is intended to stimulate initial interest and support orientation; it is not a substitute for a teacher's demonstration, performance feedback, or formal learning assessment.

The study is organized around three research questions:

RQ1. How can a Typebot-based educational chatbot organize and deliver typical beginner questions about erhu history, structure, playing techniques, repertoire, performers, and maintenance?

RQ2. How can CHAT and semantic-network knowledge representation be translated into the system structure and conversational flow of an erhu cultural-learning chatbot? RQ3. How do participants evaluate the chatbot's usability and perceived educational value through a modified 16-item Chatbot Usability Questionnaire?

Together, RQ1 addresses system content and interaction design, RQ2 addresses the operational use of the theoretical framework, and RQ3 addresses formative user evaluation. The conclusion returns to each question separately.

MATERIALS AND METHODS

Choice of Research Framework Cultural Historical Activity Theory (CHAT).

The current paper uses the Cultural Historical Activity Theory (CHAT) as the framework of overall design of the chatbot system. Created by Engestrom after the activity theory, CHAT focuses on the fact that human activities are accomplished in concrete cultural and social surroundings mediated by tools[9]. The theory has extensive application in educational technology and cultural learning studies and is well placed to analyse the learning process of traditional cultural knowledge in a digital context[6][9].

In the learning situation of the erhu, a musical instrument of the Chinese people, CHAT can be used to explain the system of interaction of the learners with the content of the knowledge of the erhu using the technological resource of a chatbot and reach the learning goals within the limitations and facilitation of the rules, community, and division of labor. Thus CHAT offers a clear analysis perspective to this study.

Figure 1 is included as an implementation view rather than as a decorative screenshot. It shows how the central menu and the linked question branches were assembled in the Typebot editor, providing traceable evidence that the proposed content structure was translated into an operational dialogue flow.

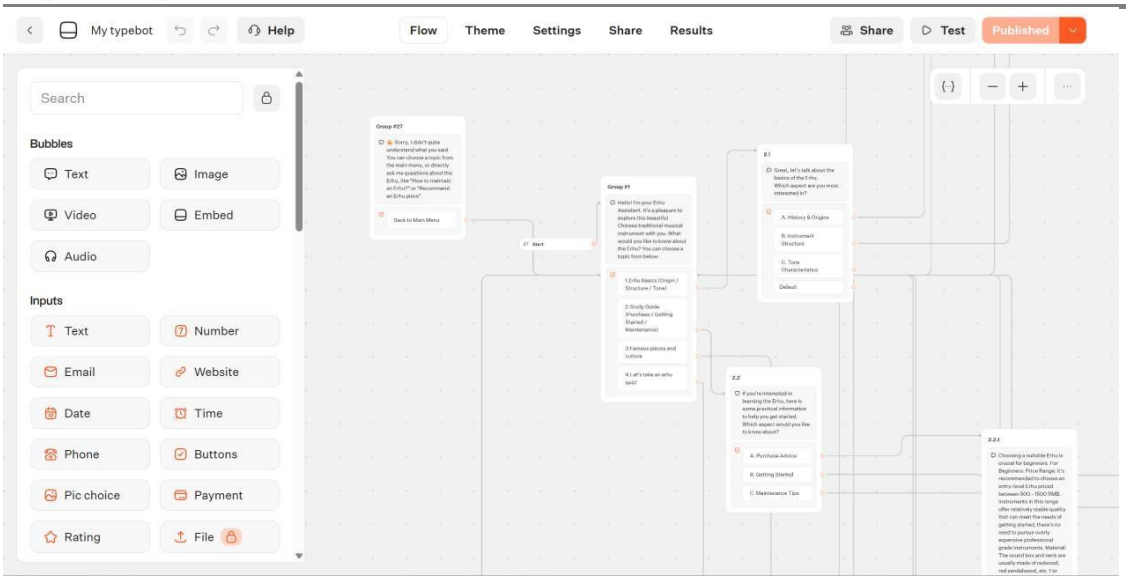

Figure 1. Typebot workflow used to implement the menu-guided Erhu chatbot.

The workflow begins with a common entry point and then separates into topic branches and return-to-menu paths. This structure supports predictable navigation and consistent answers, but it also makes clear that the current prototype depends primarily on predefined routes.

CHAT Framework Explanation

According to CHAT theory, the Erhu teaching chatbot system that will be designed in this research project includes the following six main components:

- ✧ Subject: The topic of the learners being discussed by the chatbot will be the learners who are mostly beginners and are interested in the traditional Chinese music or Erhu.
- ✧ Tool: The tool will be the Erhu instructing chatbot by Typebot platform, where it is utilized to convey knowledge and direct learning.
- ✧ Object: The object is the purpose of the learning task, i.e. assist the learners to comprehend the history, structure, playing methods as well as the cultural worthiness of the Erhu.
- ✧ Rules: Rules have the preset dialogue flow of the chatbot, order of questions and usage to make the learning process orderly.
- ✧ Community: The community is the learning group that is interested in the traditional Chinese music culture; the chatbot can be used by this group as a community learning resource.
- ✧ Division of Labor: The division of labor can be seen in the fact that the chatbot is expected to take care of knowledge explanation and guidance, whereas learners should be expected to pose questions and engage in the process.

A combination of the above content makes the entire system of learning activities complete, which provides the proper functioning of the chatbot in the cultural learning situation.

Figure 2 summarizes the architectural boundary of the prototype. It is included to distinguish the learner-facing chat interface from the Typebot control layer, predefined actions, and knowledge base. The diagram therefore explains where user input enters the system and how a response is produced from the prepared content.

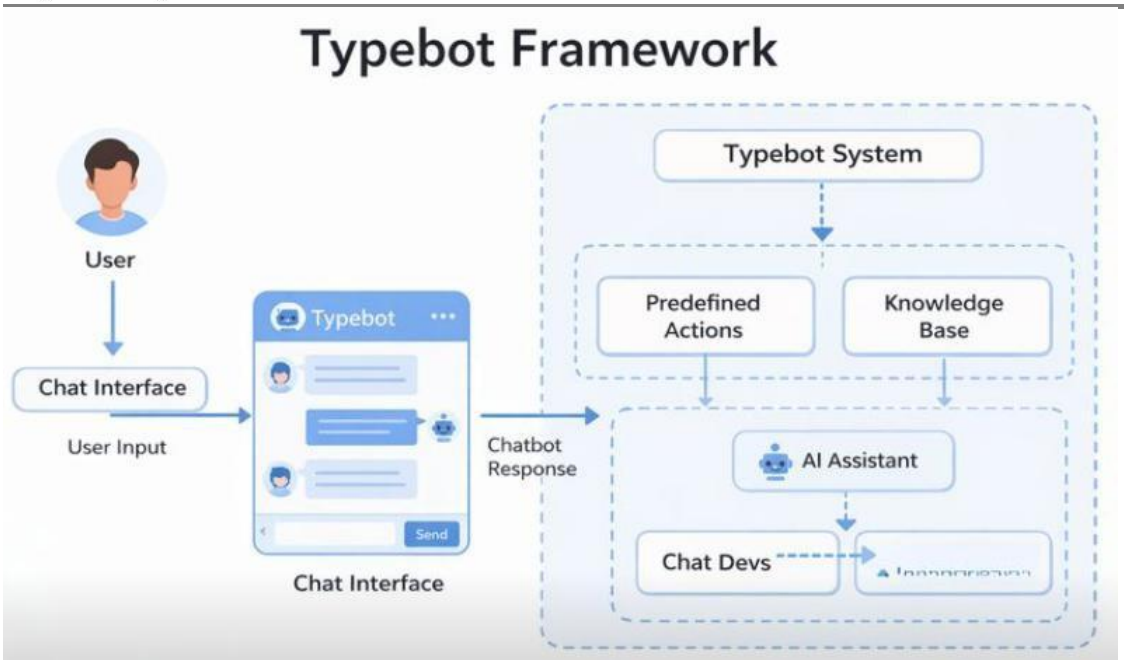

Figure 2. Typebot-based architecture of the Erhu educational chatbot.

The separation between interface, actions, and knowledge resources is important for replication: content can be revised without redesigning the complete interface, while conversation rules can be tested independently from the cultural material.

Semantic Networks Knowledge Representation Methods.

Regarding knowledge representation, semantic network approach is used to structure the erhu-related knowledge. Semantic networks capture the knowledge point logical relationships in terms of nodes (Concepts) and relations (Relations), and thus are appropriate at teaching content with straightforward conceptual hierarchies [5][10].

Erhu is used as the central node in this study, which is interrelated with other sub-nodes like historical origin, structural composition, playing techniques, representative repertoire, and cultural value. As an illustration, the word "erhu" is related to structural composition with the help of an inclusion relationship, whereas the words playing techniques and representative repertoire have an application relationship. This knowledge representation aids the chatbot to be consistent and coherent in responding to user queries and assists in the growth of knowledge.

Our System Development Process Description.

The Erhu teaching chatbot is developed in the form of the following steps:

- ✧ Problem Analysis and Needs Confirmation: The determination of the current issue in the spread of the Erhu culture and the educational goals of the chatbot.
- ✧ Framework Design: The system structure and functional modules are planned as per CHAT theory.
- ✧ Knowledge Organization and Modeling: Gathering and sorting out materials about Erhu in order to create a knowledge structure in the form of semantic network.
- ✧ Chat Flow Design: This teaches a person how to chart the dialogue paths, question branches, and user options using the Typebot platform.
- ✧ System Testing and Optimization: Multiple rounds of testing the chatbot to make sure that the responses are correct and that the interaction is smooth.

Figure 3 visualizes the semantic-network role in the development process. It is included to show how user queries, intent and context, predefined actions, the knowledge base, erhu concepts, information retrieval, and user feedback are related around the Typebot system. The figure is a conceptual knowledge map, not a measurement of model intelligence or retrieval accuracy.

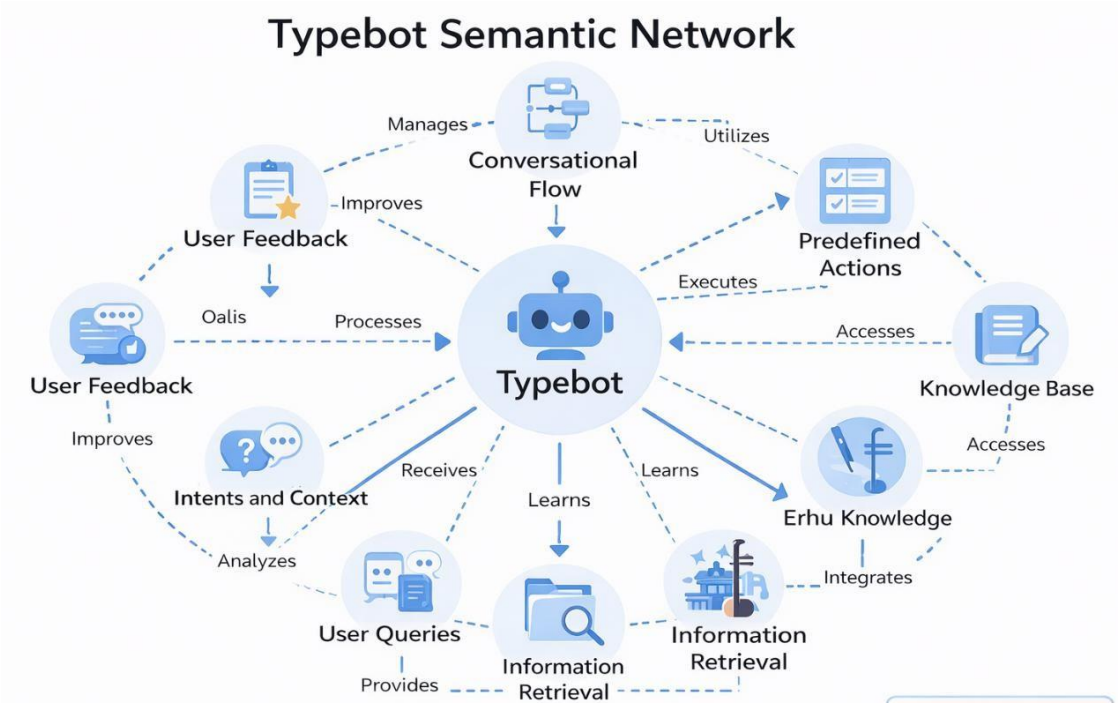

Figure 3. Semantic network linking Typebot functions, user interaction, and Erhu knowledge.

Reading outward from the central Typebot node shows the main relationships that guide content selection and response delivery. This visual representation explains why the knowledge base is organized by connected concepts instead of as an unstructured list of answers.

Chatbot System Design

The teaching chatbot (the erhu or the two-stringed bowed instrument) created at this research institute uses the Typebot platform as its foundation, and the overall design is focused on simplicity, clarity, and usability by novices. The system lacks the use of any complicated artificial intelligence algorithms, but rather just produces a clear flow of dialogue and menu-based guidance to enable the users to learn about the erhu gradually, just as it would happen when communicating with a person[1][5].

Upon using the system through a link, the chatbot greets the user with a short welcome message, which informs the user about the services the chatbot can deliver by helping one learn the basics of the erhu, learning techniques, and cultural information. The system then gives out a menu which is used by the user to choose what they want to learn depending on their individual interests. The design will relieve learning pressure and support rapid user onboarding in case of users of various backgrounds.

There are four directions of learning in the main menu. The former is a general erhu knowledge course, which has mostly involved familiarizing the users with the history of the erhu, the structure of the instrument and the sounding properties of the instrument. The user is able to choose among the options according to his/her interest like learning the development of the erhu of the Tang Dynasty Xiqin, or seeing the names and functions of the different parts of the erhu. The system also relies on images in introducing the structure of the instrument to enable the users learn the relevant content in a more intuitive manner.

Figure 4 is presented as a descriptive access-count summary that helps explain which content areas attracted the most navigation in the available record. It complements the menu description by showing the relative use of history, structure, playing techniques, repertoire, and performer topics.

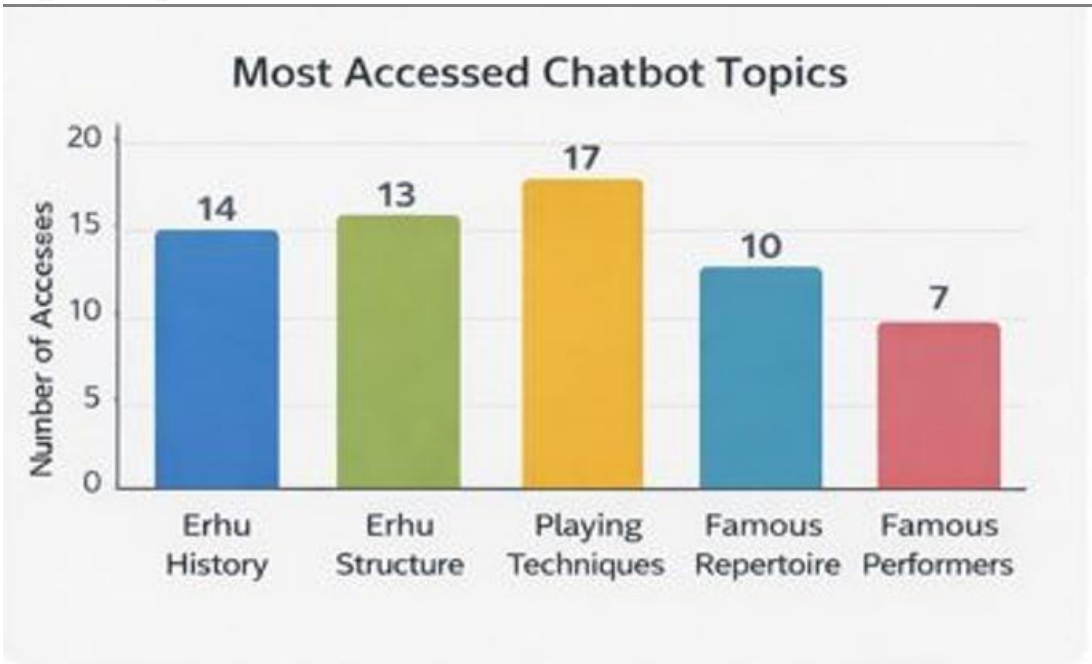

Figure 4. Access counts for the main Erhu chatbot topics.

Playing techniques received the largest count (17), followed by history (14), structure (13), repertoire (10), and performers (7). These values are descriptive navigation counts; they should not be read as unique-participant totals or as evidence of learning gain without a documented logging and outcome protocol.

The second one is the Learning Guide which is mainly directed to beginners. The chatbot will offer convenient learning tips, such as purchase suggestions, introductory learning techniques, and tips to maintain it on a daily basis. As an example, the purchase advice section describes appropriate price ranges and material selection to the beginner; the introductory learning section briefly describes proper holding, basic practice, and the need to experience gradual progress; and the tips on maintenance section to remind users of the need to be really aware of their humidity and storage choice, the care of the bow, and its strings. This material is directly connected with the everyday experience that is very pragmatic.

The Famous Music and Cultural Introduction module is the third one. In this part, the chatbot presents some of the most representative examples of erhu pieces and styles of performances in various regions, briefly elaborating on the importance of these pieces and styles in the Chinese culture of music. The system also refers to the use of the erhu in the contemporary music, film soundtracks, and cross-genre performances, which allows users to understand that the erhu is not only a part of the traditional music but it still modernizes in the modern music industry.

The fourth module is the Quiz module. In order to make the learning process more interactive, the system has a short multiple choice quiz. The users may be engaged in a quiz after learning. The system will give the feedback of the answer after every answer and briefly explain the correct answer. This will make the users overview what they have learned and this will improve the overall learning process.

On the whole, this chatbot, with the help of its uncomplicated dialog system and conversational manner, demonstrates erhu-related information to the users in a comparatively easy-to-follow manner, greatly reducing the obstacle to learning this classical instrument and greatly boosting the interest of the users. On a personal level, I have also learned a lot of information about the erhu with the help of my chatbot.

Figure 5 provides a concrete interface example so that the reader can see how the design is experienced rather than relying only on the architectural diagrams. The selected example follows the basics-to-history route and displays both user choices and the resulting cultural explanation.

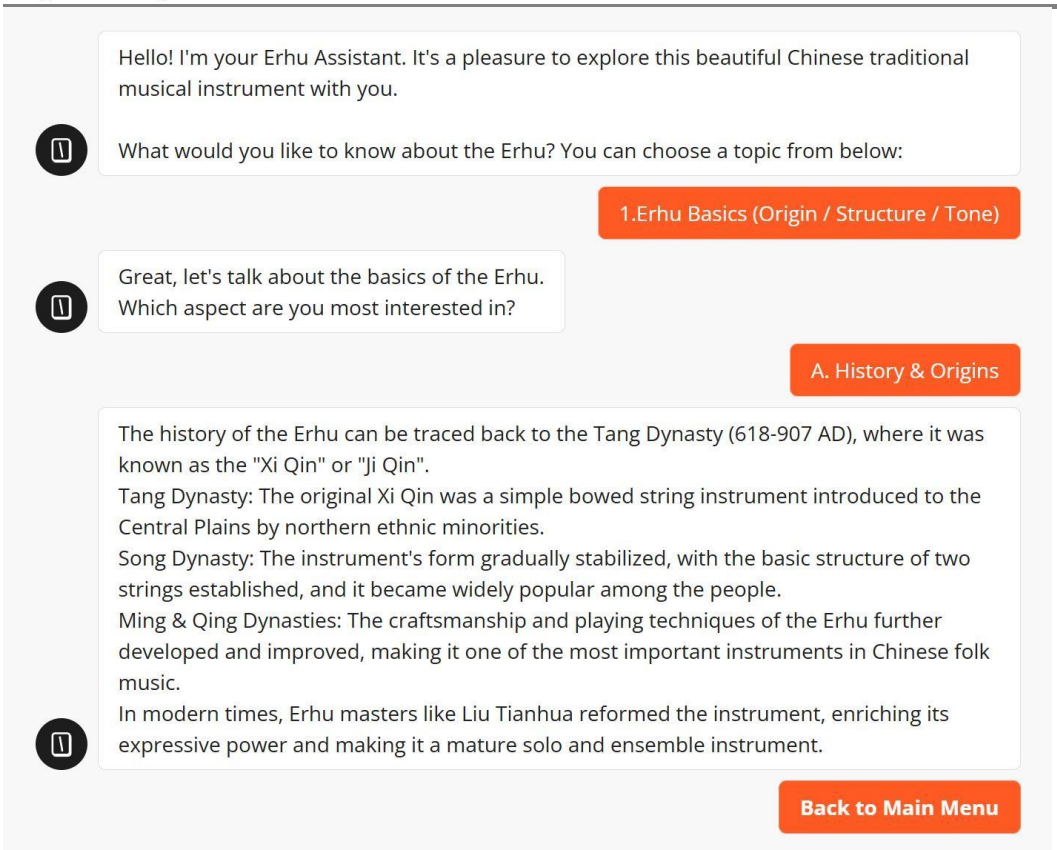

Figure 5. Example Typebot conversation for the Erhu history pathway. The interface shows the welcome message, topic selection, subtopic selection, a structured answer, and a return-to-menu control. These elements explain how the prototype lowers the initial interaction burden while keeping the user inside a guided sequence.

Figure 6 abstracts the same interaction into a decision-flow diagram. It is included to document expected system behavior for both supported and unsupported questions and to clarify where a user is asked to rephrase an input.

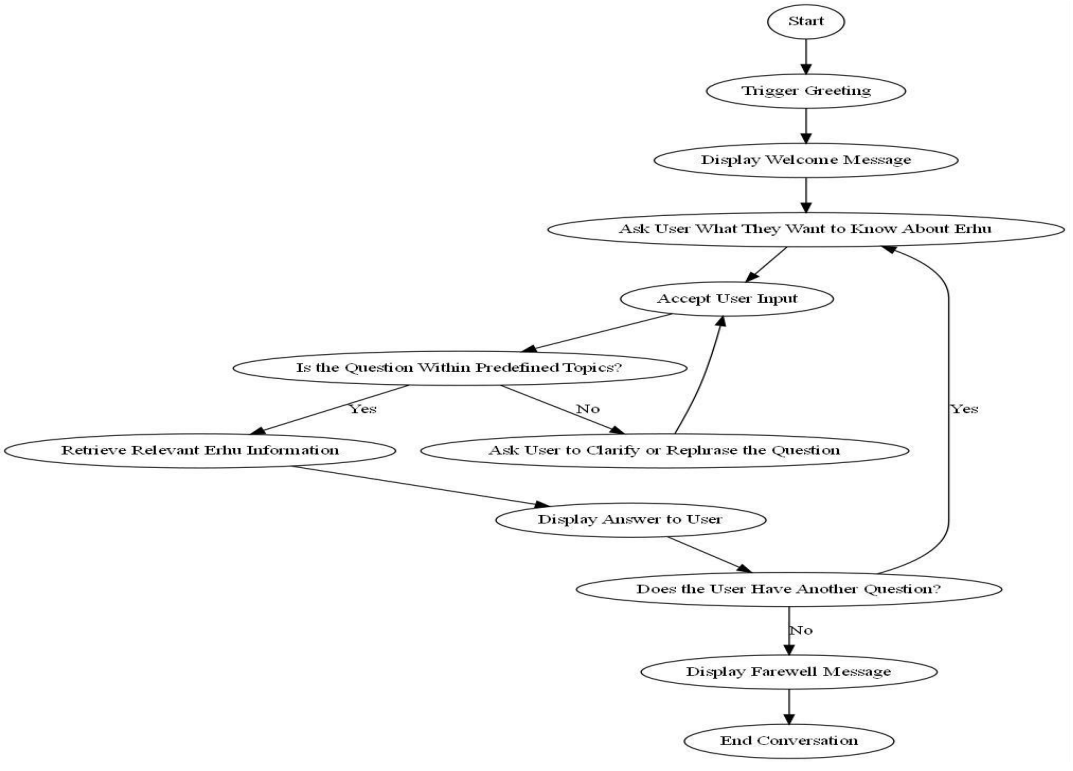

Figure 6. Decision flow of the proposed Erhu educational chatbot.

When a question matches a predefined topic, the system retrieves and displays the relevant erhu information; otherwise, it requests clarification and returns to the input stage. The final loop allows another question or ends the conversation. This diagram also identifies the main limitation of the current prototype: coverage is bounded by the prepared topics and branches.

System Evaluation (CUQ)

The prototype was evaluated with a modified Chatbot Usability Questionnaire (CUQ) [1][3][7]. The evaluation reports the participant sample, the overall CUQ distribution, and item-level responses. Because the instrument measures perceived usability and experience, the results are interpreted separately from actual learning gain.

Participant Information, Selection Rationale, and Overall CUQ Score

There were a total of 44 individuals invited to join this usability test. After the experience with the Erhu chatbot, all the participants went through the 16-item CUQ questionnaire.

The 44 participants are treated as a formative usability sample rather than as a statistically representative population. This choice is suitable for an initial assessment of whether prospective users can understand the interface, follow the menu, and judge the usefulness of its content without requiring specialist erhu expertise. However, the study did not retain a demographic breakdown of age, education, musical training, cultural background, or prior chatbot experience. Results therefore cannot be generalized to particular demographic groups, and future work should use stratified samples that include school pupils, adult beginners, music teachers, older learners, and international users.

The overall CUQ results were high: the mean was 93.4 out of 100 (SD = 6.9), the median was 96.1, and the observed scores ranged from 73.4 to 100. These descriptive statistics indicate consistently favorable usability ratings within the 44-person formative sample; they do not establish population-level effects.

Accordingly, the prototype can be described as easy and comfortable to interact with from the perspective of these respondents. Claims about knowledge improvement or sustained interest require a separate learning-outcome design.

Individual CUQ Item Scores

Figure 7 introduces the CUQ results infographic by placing the overall score distribution and the mean score for each questionnaire item in one view. The left panel reports the participant count, mean, standard deviation, minimum, maximum, and median; the right panel supports inspection of the positive and negatively worded items discussed below.

Mean scores for the positively worded items (questions 1, 3, 5, 7, 9, 11, 13, and 15) ranged from 4.7 to 4.8 out of 5. Respondents therefore reported favorable perceptions of ease of use, dialogue clarity, information usefulness, conversation organization, satisfaction, and willingness to use the chatbot again.

Mean scores for the negatively worded items (questions 2, 4, 6, 8, 10, 12, 14, and 16) ranged from 1.2 to 1.3. After accounting for item direction, these low scores are also favorable: respondents generally disagreed that the chatbot was confusing, irrelevant, frustrating, or poorly organized.

Item-level standard deviations were generally 0.4 to 0.5, showing limited dispersion around the mean responses in this sample. The individual item pattern is displayed in Figure 7 and the modified questionnaire wording is listed in Table 1.

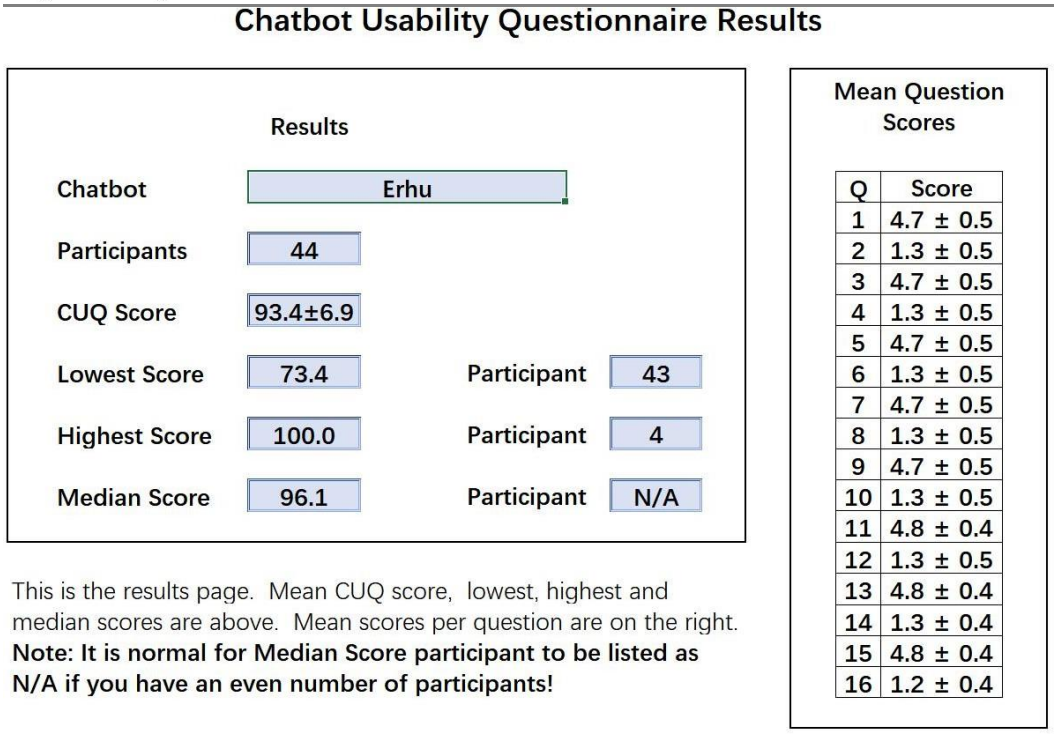

Figure 7. Overall and item-level Chatbot Usability Questionnaire results.

The infographic is included to connect the high overall CUQ score with the item pattern rather than presenting a single summary number in isolation. The low means for negatively worded questions are favorable after accounting for item wording; they should not be interpreted as low usability.

RESULTS DISCUSSION

The overall score and item pattern indicate high perceived usability for the prototype within the evaluated sample. The result is most directly interpreted as evidence that respondents could understand the interface and navigate the prepared content paths.

Participants reported that the prompts were understandable, the conversation structure was logical, and the supplied information was useful. These responses support the system's role as an introductory information guide, while remaining self-reported judgments rather than objective learning measures.

The contrast between high positive-item means and low negative-item means is internally coherent after item direction is considered. Even so, reliability coefficients and inferential tests were not reported, so the analysis is limited to descriptive interpretation.

The strongest evidence concerns ease of use, clarity, perceived usefulness, interaction satisfaction, and intention to use the chatbot again. The present evaluation cannot determine whether the chatbot increased erhu knowledge or long-term interest; those outcomes require pre-use and post-use measures and an appropriate comparison condition.

Number	Question
1	The chatbot was easy to use and understand.
2	I found the chatbot confusing to interact with.
3	The chatbot responded in a clear and understandable way.
4	The chatbot often misunderstood my questions.

Number	Question
5	I felt comfortable using the chatbot without needing extra help.
6	I needed to spend a lot of effort figuring out how to use the chatbot.
7	The information provided by the chatbot was useful for learning about the Erhu.
8	The chatbot provided information that was irrelevant or unhelpful.
9	The structure of the chatbot conversation felt logical and well organized.
10	The conversation flow felt disjointed or poorly designed.
11	I was satisfied with the overall interaction experience.
12	Using the chatbot was a frustrating experience.
13	The chatbot helped me better understand Chinese traditional music.
14	The chatbot did not contribute much to my understanding of the topic.
15	I would be willing to use this chatbot again in the future.
16	I would avoid using this chatbot if other learning options were available.

Table 1. Modified Chatbot Usability Questionnaire (CUQ) items.

Research Question Responses, Limitations, and Conclusion

Response to RQ1: Organizing and Delivering Beginner Erhu Knowledge

RQ1 asked how a Typebot chatbot could organize and deliver typical beginner questions. The implemented system answers this question through a common welcome point, a menu of erhu basics and study guidance, branches for history, structure, tone, playing techniques, repertoire, performers, maintenance, and quizzes, and return-to-menu controls. The interface and flow diagrams show that a novice can reach prepared information through a small number of explicit choices. The result is an accessible introductory guide that can support orientation and initial curiosity, although it does not replace teacher-led demonstration or performance correction.

Response to RQ2: Applying CHAT and Semantic-Network Structure

RQ2 asked how CHAT and semantic-network representation could be translated into system design. CHAT defined the learner as the subject, erhu knowledge acquisition as the object, the chatbot as the mediating tool, and the dialogue rules, learner community, and division of labor as the surrounding activity system. The semantic network then connected history, structure, technique, repertoire, cultural value, user queries, actions, and feedback. Together, these frameworks produced the content hierarchy and guided conversation flow shown in Figures 1-3 and 6. They provide a reproducible educational structure, but they do not make the current rule-based chatbot fully adaptive or generative.

Response to RQ3: Usability and Perceived Educational Value

RQ3 asked how participants evaluated the chatbot through the modified CUQ. Among 44 participants, the mean score was 93.4 out of 100 (SD = 6.9), the median was 96.1, and the observed range was 73.4-100. Positive items averaged 4.7-4.8 out of 5 and negative items averaged 1.2-1.3, indicating favorable perceptions of ease of use, clarity, usefulness, conversation organization, satisfaction, and willingness to use the chatbot

again. These results answer the usability part of RQ3 and indicate perceived educational value. They do not establish actual knowledge improvement or increased long-term interest, because the study did not include baseline measures, a post-use knowledge test, or a comparison group.

Limitations, Transferability, and Future Work

The conclusions are limited by the formative sample, the absence of demographic and musical-background data, reliance on self-reported usability, and the prototype's predefined conversation paths. A later study should compare pre-use and post-use knowledge, measure continued interest after a delay, record task completion and navigation errors, and recruit stratified participant groups. The framework can be extended to children, adult beginners, diaspora communities, music teachers, older learners, and users studying other traditional instruments, but the language level, accessibility, cultural examples, and evaluation design must be adapted for each population. Future technical work may add audio examples, voice input, multilingual content, teacher-reviewed open-ended responses, and richer analytics. Within these limits, the project demonstrates a feasible way to combine cultural theory, structured knowledge, and a low-code chatbot for introductory traditional-music education.

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