Stewarding Quantum Intelligence and RALL in Evolving EFL Communication through Maritime Teaching Materials for Sustainability

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Abstract: This study examines how Quantum Intelligence (QI) and Robot-Assisted Language Learning (RALL) can be used to improve English as a Foreign Language (EFL) communication skills using maritime-themed teaching materials for sustainability education. The purpose of this study is to create and test a new learning model based on need-based learning that uses intelligent tutoring systems (ITS), AI-powered feedback, and maritime information to help students strengthen their communication skills while improving their understanding of cultural and environmental issues. This research is important today because there is a growing need for culturally responsive and AI-integrated teaching that is aligned with the UN Sustainable Development Goals (SDGs), specifically SDG 4 (Quality Education), SDG 13 (Climate Action), and SDG 14 (Life Below Water). Twenty-four junior high school students were purposively selected respondents with characteristics of being proficient in AI tools and basic EFL who participated in this study. They completed a 20-item Likert scale questionnaire regarding their needs responses in RALL-based teaching, which included various activities, including AI engagement, environmental discussions, poster drawing, storytelling, and simulating marine life. The results indicated that students' enthusiasm and ability to communicate in EFL had increased significantly, with good reliability scores (Cronbach's $\alpha = .963$). Students reported that they were genuinely interested in using the AI tutor to learn about things like sailing, seafood, maritime rituals, and coastal life. This study adds to the body of knowledge about sustainable EFL teaching using AI-enhanced QI and culturally relevant content to engage students in conversations about ocean health in English. This study has implications for how future curricula are created by demonstrating how intelligent systems can help students learn about the environment, language, and engagement through personalised, human-like AI interactions.

1 INTRODUCTION

The digital era, marked by rapid technological advancements, has significantly transformed the field of education. Recent developments in Quantum Intelligence (QI) and Robot-Assisted Language Learning (RALL) have opened new possibilities for the future of teaching English as a Foreign Language (EFL). As artificial intelligence becomes increasingly human-like, its role in supporting students' communication skills through intelligent tutoring systems (ITS) has attracted growing scholarly attention [1]. RALL has demonstrated its effectiveness in EFL contexts by providing personalised and immersive learning environments that promote independent practice, real-time feedback, and emotional engagement [2], [3].

Alongside these technological developments, sustainability education has become an essential component of 21st-century learning. By incorporating environmental themes into teaching materials - specifically the maritime environment, which encompasses local knowledge, ecological awareness, and socio-cultural narratives - educators can provide meaningful learning experiences while encouraging students to become responsible

environmental stewards and global citizens aligned with the Sustainable Development Goals (SDGs) [1]. This study integrates advanced intelligent systems with the educational potential of maritime cultural heritage to propose an innovative teaching approach grounded in technological, cultural, and ecological literacy.

Although recent research on RALL and educational robotics has expanded, significant gaps remain. First, limited attention has been given to how anthropomorphic AI or quantum-based intelligent entities can be integrated into EFL curricula that incorporate maritime-based environmental culture or sustainability themes [1]. Second, while intelligent tutoring systems have been widely applied in general education and STEM fields, their effectiveness in cross-cultural language learning - particularly through indigenous or maritime narratives and domain-specific maritime vocabulary - remains underexplored. Third, many existing EFL instructional models do not sufficiently consider social contexts, learners' needs, or geographical characteristics, such as those of Indonesia, a nation rich in marine ecosystems. This lack of contextualisation often results in reduced learner motivation and limited awareness of real-world environmental issues when language instruction relies heavily on decontextualised textual materials.

The urgency of this research is underscored by the growing demand for comprehensive digital pedagogy that integrates AI literacy, cultural sensitivity, and sustainability principles within language education [4]. Language is no longer merely a medium for communication; it also serves as a tool for describing environmental phenomena and preserving cultural identity. Therefore, developing pedagogical models that integrate these dimensions is increasingly important.

This study is grounded in the Technological Pedagogical Content Knowledge (TPACK) framework, which supports the meaningful integration of technology into teaching and learning processes [5] and facilitates the delivery of authentic learning content [6]. Furthermore, previous studies indicate that human–robot interactions can enhance learners' motivation, engagement, and retention in EFL contexts through RALL-based activities [7], particularly when learning themes focus on real-world issues such as marine conservation, ocean pollution, and environmental sustainability.

This research contributes to the design of a quantum-powered RALL instructional model that foregrounds the maritime environment - an area that remains largely unexplored in existing studies. By integrating maritime culture-based digital content into sustainability-oriented English instruction, this study examines how learners think, feel, and behave when interacting with human-like intelligent tutoring system agents.

In addition, the study provides EFL educators with a pedagogical framework for connecting global technological innovations with local cultural knowledge and environmental sustainability. The primary objective is to develop an integrated English teaching model that combines artificial intelligence, robotics, EFL pedagogy, and maritime knowledge to enhance students' communication skills. This research was conducted through a collaborative and interdisciplinary approach encompassing these interconnected domains.

2 LITERATURE REVIEW

The growth of EFL learning now includes the idea of RALL, a novel form of teaching that is part of the larger field of maximizing Artificial Intelligence In Education (AIED). RALL helps people learn a second or foreign language in an immersive, responsive, easy-to-use, motivating, and non-judgmental setting with the use of Social Interactive Robots (SIR) and Intelligent Teaching Systems (ITS). In [8] suggested that social robots can assist people learning a language by copying how people talk to each other, like by using facial expressions, gestures, and voice intonation. This keeps them motivated, interested, and engaged.

These things make virtual robots like Cici Bot or AI simulants perfect partners for learning emotional language, especially for people who are shy or not very proficient at the language. [9], [10] found that RALL helps students feel more sure of themselves when they talk to one another, retain words, and make sentences, especially in primary and secondary schools. RALL systems like NAO, Pepper, and QTrobot have worked well in bilingual classrooms in East Asia, Europe, and the Middle East [11], [12]. RALL helps students who don't hear a lot of real English conversation in EFL settings by filling in the gaps between intake, engagement, and output. They achieve this by offering them chances to talk that are almost real.

The RALL taxonomy works because it is based on Vygotsky's Zone of Proximal Development and the social constructivist learning model. This hypothesis says that the robot functions as a responsive, "more capable other", helping the learner speak in a safe and fun way. ITS-driven RALL systems can also change

the feedback they give, keep up with the learner's pace, and record how well both the teacher and the student are doing during the learning process. As a result, these systems are excellent for formative assessment in EFL [13].

Maximizing RALL with QI is a new area of study that merges quantum computing and cognitive science. It suggests a way for robots to reason that isn't linear, contextual, or based on chance. Classical AI often uses binary logic, but QI incorporates quantum superposition and entanglement to make responses that are more complicated. The complexity makes it great for hard cognitive tasks, including figuring out what someone means, clearing up confusion, and figuring out how someone feels during interventions [14]. QI systems can handle semantic ambiguity, polysemy, and imitating human-like pragmatics better than regular AI, just like they can when learning a language.

This suggests that QI could be a big step forward in fields like automatic essay grading, dialogue systems, and pronunciation training, where correctness and being aware of the situation must work together. [1] studied how a QI-enhanced robot in an EFL context made emotional responses that changed based on how the learner was feeling. The results led to increased encounters based on empathy in real life. Additionally, QI aligns with neuroscience models of brain function, which indicate that people think not only logically but also probabilistically and with situational awareness. Using it to learn a language could lead to emotionally intelligent AI tutors who can give real-time social feedback, tell stories that alter based on what the learner says, and learn from what the learner says, taking human-machine collaboration to this level.

According to [15] a localized and decolonized English Language Education (ELT) curriculum makes students motivated, offers them more control over their identities, and makes them more aware of their surroundings. Also, AI can be used to teach marine stories and symbols in other ways, including through pictures, music, role-plays, simulations, or digital games. Using nautical themes in ELT makes it more culturally relevant and open to everyone, especially in places where Western-dominated curricula have left it out in the past.

Using this kind of information with AI or robotic platforms makes learning a language fun and can get students more involved in investigating their surroundings in a real and values-based approach [16]. This helps students see themselves in the lessons and learn how to talk about the health of the marine environment in English, which is a crucial SDG skill. This study backs up the United Nations Sustainable Development Goals (SDGs), especially SDG 4 (Quality Education), SDG 13 (Climate Action), and SDG 14 (Life Below Water), which call for a way of learning that combines knowledge, skills, values, and action. One way to include maritime content in EFL lessons is to teach students how to talk about marine pollution, overfishing, and cultural traditions in English [17].

Another way is to promote values like protecting the environment, preserving heritage, and being excellent stewards. Finally, you can encourage kids to do things like make films or run AI chatbot campaigns to protect the oceans. Language is a skill that can be used to advocate for the environment. Thematic training focused on maritime environmental issues can help students share their culture with others all around the world. This is where EFL becomes a tool for global education: talk for sustainability and think globally. AIED, or artificial intelligence in education, is the future of language learning that lasts. All of these technologies - RALL, QI, and ITS are part of AIED. These technologies have changed to include things like intelligent analytics, affective computing, personalised dashboards, gamification, and training based on data. AIED helps with more than only cognitive outcomes [18].

The novelty of this study is that incorporating environmental topics, like maritime, into English Language Teaching (ELT) is a new strategy to meet local requirements and the need to safeguard the environment around the world, driven by AI. Maritime history is an excellent supply of material for listening, speaking, reading, and writing assignments. It contains sailing traditions, the lives of fishermen, folklore, navigation, and ceremonies.

Additionally, since the students are located in a maritime area, this study aligns with enhancing the quality of Education for Sustainable Development (ESD) by helping people understand the resilience of coastal areas, the functioning of biodiversity, climate ethics, and the interdependence between people and economies. For instance, in Indonesia, employing legendary sailor stories like Jokotole, Sandeq, or Larung Sesaji to educate not only helps students learn the language but also helps them understand other cultures and keeps the local maritime culture alive.

It also helps with metacognition, emotional resilience, and functioning with others. When combined with maritime themes that align with ESD, AIED systems can change to suit the needs of diverse learners based on their culture, environment, and language; predictive analytics features provide real-time feedback that is both formative and summative;

and can help students learn how to communicate in English around the world by sharing local experiences and cultural richness. Incorporating AI-based simulations, students can explore underwater landscapes, practice talking to people in a harbor, act out coastal disaster drills, or talk to AI avatars that seem like real sailors or marine biologists.

3 METHODOLOGY

3.1 Research Design

This study uses a quantitative research method with a pre-experimental design. This research design uses a pre-test and post-test of one group to see if combining Robot-Assisted Language Learning (RALL) and Intelligent Tutoring Systems (ITS) can help students improve their English as Foreign Language (EFL) communication skills with a focus on environmental and maritime sustainability. We chose this strategy so that we could see measurable learning improvements before and after therapy using a structured instruction series without a control group (Creswell & Creswell, 2018).

3.2 Participants

The participants in this study were 24 junior high school students, aged 12–13, who had taken basic EFL classes and demonstrated that they could use AI-based teaching tools effectively. We selected them through purposive sampling, using the following criteria:

1) All students can understand and operate AI applications such as ChatGPT, Cicibot, or other ITS bots.
2) Basic understanding of the Indonesian maritime environment and culture and environmental challenges.
3) Willingness to take a RALL course focusing on sustainable maritime communication.

3.3 Research Instruments

Observation and structured questionnaires were the main research tools used in this study. The survey was made to assess students' communication skills, motivation to learn, and feelings about their learning experience with RALL and ITS. The questionnaire used a 5-point Likert scale with Strongly Disagree (1) on one side and Strongly Agree (5) on the other. Language education specialists reviewed the questionnaire, and it was based on previous research on the use of AI to help people learn practical EFL [3].

The survey instrument consisted of a structured 20-item questionnaire designed to evaluate five core dimensions:

1) utilization of English-language instructional materials related to marine themes;
2) system interoperability and functional efficacy of the Intelligent Tutoring System (ITS);
3) self-perceived progress in oral communication competencies (speaking and listening);
4) cross-cultural awareness and environmental consciousness;
5) learner satisfaction with AI-integrated pedagogical approaches.

3.4 Research Procedure

This study uses marine sustainability as the main topic. This study uses quantitative data to determine how much interest, awareness, and readiness of students to learn English through RALL and QI technology.

Prepare the instrument by designing a systematic questionnaire based on the following theoretical frameworks:

1) RALL and how well it works in EFL [7];

2) QI in customized learning [1] talk about ESD. In this questionnaire, there are 20 closed questions, and each has a 5-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (5).

The questions are intended to cover four areas:

1) wanting to learn English with the help of AI and robots;

2) knowledge and interest in maritime and environmental issues;

3) benefits of using AI-based tutoring solutions;

4) using RALL and QI in classroom activities.

Two professionals in language education checked the instrument to ensure it was clear, reliable, and consistent (Cronbach's Alpha > 0.80). Then, the instrument was tested on 10 students.

This study used purposive sampling; we selected participants. They were in high school and met the following requirements:

1) had a basic level of English (A2–B1);

2) had used AI tools before, such as ChatGPT, Replika, Grammarly, or Duolingo;

3) were in an EFL class that included lessons about the environment or the ocean.

The data collection process consisted of four systematic steps to ensure comprehensive participation and data integrity.

3.4.1 Step 1: Informing Participants

Students were informed about the study, which was to find out how interested they were in learning English with the help of an AI robot and a smart tutoring system using ocean and sustainability subjects. People could choose to participate, and their information was kept confidential.

3.4.2 Step 2: Giving the Questionnaire

Teacher delivered the questionnaire via Google Forms, enabling people to easily complete it from any location. During the scheduled class time, students had 20 to 30 minutes to complete the survey. The teacher or research assistant supervised the process to help troubleshoot any technical difficulties that arose.

3.4.3 Step 3: Monitor Responses

Teacher used a WhatsApp group and follow-up emails to remind people to respond and ensure the accuracy of the data. All responses were immediately saved and recorded in a safe place.

3.4.4 Step 4: Organizing and Analyzing the Data

After receiving all responses, we transferred the data from Google Forms to SPSS version 26. The study included descriptive statistics such as means, frequencies, and standard deviations to see what people were generally interested in and what the trends were. This study also used cross-tabulations to examine the correlation between people's interest and their prior use of AI tools. Additional open-ended responses were classified thematically to provide more qualitative information. The school provided its ethical clearance. All subjects gave informed consent. We informed the students that their participation in the study would not impact their grades or standing at school.

3.5 Data Analysis

The data analysis for this study is based on a survey conducted through a questionnaire analyzed using SPSS version 26. We used descriptive statistics, such as the mean and standard deviation, to get an overview of how students feel about the learning model as a whole. We used a paired sample t-test to find out if there is a significant difference in how well students can communicate in English before and after the treatment. The level of significance was set at $p < 0.05$.

Cronbach's alpha was used to check how reliable the questionnaire, if the results above 0.80 indicate that the tool is very reliable.

4 RESULTS

Based on the data from Table 1 below the data statistical results show optimism about the potential of QI and RALL through maritime for communication activities in EFL classroom.

There are several statements supported maritime conversation, such as talking about sailing (M = 3.46), introducing Indonesian boats (M = 3.46), or interviewing fishermen (M = 3.46), also indicating that students are quite interested in communicating their language skills in this area. This activity makes students act as if they are solving real-world problems, which activates quantum skills such as adaptive thinking, contextual awareness, and empathetic communication.

Respondents expressed their support for having a dialogue about marine weather (M = 3.13) or reading a maritime poem (M = 3.21). This could mean that focused tasks with real-life interactions or visual aids can improve communication skills. This shows how important AI-based simulations or gamification are to keep people engaged [19].

According to the information in Table 1 and Table 2, QI aims to encourage students to be aware of their thinking when faced with tough or confusing situations by using the RALL-based learning model and providing support through an intelligent tutoring system, allowing them to interact with knowledge that has various meanings in a flexible and adaptable learning process.

The data in Table 3 with the interpretation of the findings shown by the data on QI and RALL and how both can help students improve their English as Foreign Language (EFL) communication skills, especially in the context of maritime and sustainability education.

The results of checking the reliability of the questionnaire, consisting of 20 items, have a Cronbach's Alpha rating of 0.963, indicating that the questionnaire is very reliable and consistent in it. A reliability coefficient above 0.9 is "very good". This means that the tool is very consistent in measuring students' feelings about English learning with QI and RALL technology. Alpha values above 0.90 are very good category and they indicate that the items measure the same basic ideas.

Then the data results shown in Figure 1 show data from the histogram visualization, showing that the scores are quite evenly distributed, with an average of

67.75, indicating that the scores are close to normal. The bell-shaped curve is very close to the bar, meaning there is no large skew.

In addition, the P–P plot of the mean values shows that the data points are close to the diagonal line. This means that the residual distribution is close to a normal distribution.

Table 1: Descriptive statistics of QI and RALL for communication.

4	N	Min	Max	Mean	SD
1) I want to learn to speak English based on RALL with the topic of fishermen's lives.	24	1.00	5.00	3.3750	1.13492
2) I want to practice making dialogues about sailing using AI in English learning.	24	1.00	5.00	3.4583	1.17877
3) I am interested in using AI to help me tell a story in English that has a maritime theme.	24	1.00	5.00	3.2083	1.28466
4) 4.I want to practice introducing types of Indonesian fishing boats in English, based on RALL.	24	1.00	5.00	3.4583	1.28466
5) I want to discuss in English the living habits of coastal communities based on RALL.	24	1.00	5.00	3.7500	1.22474
6) I want to practice promoting maritime cultural rituals such as *"Mappandesasi"* (feeding the sea) and *Kenduri Laut* (prayer of safety) with the help of RALL.	24	1.00	5.00	3.5833	1.17646
7) I want to make a presentation about maritime cultural festivals in Indonesia in English to practice QI skills.	24	1.00	5.00	3.3750	1.27901
8) I want to practice describing beaches, seas, and ports using AI.	23	1.00	5.00	3.6087	1.19617
9) I am interested in practicing making an AI-assisted vlog about local sailing traditions.	24	1.00	5.00	3.2917	1.45898
10) I want to create a coastal cultural tourism brochure based on RALL.	24	1.00	5.00	3.3333	1.23945
11) I am interested in practicing speaking about food and typical marine products with the RALL model.	24	1.00	5.00	3.9167	1.10007
12) I want to play a role in presenting the maritime environment based on RALL.	24	2.00	5.00	3.2083	1.06237
13) I want to create a simulation video that showcases the activities of local sailors, based on RALL.	24	1.00	5.00	3.2917	1.16018
14) I want to have a dialogue about changes in sea weather and shipping safety based on RALL.	24	1.00	5.00	3.1250	1.07592
15) I am interested in reading maritime poetry and presenting it with a RALL-based learning model.	24	1.00	5.00	3.2083	1.35066
16) 16. I want to practice discussions about marine ecosystems and their preservation based on RALL.	24	1.00	5.00	3.3333	1.09014
17) I am keen to learn shipping vocabulary in English using AI.	22	1.00	5.00	3.5000	1.43925
18) I am interested in practicing interviewing fisherman figures in an English class simulation based on RALL.	24	1.00	5.00	3.4583	1.06237
19) I want to practice making shipping or weather announcements in English with the help of AI.	24	1.00	5.00	3.1667	1.20386
20) I find it easier to understand maritime communication topics with learning models RALL.	24	1.00	5.00	3.5417	1.14129
Valid N (listwise)	21				

Table 2: The QI and RALL implication in EFL.

Item	Description	Mean	Implication
12	Speaking about marine food products with RALL	3.92	Reflects high cultural-linguistic engagement and practical value.
5	Discussing coastal community habits via RALL	3.75	Indicates student interest in real-world socio-cultural applications.
8	Describing seascapes using AI	3.61	Supports multimodal intelligence (visual + verbal).
6	Promoting cultural maritime rituals	3.58	Aligns with QI's spiritual-cultural axis.
20	Understanding maritime communication through RALL	3.54	Suggests pedagogical clarity of AI/RALL tools.

Table 3: Reliability statistics.

Cronbach's Alpha	N of Items
.963	20

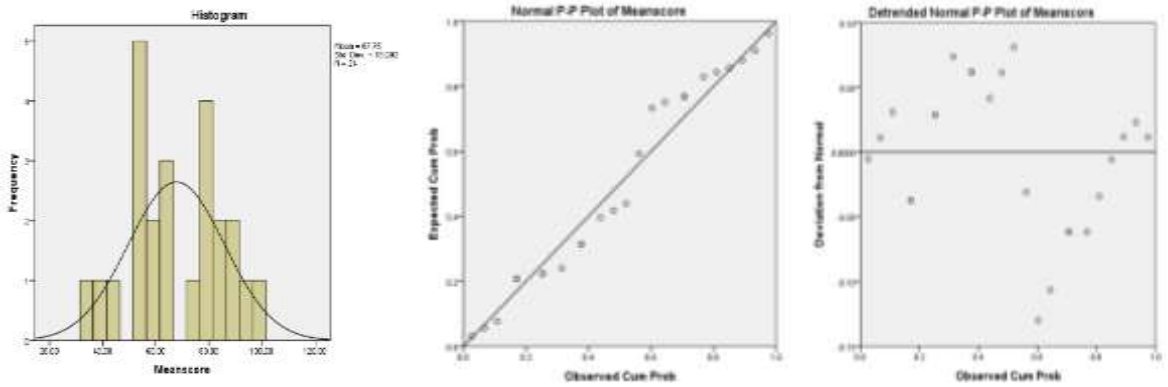

Figure 1: Histogram and normal P-Plot of Qi and Rall in Efl maritime content.

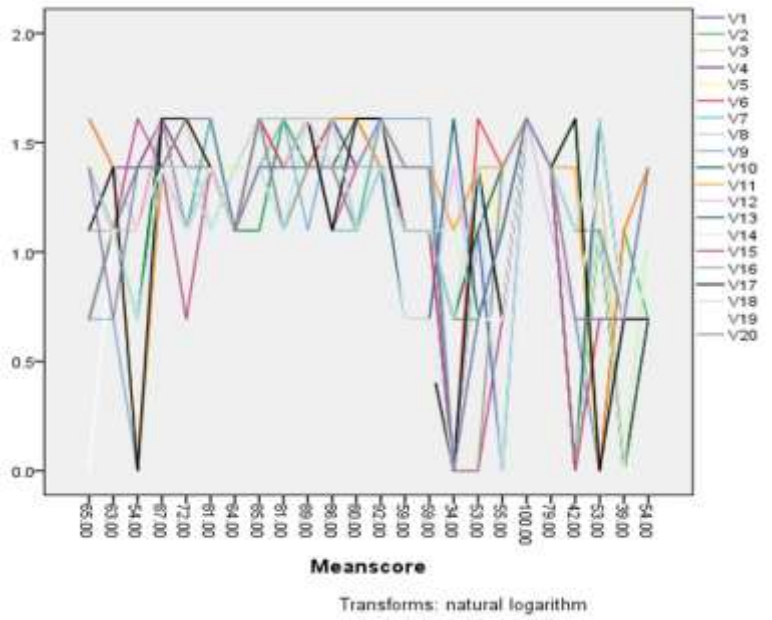

Figure 2: Logarithm.

The line chart depicting the 20 questionnaire items after transformation (natural logarithm) shows that the values change from item to item (V1–V20) on Figure 2. This difference shows how different students' interests, comfort, and desires are to use RALL technology to communicate. On the other hand, the general trend remains the same, meaning that people are still interested in things like AI tutor interaction, understanding maritime vocabulary, talking about maintaining ocean health, and how to use technology to teach people about the environment.

By combination of AI and QI through RALL-based AI can improve language modelling, student learn new words, and get feedback on how to pronounce words (cognitive augmentation). In addition, AI-driven emotional and spiritual stimulation allows students to experience culturally rich places, which is an important part of QI. The RALL learning model can also help students think

about their own thinking, which is an important part of QI, by letting them see how well they are using language through robotic feedback in line with [7] investigation.

This study support the curriculum designers with marine environmental materials should focus on hands-on, project-based marine materials, where students create media such as vlogs and brochures assisted by AI. Therefore, the concept of quantum pedagogy should be part of teacher training so that teachers can help students deal with the emotional and cultural aspects of learning. Tables 1 and 2 show that students showed their interest and enjoyed using AI tools and RALL. In addition, the content of learning English through maritime content is a sustainable learning need.

In line with the findings, this study introduces a novel approach to exploring adaptive systems, including quantum technologies such as customized bots, intelligent feedback, and semantic commands, aimed at helping EFL students learn languages in a practical manner. This is in line with what current research says about how QI and embodied AI agents can help people learn languages. QI is not only computational but also context-sensitive and adaptable, allowing bots to respond to what learners say in meaningful and changing ways similar to the findings [1].

The RALL based learning model allows junior high school students to learn languages in a way that is tailored to the needs of students because it is designed with materials that have interactive dialogue simulations and get immediate feedback, all of which are important for becoming better communicators, similar to research [20], [21] and in line with the investigation [22], which claims that ITS systems incorporating QI, such as ChatGPT or AI tutors, mimic real world conversations, which helps people who are nervous about speaking and helps them practice their language skills in low risk situations.

In addition, incorporating the theme of maritime sustainability gives the content more meaning and cultural relevance, which encourages people to engage more. [23] said that "the local cultural context embedded in language learning stimulates learner motivation and global literacy."

This study shows that junior high school students expressed their learning needs positively when using QI and RALL in EFL lesson, particularly when these lessons were presented through stories about marine sustainability. The results of this study have implications for creating intelligent, localized, and culturally rich EFL curriculum that use modern AI techniques to improve communication skills and ecological literacy is a good way to teach.

5 CONCLUSIONS

This study looked at the data and observed how students expressed their EFL learning needs. It was found that students needed to learn EFL using QI and RALL as a good way to help learners improve their communication skills and ecological awareness, especially when the lesson was about maritime sustainability. The results of the data based on the needs analysis indicated that students were more interested and excited when they worked with the ITS bot, did AI-assisted language challenges, and talked about real-world marine topics. The RALL approach not only helped junior high school students learn the language but also taught them principles such as protecting the environment and being proud of their culture.

The results of this study have a significant impact on curriculum makers and policy makers. The study suggests that language learning with AI should include environmental themes and quantum adaptive feedback systems. Teachers and schools can consider using QI-based ITS systems in language classes to help students improve their cognitive, emotional, and intercultural skills.

Therefore, it is hoped that longitudinal studies can see the long-term impact of RALL with QI on language retention and social and emotional learning in the future. In addition, more robust AI-based simulations, virtual reality environments, or multilingual bot systems could make maritime scenarios more flexible and realistic. Furthermore, the study suggests that improved teacher training programs should include the idea of quantum pedagogy so that teachers can teach languages in a technologically enabled, environmentally friendly, and culturally based manner.

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