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English Education Using Robots for Effective Collaborative Language Learning

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In this study, we aim to investigate the impact of robotics on students' language learning and collaboration in college English education. Utilizing a quantitative research design, we collected data from 121 students through surveys, and the perceived usefulness, engagement, collaboration, and language learning of robotics were assessed. The participants' scores were 3.6512 on average for perceived usefulness and relevance and 3.7537 for collaborative learning with robots. The regression model indicated that engagement and motivation influenced perceived usefulness significantly ($B = 0.321$, $p < 0.001$). The results of this study indicated that robotics positively influenced language learning acquisition and fostered student collaboration in class. Robotics integrated into language education led to increased educational outcomes and ensured the effectiveness of robot-assisted language learning (RALL) in higher education. The results also provide important information for understanding and verifying the role of robotics in language education. Therefore, educators need to adopt innovative technology such as robotics to increase students' engagement in learning to enhance their English proficiency.

1. Introduction

The application of robots in education has attracted significant attention, especially in language education. Using robots in teaching enhances the language learning and collaborative learning of students.(1) Interactive robots in the classroom facilitate active learning in language learning processes as they motivate student participation. Using robotics in education allows students to have personalized learning experiences and to practice language skills to gain higher proficiency and confidence.(2) Robots in the classroom also boost social interactions between students, thereby enabling collaborative learning, which is crucial for language development. Sensor-driven learning using robots is regarded to be effective in language education as it provides immersive and interactive learning experiences. Sensor data collected by a robot is used to monitor student engagement and participation in learning activities (Fig. 1).(3) Sensor-driven learning environments provided by robots promote language learning through

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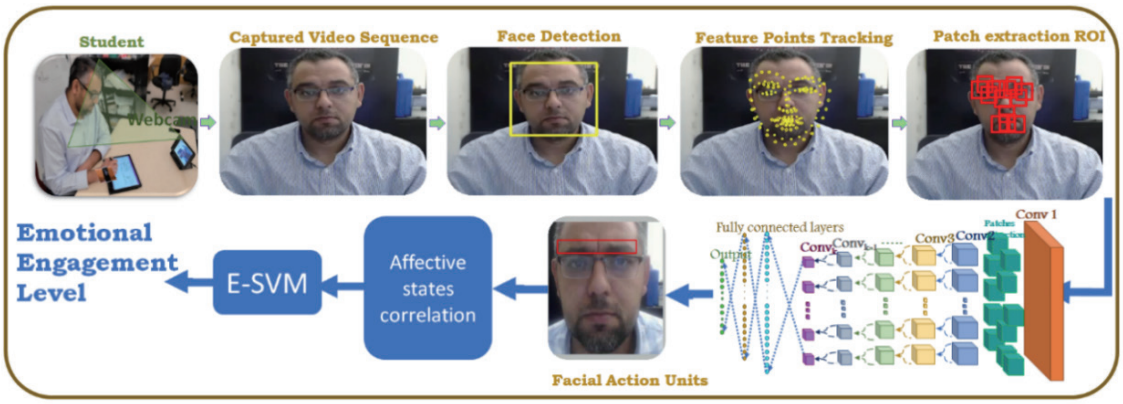

Fig. 1. (Color online) Emotional detection using sensors utilized in education.

collaborative activities such as peer-to-peer communication, and robots are an effective tool in language education as they enable personalized learning.

The results of previous research on robots in education have indicated how robotics affected student engagement and outcomes of English learning. While robots are widely utilized across various industries, their availability and implementation in education need to be further validated. Nevertheless, there is limited research on the advantages and disadvantages of using robots in higher education, and not many educators are convinced about the effectiveness of robotics in teaching because of their unreliable performance.[4] In addition, the potential of robots in collaborative learning has not been explored extensively, although it has been proved that robots enable collective learning and efficient communication.[5] Therefore, it is necessary to investigate how robots foster collaborative learning in language education and develop effective teaching strategies with robots to enhance learning outcomes.

Therefore, this study was carried out to analyze the impact of robots on language learning and collaborative learning in college English education. We explored how robot-integrated learning influenced the enhancement of vocabulary development, grammar acquisition, and communicative competencies. The results of this study can be used to investigate individual differences in learning motivation and outcomes when robots are utilized in language education.

2. Materials and Methods

We explored the effect of robots on students' language learning and collaborative learning in college English education. Data were collected and analyzed through regression and correlation analysis to explore the relationships among robot application, language proficiency, and collaborative learning. We conducted questionnaire surveys before and after the implementation of robots to assess the effectiveness of using robots. Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS).

2.1 Participants

We recruited 121 participants from English education departments in one college that had implemented robot-assisted learning programs. The participants were undergraduate students from freshmen to seniors (from 18 to 24 years old) who took English courses using robots. Their demographic information, including age, gender, major, and prior experience with using robots or technology-enhanced learning environments, was gathered. In recruiting participants, we considered their different backgrounds and experiences to ensure sample diversity. Faculty members teaching English courses with robots were interviewed to refine the questionnaire.

2.2 Data collection

Participants were surveyed before and after using robots in English learning. The robots used in this study were Kebbi Air (Nuwa Robotics, Taiwan) and Sophia (Hanson Robotics, Shenzhen, China). The two robots were selected considering their capability, ease of maintenance, and adaptability to college-level English instruction. Kebbi Air is an expressive educational robot that supports learning in science and engineering through interactive storytelling, facial recognition, and voice-based communication. It helps students code and practice languages, adapting its responses to each learner's pace and style. Its playful design and customizable content engage young students in classrooms. Teachers can program lessons and activities, while children benefit from a friendly, animated companion that makes learning fun and approachable.[6] Sophia is a humanoid robot that performs natural conversation and emotional engagement. It uses AI to simulate human-like expressions and dialogue, which is effective for language learning and social emotional development. Sophia's cloud-based intelligence allows it to update its knowledge in diverse topics. The robot helps students build confidence in communication and fosters curiosity about robotics and artificial intelligence.[7]

The participants recruited in this study were majoring in English-related subjects at one college in Jiangsu province. Surveys were conducted to assess language learning, student engagement, and collaborative learning. A five-point Likert scale was employed in the questionnaire survey. A standardized language proficiency assessment was also conducted to estimate students' language skill improvement before and after using robots. The assessments were carried out to assess vocabulary acquisition, grammar usage, and communicative competence. The survey data and the proficiency assessment results were analyzed to explore the changes in student outcomes owing to the use of robots.

2.3 Data analysis

The collected data were analyzed to obtain descriptive statistics, and regression and correlation analyses were conducted using the data. The descriptive statistics included the participants' demographics, language proficiency, and engagement levels. The relationships among the frequency of activities with robots, student engagement, and language proficiency were explored to understand how robots supported language learning outcomes and identify the

significant predictors of language learning. Correlation analysis was conducted to investigate the relationship between collaborative learning and English proficiency improvement when using robots in English learning. The effect of collaborative learning was also assessed for language skill acquisition.

3. Robots on Language Learning

The integration of robots in language education fosters language learning as it helps students increase grammatical understanding and vocabulary acquisition.[8] Robot-assisted language learning (RALL) enables interactive and engaged learning for effective language acquisition.[9] For instance, students' interactions with robots improve grammatical skills through imitation and practice (Fig. 2). Robots act as teachers and peers, and help students immerse themselves in dialogue to deepen the understanding of grammatical structures. Students learn language rules and improve their language proficiency with robots. Robots in language education also support enhancing students' vocabulary acquisition. For example, the robot tailors the interaction with students in accordance with their proficiency levels by personalizing linguistic input.[10] With such adaptive teaching, students remain engaged and challenged in learning. Students demonstrated effective vocabulary acquisition when robots used language at their level. This flexible interaction shows the significance of personalized learning to foster language learning.[10]

Robots increase students' motivation and engagement levels in language learning. Robots in the classroom help create a dynamic learning environment that keeps students engaged in learning. Students interacting with robots showed elevated motivation and willingness to learn and focus on materials (Fig. 3). The robot's assistance increases interaction with students, which significantly motivates them. When students are more engaged, they become more motivated to practice their language skills, leading to significant improvement. Therefore, interaction with robots is essential in enhancing the outcomes of language learning in RALL.

Linguistic knowledge is absorbed differently depending on the type of interaction, whether explicit or implicit. Explicit instruction is not always the best way to teach a language, while implicit teaching by learning through exposure and practice deepens the understanding and retention of grammatical structures. Students effectively learn language when engaged in

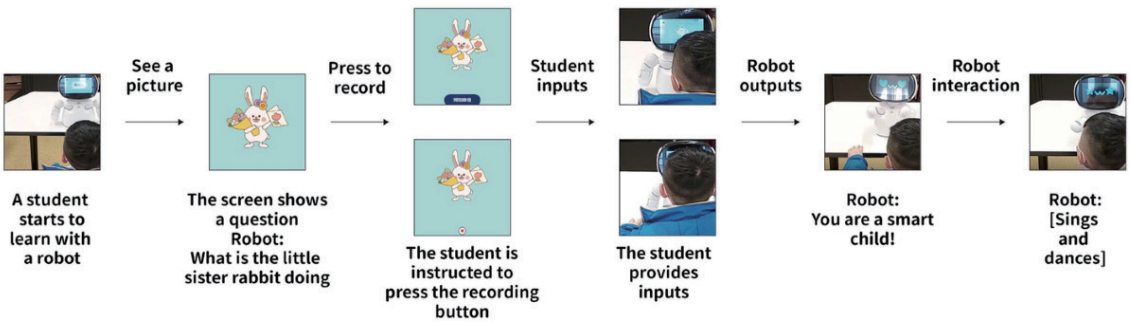

Fig. 2. (Color online) Interaction of English teaching robot Minibo with student.

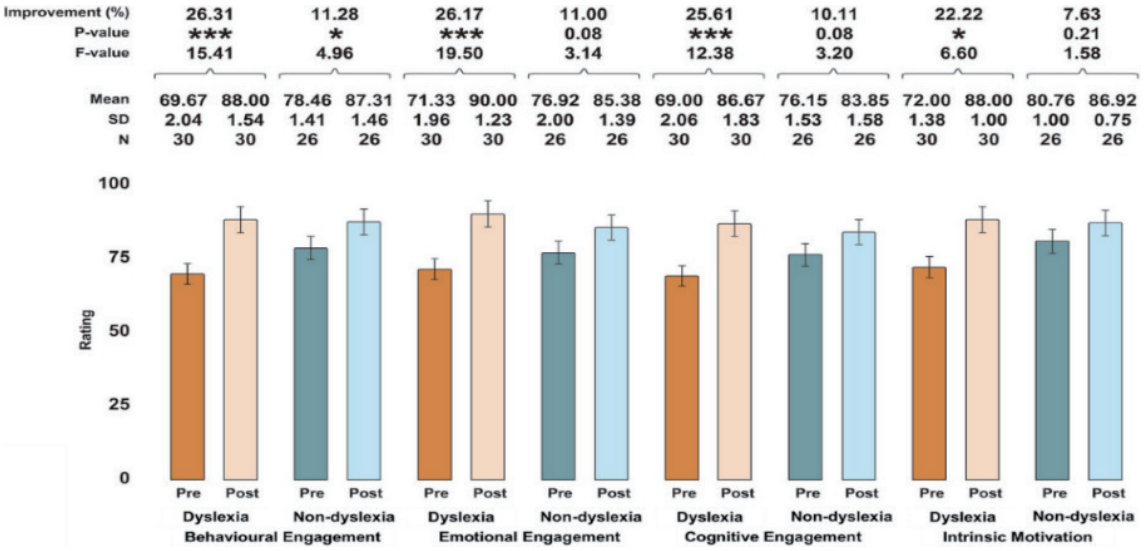

Fig. 3. (Color online) Analysis of variance (ANOVA) results of using Kebbi for engagement and motivation in learning language.

conversation with robots without being overtly corrected for mistakes. Robots foster a supportive learning environment by reducing students' fear of making mistakes and encouraging language experimentation.[11] The emotional bond of robots with students also increases the effectiveness of RALL. Students perceive robots as friendly and approachable, making them more inclined to engage in conversation and practice their language skills.[12] Positive responses of students to robots are essential in language learning. As students become less anxious about interacting with robots, they are more motivated to practice their language skills, which advances their language proficiency.

4. Robots in Collaborative Learning

Robots have been integrated into language education, contributing to collaborative learning. They enhance peer interaction, teamwork, and communication skills, which are essential for effective language acquisition. Robots encourage student participation in collaborative assignments. Students supported by robots tend to be more motivated and engaged in group tasks than those in traditional learning environments.[13] Robots in language education support interpersonal communication skills and dynamic, interactive experiences. Unlike conventional digital tools such as language learning apps, multimedia content, and digital storytelling tools, robots offer human-like interactions through gestures and facial expressions, which increases student engagement and idea sharing.[14] Additionally, the spontaneous feedback provided by robots enables real-time language practice, which enhances learning effectiveness (Fig. 4).

Language learning is often impeded by student anxiety, particularly in groups. Robots mitigate such anxiety by creating a comfortable and supportive learning environment. They are considered essential for language skill development, as they foster a sense of belonging and

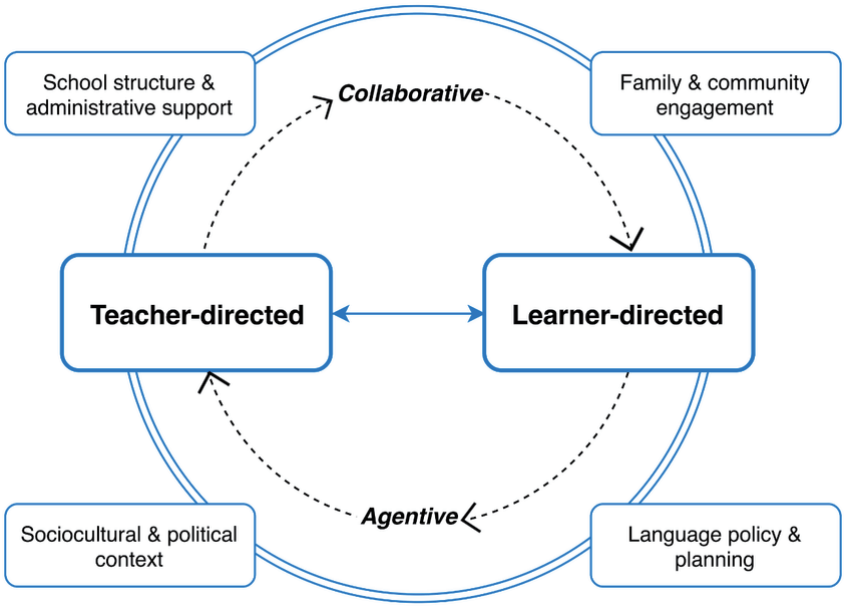

Fig. 4. (Color online) Collaborative learning process with robots.

collaboration among students.[15] Moreover, robots encourage students to use diverse linguistic forms in their native language, thereby cultivating an inclusive learning environment for the sustained progress of students' language proficiency.

5. Robots in Teaching

Robots in language education have transformed language education through RALL. Robots are used for interactive and engaging learning because of their social interaction and language learning supporting capabilities. Robots can be used as tutors that offer personalized feedback and adjust their interaction depending on the language levels of students. In language education, students possess different proficiency levels and learning styles, which must be reflected in the adaptability of robots. Teachers use robots to adapt to the different levels of language proficiency to provide personalized instruction in an inclusive learning environment.

The robot's speaking styles influence students' learning effectiveness. When instructed by the robot's charismatic voice, students used more accurate language than in cases without such instructions.[16] This confirmed the effectiveness of the robot's teaching practices and the importance of the engagement of instructors to enhance learning motivation and learning outcomes.

Robots are capable of translanguaging, which enables students to use their mother tongue and secondary language at the same time for efficient learning.[17] Such an ability is critical in multilingual teaching as students comfortably use two languages. By using students' mother tongues in learning a language, an inclusive environment is created for effective language development and maintaining cultural identity. The multimodal capabilities of robots, such as

speech recognition, gesture production, and emotional expression, facilitate dynamic and relatable interactions with students. Gestures are used to emphasize verbal instructions by providing visual cues to enhance students' comprehension. It is especially effective in language learning as visual cues assist students in clarifying the meanings of instructions. The multimodal capabilities of robots in the teaching process maximize student engagement and learning outcomes.

Amid the advancements of RALL, teachers need to be trained to effectively use robots in the present curriculum and utilize the advantages of robots in language education. However, using robots in language education has been limited owing to the challenges of integrating them into the educational process. Technical difficulties hinder the implementation of RALL in classrooms.[12] Teachers and students must be trained to use technologies effectively.

Therefore, it is necessary to improve the applicability of robots and to explore how to apply them to language education and overcome existing barriers. Teachers need to be adequately trained to integrate robots into teaching, as many teachers do not have the skills needed to effectively apply robots to collaborative learning.[18] Therefore, professional development programs are mandated for teachers to maximize their utilization of robots in language education.[19] Additionally, an appropriate investment must be made to introduce robots and necessary peripherals into classrooms. Resource allocation or infrastructure requirements must be ensured to deploy robots. The successful implementation of RALL can be supported through collaborative partnerships between educational institutions and technology developers through appropriate funding and resource sharing.

6. Results

In this study, 121 participants scored the effect of robots on language learning and collaborative learning. The mean score for "Perceived Usefulness and Relevance" was 3.6512 [2.00 to 4.80, standard deviation (*SD*) = 0.54070], implying that participants considered robots to be useful in language learning. "Collaboration and Teamwork" scored 3.7537 (*SD* = 0.50383), indicating that participants believed that robots were collaborative in learning (see Table 1). The mean score for "Engagement and Motivation" with robots was 3.2132 (*SD* = 0.53773), which suggested a moderate level of "Engagement and Motivation" of the participants with robots. "Perceived Impact on Language Learning" scored 3.6579 on average (*SD* = 0.81381), indicating students' acceptance of robots in language learning. "Challenge and Frustration" scored 3.9504 (*SD* = 0.46352), indicating that participants encountered challenges when integrating robots but perceived them as manageable. The descriptive statistics presented a favorable opinion of the participants regarding robot usage to improve their language ability and encourage collaborative learning.

The regression analysis results depicted the relationships between the independent variables "Collaboration and Teamwork", "Challenge and Frustration", "Engagement and Motivation", and "Perceived Impact on Language Learning", and the dependent variable "Perceived Usefulness and Relevance". For the regression model, R was 0.479 and R^2 was 0.230, which indicated that the independent variables collectively explained 23.0% of the variance in Perceived Usefulness and Relevance with a standard error (*SE*) of 0.48267 (see Table 2).

Table 1
Descriptive statistics of questionnaire survey results.

	N	Minimum	Maximum	Mean	*SD*
Perceived usefulness and relevance	121	2.00	4.80	3.6512	0.54070
Collaboration and teamwork	121	2.40	4.80	3.7537	0.50383
Engagement and motivation	121	2.20	4.60	3.2132	0.53773
Perceived impact on language learning	121	1.40	4.80	3.6579	0.81381
Challenge and frustration	121	2.40	4.60	3.9504	0.46352
Valid *N* (listwise)	121				

Table 2
Regression model summary.

R	R^2	Adjusted R^2	Standard error of estimate (STE)
0.479[a]	0.230	0.203	0.48267

"[a]" represents the "dependent variable" explained by the *R* value.

Table 3 presents ANOVA results of the significance of the regression model for predicting "Perceived Usefulness and Relevance" against the independent variables. At a significance level of 0.001, the regression model had an *F* statistic of 8.646. This indicated that at least one predictor variable explained the variation of "Perceived Usefulness and Relevance".

Table 4 lists the details of the correlation analysis result, including the effect of each independent variable on "Perceived Usefulness and Relevance". The statistics $B = 2.353$ ($p < 0.001$) indicated that the participants acknowledged the perceived usefulness and relevance of robots in English language learning, regardless of their scores, and a high level of engagement was closely related to the high perceived usefulness of robots. "Collaboration and Teamwork" played a positive role in improving students' perceptions of robots ($B = 0.210$, $p = 0.026$). "Perceived Usefulness and Relevance" showed a negative relationship with "Perceived Impact on Language Learning" ($B = -0.301$, $p < .001$).

"Challenge and Frustration" was positively correlated with "Perceived Impact on Language Learning" ($r = 0.414$, $p < 0.001$). A high level of perceived challenges in using robots was associated with a greater "Perceived Impact on Language Learning". "Perceived Impacts on Language Learning" ($r = 0.328$, $p < 0.001$) and "Perceived Usefulness and Relevance" ($r = 0.236$, $p = 0.009$) showed positive correlations with "Engagement and Motivation", which showed that the more engaged users were, the better they perceived the usefulness of robots in language learning. A significant positive relationship was observed for "Collaboration and Teamwork" with "Engagement and Motivation" ($r = 0.322$, $p < 0.001$) and with "Perceived Usefulness and Relevance" ($r = 0.207$, $p = 0.023$) (Table 5). This result confirms the interrelationship of collaborative learning, motivation, perceived outcomes, and learning engagement in language learning with robots.

Learning outcomes before and after using robots in learning are presented in Table 6. The average score before using robots ranged from 2.5 to 3.2, indicating moderately low scores. After using robots, a significant improvement was observed with scores ranging from 4.2 to 4.6. The scores of speaking fluency and vocabulary acquisition were increased by 1.7, showing the most notable increase. Such improvements demonstrated that robots effectively assisted students

Table 3
ANOVA results.

Term	Sum of squares	Degree of freedom	Squared mean	*F*	Significance level
Regression	8.057	4	2.014	8.646	0.000[b]
Residual	27.025	116	0.233		
Total	35.082	120			

"[b]" represents the independent variables.

Table 4
Correlation analysis result.

Model	Unstandardized coefficients		Standardized coefficient	*t*	Significance level
	B	Standard error	Beta		
(Constant)	2.353	0.509		4.620	0.000
Challenge and frustration	0.147	0.103	0.126	1.433	0.155
Perceived impact on language learning	−0.301	0.063	−0.453	−4.813	0.000
Engagement and motivation	0.321	0.091	0.319	3.531	0.001
Collaboration and teamwork	0.210	0.093	0.195	2.255	0.026

[a]Dependent variable: "Perceived Usefulness and Relevance"
"[a]" stands for dependent/outcome variable used in this regression model.

Table 5
Correlation analysis result.

		Challenge and frustration	Perceived impact on language learning	Engagement and motivation	Collaboration and teamwork	Perceived usefulness and relevance
Challenge and frustration	Correlation coefficient	1.000	0.414**	0.067	0.081	−0.074
	Significance (2-tailed)	—	0.000	0.463	0.377	0.421
	N	121	121	121	121	121
Perceived impact on language learning	Correlation coefficient	0.414**	1.000	0.328**	0.273**	−0.214*
	Significance (2-tailed)	0.000	—	.000	0.002	0.018
	N	121	121	121	121	121
Engagement and motivation	Correlation coefficient	0.067	0.328**	1.000	0.360**	0.213*
	Significance (2-tailed)	0.463	0.000	—	.000	0.019
	N	121	121	121	121	121
Collaboration and teamwork	Correlation coefficient	0.081	0.273**	0.360**	1.000	0.140
	Significance (2-tailed)	0.377	0.002	0.000	—	0.125
	N	121	121	121	121	121
Perceived usefulness and relevance	Correlation coefficient	−0.074	−0.214*	0.213*	0.140	1.000
	Significance (2-tailed)	0.421	0.018	0.019	0.125	—
	N	121	121	121	121	121

Table 6
Assessment of language learning outcomes before and after using robots.

Criteria	Before using robots	After using robots	Improvement in score after using robots
Vocabulary acquisition	2.5	4.2	1.7
Grammar comprehension	3	4.1	1.1
Speaking fluency	2.8	4.5	1.7
Listening comprehension	3.2	4.3	1.1
Collaborative skills	3	4.6	1.6
Engagement level	2.9	4.4	1.5
Overall language proficiency	3.1	4.5	1.4

in improving their language learning. The language proficiency score increased to 4.5, indicating the positive influence of robots on the participants' language skill improvement and collaborative learning. Using robots in language learning was not effective for engaging participants in vocabulary acquisition, speaking fluency, or collaborative skills. The overall language proficiency score was 3.1, which indicates the necessity of a teaching strategy to facilitate language development.

7. Discussion

The impact of robots on language learning and collaborative learning was assessed through questionnaire surveys and statistical analysis of the data. The overall mean score of the items in the questionnaire survey after using robots in English learning was 3.6512, which was evidence that robots improved language learning. This result aligned with the previous study result,[9] which indicated that robots functioned as facilitators in language education. Students showed a positive perception of the usefulness of robots and realized the benefits of robots in their learning. Such results indicated that students acknowledged personalized feedback and adaptive learning experiences provided by robots.

Enhanced language learning ability with robots was proved by a strong positive correlation between "Engagement and Motivation" and "Perceived Usefulness and Relevance". Similar results were presented by Fung *et al*.,[20] who observed increased engagement and language skills with robots. When students were engaged in robot-associated learning activities, they were more likely to be motivated and to engage in the activities. The enhanced student engagement was linked to increased language learning ability, especially in an interactive learning environment with robots. Collaborative learning significantly influenced language learning outcomes in this study. "Collaboration and Teamwork" with robots scored 3.7537, which suggested that students were satisfied with the role of robots as facilitators of collaborative learning. Ružić and Balaban also found that robots assisted students in improving peer interactions and teamwork, which led to improved communication skills.[21] Learning activities with robots enhanced language skills and developed essential socio-interpersonal skills in students. Conversations of students with robots contributed to fruitful language practices.

"Engagement and Motivation" had a significant relationship with "Perceived Usefulness and Relevance." Students with higher levels of engagement tended to perceive the usefulness of robots in English learning. This result emphasized the importance of motivation in language learning. Robots helped to reduce the anxiety of students when speaking through conversational interaction with a robot, which enabled students to practice more extensively. Students engaged in robot-associated learning felt that using robots in learning was relevant and useful for their language development. "Challenge and Frustration" was shown by students when using robots. While there are still challenges in using robots as a learning tool, robots have shown great potential in language learning.[22]

Training and support for teachers are mandated to facilitate more integration of robots in language education, while addressing technological issues related to the speech recognition and speech synthesis of robots. Inaccurate feedback and instruction of robots hinder the enhancement

of learning outcomes. Response time delay also impedes effective interaction, preventing students from actively engaging in learning. To avoid such problems, the accuracy and responsiveness of robots need to be improved using AI and machine learning (ML).

Appropriate teaching strategies must be formulated considering students' traits and preferences. While adult learners require different pedagogical interventions from those for younger learners, self-learning and critical thinking are also essential for effective learning.[23] However, existing RALL does not meet such needs. Therefore, it is essential to modify RALL to allow it to be flexible and relevant to real-life applications.

Robots might distract students in class, but enhance their engagement in learning.[18] It is necessary to develop teaching strategies when using robots to prevent unnecessary interruptions and ensure language learning ability. To develop such strategy, teachers need to be trained in the necessary skills and knowledge to implement robots successfully.

Further research is required to identify the pedagogical methods of adopting robots in language learning. The methods can be developed especially to tailor them to adult students' cognitive styles and preferences, and their collaborative learning. RALL that meets individual needs can improve the overall effectiveness of using robots for language learning. To solve these issues, language teaching institutions and technology developers must collaborate to determine the role and significance of 'technological advancement' and apply it to pedagogical systems to improve language teaching practices.

8. Conclusions

We investigated the effect of robots on language learning and collaborative learning in college English education. Through surveys of 121 students majoring in English-related subjects, how students perceived language learning using robots was explored. "Perceived Usefulness and Relevance" and "Engagement and Motivation" were regarded as important, showing that students considered robots to be an interesting and helpful device in enhancing their language learning abilities. The "Engagement and Motivation" of students positively affected their "Perceived Usefulness and Relevance". This suggested the importance of robots in language learning and building an encouraging and collaborative learning environment. "Collaboration and Teamwork" were enhanced by using robots. Robots contributed to developing students' language skills and improving teamwork and communication. "Engagement and Motivation" were correlated significantly with "Perceived Usefulness and Relevance", indicating the importance of student engagement in robot-integrated learning.

In educational practice and research in language education, RALL influenced the effectiveness of language learning and collaborative learning. The effectiveness of advanced technology in developing engaging learning environments was proven in this study, which aligned with the results of previous studies. The results of this study emphasize that the use of robotic technologies in language education motivates and entices students to learn a language.

However, technical limitations and possible distractions of using robots in education must be addressed. Appropriate training programs for teachers are also mandated to enhance the effectiveness of using robots. It is still necessary to develop curricula and corresponding

teaching strategies tailored to the diverse traits and requirements of students to provide personalized education and efficient learning environments.

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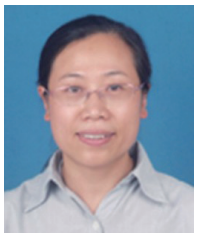
About the Authors



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