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Enhancing self-regulation and learner engagement in L2 speaking: exploring the potential of intelligent personal assistants within a learning-oriented feedback framework

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Abstract

Introduction Developing L2 speaking proficiency can be challenging for learners, particularly when it comes to fostering self-regulation and maintaining engagement. Intelligent Personal Assistants (IPAs) offer a potential solution by providing accessible, interactive language learning opportunities.

Methods This mixed-methods study investigated the effectiveness of using Google Assistant within a learning-oriented feedback (LOA) framework to enhance L2 speaking proficiency, self-regulation, and learner engagement among 54 university-level EFL learners in China. Convenience sampling assigned participants to either an experimental group ($n = 27$) using Google Assistant with tailored activities or a control group ($n = 27$) using traditional methods. The Oral Proficiency Interview (OPI) assessed speaking performance. Self-reported questionnaires measured L2 motivation and the Scale of Strategic Self-Regulation for Speaking English as a Foreign Language (S2RS-EFL) evaluated speaking self-regulation. Additionally, semi-structured interviews with a subsample of the experimental group provided qualitative insights.

Results The Google Assistant group demonstrated a statistically significant improvement in speaking performance compared to the control group. While no significant difference in motivation was found, thematic analysis of interviews revealed perceived benefits of Google Assistant, including increased accessibility, interactivity, and immediate pronunciation feedback. These features likely contributed to a more engaging learning experience, potentially fostering self-regulation development in line with the core principles of LOA.

Conclusion This study suggests Google Assistant as a promising supplementary tool for enhancing L2 speaking proficiency, learner autonomy, and potentially self-regulation within an LOA framework. Further research is needed to explore its impact on motivation and optimize engagement strategies.

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Keywords Learning-oriented feedback, L2 speaking, Motivation, Self-regulation, Intelligent Personal Assistant (IPA), Self-directed learning

Introduction

For learners of English as a Foreign Language (EFL), particularly those with limited access to native speakers or extensive classroom instruction, achieving fluency in spoken English remains a significant hurdle. Traditional methods often struggle to provide the personalized practice and immediate feedback essential for effective speaking skill development [1, 2]. This gap underscores the potential of technology-assisted feedback practices within a learning-oriented framework (LOA) to bridge this gap.

The recent emergence of Intelligent Personal Assistants (IPAs) like Google Assistant presents a promising new avenue for L2 learning [3, 4]. These AI-powered applications can serve as readily available conversation partners, fostering learner engagement through real-time feedback and facilitating convenient and flexible speaking practice [5, 6]. However, a critical limitation of current research on IPAs in L2 learning is its focus on general language acquisition outcomes, with limited exploration of their impact on specific skills like speaking proficiency, motivation, and self-regulation – all core principles of LOA that emphasize student-driven engagement with feedback and the development of autonomous learning skills [7–10].

This mixed-methods study addresses this crucial knowledge gap by investigating the effectiveness of Google Assistant on L2 speaking performance, motivation, and self-regulation among Chinese EFL learners. By employing a combination of quantitative and qualitative data analysis, this research delves deeper than previous studies to explore how IPAs can influence the L2 learning experience within an LOA framework. We examine how Google Assistant, through features like accessibility, interactivity, and immediate feedback, might foster a more engaging and self-directed learning experience, potentially leading to improvements in speaking skills and self-regulation development, thus aligning with the core tenets of LOA. To address this knowledge gap, the study investigates the following research hypotheses:

H1 Students in the experimental group who utilize Google Assistant will demonstrate significantly greater improvement in L2 speaking performance compared to the control group.

H2 Students in the experimental group who utilize Google Assistant will report significantly higher levels of L2 motivation compared to the control group.

H3 Students in the experimental group who utilize Google Assistant will exhibit greater development of self-regulation strategies for L2 speaking compared to the control group.

This research not only contributes to a more nuanced understanding of technology's role in L2 speaking proficiency development, but also offers valuable insights for educators and researchers in optimizing the use of IPAs within learning environments. By exploring how Google Assistant fosters engagement with feedback and potentially impacts learner motivation and self-regulation, the study informs the design and implementation of technology-assisted LOA practices. This knowledge can be harnessed to develop strategies that leverage IPAs to enhance L2 speaking skills, promote learner autonomy, and ultimately, contribute to more effective EFL speaking instruction.

Literature review

Theoretical framework: learning-oriented feedback (LOA)

This study is grounded in the theoretical framework of Learning-Oriented Feedback. LOA emphasizes the importance of shifting the focus from simply providing feedback to creating a learning environment where students actively engage with the feedback to improve their learning outcomes [11]. This approach aligns with the growing recognition of the learner as a central participant in the feedback process, moving beyond teacher-centered models.

Effective feedback in an LOA framework clearly links feedback to specific learning goals and desired outcomes [10]. In this study, the learning goals will be related to L2 speaking proficiency, self-regulation skills, and motivational factors influencing learner engagement with Google Assistant. LOA also emphasizes strategies that promote student engagement with feedback. This includes providing clear, timely, and actionable feedback that is tailored to individual needs [10]. Our investigation of Google Assistant's features, such as accessibility, interactivity, and immediate pronunciation feedback, will explore how this technology might foster engagement with feedback in the context of L2 speaking practice. Also, a core principle of LOA is to cultivate self-regulation in learners. Effective feedback practices help students develop the skills to monitor their own learning, set goals, and utilize feedback to improve their performance [9]. This study will examine how Google Assistant, through its interactive nature and potential to provide immediate feedback, might contribute to the development of self-regulation skills among L2 learners.

While traditional LOA practices often focus on teacher-delivered feedback, advancements in technology have opened doors for technology-assisted feedback mechanisms [12]. However, research in this area presents both challenges and affordances [13]. This study explores how Google Assistant, as a readily available and interactive language learning tool, can potentially offer feedback within an LOA framework for L2 learners. By investigating how learners engage with Google Assistant's feedback features, this study aims to contribute to the ongoing exploration of the potential for technology-assisted learning aligned with LOA principles.

This study examines the effectiveness of Google Assistant as a tool for enhancing L2 speaking proficiency, self-regulation, and learner engagement among EFL learners in China. It utilizes a mixed-methods approach to not only assess speaking performance but also delve deeper into learner perceptions and experiences with Google Assistant. By analyzing both quantitative data and qualitative interview data, the study aims to understand how Google Assistant's features and functionalities might foster engagement with feedback, potentially impacting self-regulation development and ultimately, L2 speaking proficiency. This investigation aligns with the principles of LOA by focusing on student engagement, self-regulation, and the use of technology to facilitate a more learner-centered feedback experience.

Technology-assisted L2 speaking

Numerous studies have highlighted the effectiveness of various technologies in promoting L2 spoken proficiency. Mobile applications like WhatsApp offer convenient platforms for informal speaking practice, facilitating frequent interaction and potentially leading to improved fluency and confidence [14]. For more structured speaking activities, videoconferencing platforms provide opportunities for interaction with native speakers or remote peers. This technology can create an immersive and interactive environment, promoting active participation in discussions and presentations [15].

Web-based language learning (WBLL) platforms offer a structured approach to L2 speaking development. These programs often include interactive exercises, pronunciation drills, and recorded speaking practice, providing valuable resources for learners seeking self-directed practice and focused improvement [16]. The versatility of mobile devices extends beyond communication apps. iPads, for example, can be leveraged to maximize L2 speaking practice by utilizing language learning apps, recording tools, and multimedia resources. This caters to different learning styles and practice preferences [17]. Mobile technology can even be harnessed to enhance specific aspects of L2 speaking, such as pronunciation. By allowing learners to record and compare their

pronunciation to native speakers through mobile apps employing "shadowing" techniques, mobile tech offers valuable feedback and supports pronunciation development [18].

A recent innovation in L2 learning contexts is the use of IPAs. This review now explores the growing body of research on the efficacy of IPAs in enhancing L2 speaking skills, learner motivation, and autonomous learning. Several studies have investigated the effectiveness of IPAs for out-of-classroom language practice, demonstrating significant improvements in L2 learners' oral proficiency and willingness to communicate (WTC) [4, 7, 8]. These positive impacts are attributed to factors like increased speaking opportunities, immediate feedback mechanisms, and reduced anxiety associated with human interaction [8]. Interestingly, Tai [7] found that IPA interaction even led to higher WTC than interaction with human L1 or L2 speakers, potentially due to the convenience, flexibility, and non-judgmental nature of IPAs.

Yang et al. [4] investigated the potential of IPAs for fostering autonomous L2 learning (ASLL). Their findings suggest that learners who received both an IPA (Google Assistant) and teacher guidance saw significant improvement in listening and speaking skills. This indicates that IPAs can be a valuable tool for independent language practice, particularly when coupled with some level of teacher support to guide learners towards effective use of the technology and address any identified gaps.

However, limitations associated with IPAs necessitate further exploration. Dizon's [3] case study highlighted limitations in speech recognition, particularly for L2 learners with heavy accents. This suggests that IPAs may be more beneficial for learners with higher proficiency levels or those with specific accents that the IPA is trained to recognize. Dizon's [19] review further emphasized the need for additional research on IPAs in L2 learning contexts, particularly regarding their effectiveness for learners with varying language abilities, learning styles, and access to teacher support. Additionally, future research should explore how IPA interaction can be integrated with other language learning activities and platforms to create a more comprehensive learning experience.

In conclusion, current research suggests that IPAs offer a range of affordances for L2 learning, particularly for speaking skills, learner motivation, and promoting autonomous learning. However, limitations in speech recognition and the potential need for additional support highlight the importance of further research to optimize IPA use in L2 learning environments. By understanding these affordances and constraints, educators and learners can leverage IPAs to create more engaging and effective language learning experiences.

Second language motivation

The motivation behind acquiring L2 constitutes a multifaceted area of research that significantly contributes to the field of language learning and teaching. This section explores seminal theories and empirical findings that have shaped our understanding of second language motivation. Gardner and Lambert [20] pioneered the study of second language motivation with their socio-educational model, emphasizing the role of integrative and instrumental orientations. Integrative motivation, the desire to learn a language to integrate into a cultural community, and instrumental motivation, driven by practical reasons such as career advancement, have been fundamental in understanding why individuals embark on the journey of learning a second language. Their work laid the groundwork for subsequent research on the motivational dynamics in L2 acquisition. Dörnyei [21] further advanced the field by introducing the concept of motivational strategies within the framework of L2 learning. His emphasis on the dynamic nature of motivation, proposing that teachers can significantly influence their students' motivation through specific teaching strategies, has been influential. This idea opened new avenues for research, focusing on how educators can foster a motivational classroom environment that encourages sustained language learning.

Recent developments have moved towards more nuanced perspectives on motivation. Dörnyei and Ushioda [22] introduced the L2 Motivational Self System, drawing on psychological research into the notion of the self. This theory suggests that L2 motivation is profoundly influenced by learners' self-identities, including the Ideal L2 Self, which reflects the learner's aspirations to become a proficient L2 user, and the Ought-to L2 Self, which pertains to the attributes learners believe they should possess to avoid negative outcomes. This perspective has highlighted the importance of self-related psychological processes in the motivation to learn a second language. Moreover, the role of the learning environment in shaping motivation has received increasing attention. Csizér and Dörnyei [23] have demonstrated how classroom dynamics, teacher behavior, and the broader educational context influence students' motivational trajectories. Their work underscores the significance of creating a supportive, engaging, and contextually sensitive learning environment to enhance L2 motivation.

The concept of willingness to communicate (WTC) in an L2, as explored by MacIntyre et al. [24], integrates the dynamic nature of motivation with the actual use of language. They argue that the ultimate goal of language learning is to engage in communication; thus, understanding the factors that promote or hinder learners' willingness to use the language is crucial. Their model incorporates a wide range of variables, from individual

personality traits to the social and educational context, offering a comprehensive view of how motivation to communicate can be nurtured.

Technology has emerged as a powerful tool for fostering motivation in L2 learning environments. Studies highlight the potential of technology to connect learners with their ideal L2 selves [25]. By utilizing online platforms and digital resources, learners can engage in activities and interactions that bring them closer to their aspirations of becoming proficient speakers [25]. This alignment with desired future selves can enhance intrinsic motivation and fuel continued learning efforts. The concept of social situatedness is another key factor influencing L2 motivation through technology. Henry [26] emphasizes the importance of online media creation tools that allow learners to engage in collaborative projects and share their work with a wider audience. This sense of community and the opportunity to contribute to a larger conversation can motivate learners to actively participate and refine their language skills [26].

Furthermore, technology's inherent appeal and novelty can contribute to increased motivation. Panagiotidis et al. [27] discuss the allure of technology, suggesting that its interactive nature and engaging features can make language learning more enjoyable and less like a traditional classroom setting. This positive association with learning can lead to increased engagement and sustained motivation [27]. While the studies above focus primarily on technology's impact on general L2 motivation, Tavakoli et al. [28] offer a more specific example. Their research explores the use of Computer-Assisted Language Learning (CALL) in Task-Based Language Teaching (TBLT). They found that CALL-mediated TBLT activities enhanced motivation for L2 reading, suggesting that technology can be strategically integrated into specific instructional methods to target different language skills and motivational aspects [28]. Emerging technologies like Augmented Reality (AR) offer even more possibilities for boosting L2 motivation. Liu et al. [29] investigate the impact of AR on L2 learning motivation in EFL learners. Their findings indicate that AR can foster intercultural competence and a sense of excitement about language learning, potentially leading to increased motivation [29].

In conclusion, technology offers a multitude of tools and approaches to enhance L2 learning motivation. From aligning learners with their ideal L2 selves to fostering a sense of community and employing engaging features, technology can create a more motivating and rewarding learning experience for L2 learners. By strategically integrating technology into their teaching practices, educators can leverage its motivational power to ignite a passion for language learning.

Self-regulated learning

Self-regulated learning (SRL) has emerged as a central framework for understanding how learners take charge of their own learning journeys, particularly when it comes to navigating the complexities of acquiring a new language (L2). Zimmerman [30] defines SRL as a dynamic process where learners set goals, actively monitor and regulate their cognition, motivation, and behavior in response to the learning environment. This multifaceted nature of SRL highlights its dependence on a combination of cognitive, metacognitive, and motivational components.

A substantial body of research underscores the strong correlation between SRL skills and success in L2 learning. Pintrich [31] argues that the ability to regulate one's learning is just as crucial as intellectual ability in achieving language proficiency. This is supported by Dignath et al. [32] who found a significant positive link between SRL strategies and academic performance across various disciplines, including L2 learning.

Recent advancements explore the role of technology in facilitating SRL within L2 education. Azevedo [33] examines the use of intelligent tutoring systems, adaptive learning environments, and learning analytics as tools to enhance SRL by providing learners with personalized feedback and scaffolding. These technological interventions align well with the dynamic nature of SRL, offering opportunities for learners to refine their strategies based on immediate feedback.

The social context of SRL is also garnering attention, recognizing that language learning is often a collaborative endeavor. Hadwin et al. [34] emphasize the importance of social contexts in shaping self-regulatory practices. Their research suggests that collaborative learning environments can foster SRL by providing opportunities for learners to discuss their thinking, engage in reflection, and adjust their strategies based on peer feedback.

The concept of SRL has been extensively applied within the domain of L2 education, revealing both unique challenges and opportunities for language learners. Tseng et al. [35] highlight the critical role of motivation and self-regulation, suggesting that effective L2 learning goes beyond cognitive ability and requires learners to manage their own learning processes. A key component of SRL in L2 education is metacognitive strategy use, which involves planning, monitoring, and evaluating one's learning. Vandergrift and Goh [36] emphasize the importance of metacognitive strategies in listening comprehension, a fundamental skill in L2 acquisition. Their research suggests that successful L2 learners are those who can effectively deploy metacognitive strategies to enhance their understanding and retention of language input.

Another significant aspect of SRL in L2 education is the management of affective factors. Oxford [37] delves into

the emotional dimensions of language learning, recognizing that negative emotions can impede progress. Effective self-regulation involves not only cognitive and metacognitive strategies but also strategies to manage these emotional responses.

The role of technology in facilitating SRL among L2 learners has also been explored. Godwin-Jones [38] discusses how digital tools and online resources can support the development of autonomous learning skills, providing learners with access to authentic language input and interactive platforms for practice outside the classroom. This integration of technology with SRL strategies offers a promising avenue for enhancing the efficacy and engagement of L2 education.

Furthermore, the social aspect of SRL in L2 learning highlights the importance of interaction and collaboration. Kormos & Csizér [39] found that collaborative tasks and peer feedback mechanisms are effective in fostering not only language skills but also self-regulatory capacities among learners. This social dimension emphasizes the role of the learning community in supporting individual regulatory efforts.

In conclusion, self-regulated learning serves as a powerful framework for understanding and promoting success in L2 education. By fostering a combination of cognitive, metacognitive, and motivational skills, learners can navigate the complexities of language acquisition and achieve greater proficiency.

Methods

Participants

Fifty-four university students enrolled in two intact EFL classes at a university in China participated in this study. Convenience sampling was employed, with the classrooms serving as sampling units. Due to the pre-existing structure of the classes, random assignment to groups wasn't feasible. However, to ensure group equivalence, both classes were taught by the same instructor and followed the same curriculum.

Inclusion criteria ensured a homogenous participant pool: all were native Chinese speakers with Mandarin as their first language, enrolled in the same EFL program with at least two semesters of English instruction demonstrating B1 proficiency according to the CEFR, and with no prior experience using Google Assistant for language learning. Basic computer literacy and access to a smartphone or internet-connected device were also prerequisites.

While random assignment was not possible due to the intact classroom structure, a sample size of 54 participants (27 in the experimental group and 27 in the control group) was determined using G*Power software [40]. This a priori sample size calculation considered an effect size of 0.5 (medium), alpha level of 0.05, and power of

0.80 to detect statistically significant differences between the groups on the outcome measures. This sample size is appropriate for conducting mixed-methods research with a quantitative strand employing analysis of variance (ANOVA) techniques [41].

Participants were not randomly assigned due to the intact classroom structure, but efforts were made to create groups with similar baseline characteristics, particularly B1 CEFR proficiency. The experimental group ($n=27$, 14 male, 13 female) received access to the Google Assistant application and participated in language learning activities specifically designed to incorporate the tool. Conversely, the control group ($n=27$, 15 male, 12 female) did not have access to the Google Assistant and relied on traditional learning methods with teacher guidance and peer interaction.

To gain a deeper understanding of the participant pool, a demographic questionnaire was administered during the pre-intervention phase. This questionnaire collected data on age (average 22 years, range 19–25), gender (52% male, 48% female), English language learning experience (average 4 years of formal and informal learning), and self-reported frequency of technology usage for language learning.

Instruments

This section will detail the instruments used to measure the research variables: L2 Speaking Performance, L2 Motivation, and L2 Self-regulation. Additionally, the interview guide for the qualitative phase will be presented.

L2 speaking performance

In the assessment of L2 Speaking Performance, the Oral Proficiency Interview (OPI), developed by the Educational Testing Service (ETS), serves as a pivotal tool for evaluating speaking abilities, reflecting its effectiveness and reliability in linguistic proficiency evaluation. The OPI's notable consistency across various levels of language proficiency is underpinned by its substantial inter-rater reliability, which is further evidenced by intraclass correlation coefficients (ICCs), as highlighted in the research by Sarwark et al. [42]. This reliability is complemented by the OPI's robust construct validity, which aligns seamlessly with the ACTFL proficiency guidelines, underscoring its accuracy in reflecting true speaking abilities. Additionally, the OPI's validity is affirmed through its predictive relationship with parallel measures of speaking proficiency, a correlation meticulously documented by Chalhoub-Deville & Fulcher [43]. This seamless integration of reliability and validity in the OPI's design and application ensures a comprehensive and accurate assessment of oral proficiency, establishing

a solid foundation for evaluating speaking performance in the study.

L2 motivation

Learning motivation among students learning English was gauged using a five-item scale, refined from instruments developed by Yashima [44] and Feng and Papi [45]. These items, rated on a scale from 1 (“completely unlike me”) to 7 (“exactly like me”), are designed to capture the fervor of students' motivation toward mastering English. A greater score signifies a deeper commitment to learning the language.

Speaking self-regulation

The assessment of self-regulatory strategies in speaking English as a foreign language employed the Scale of Strategic Self-Regulation for Speaking English as a Foreign Language (S2RS-EFL), as formulated by Sun [46]. This instrument includes a comprehensive set of 52 strategies related to self-regulated learning (SRL) in speaking, rated on a 7-point Likert scale. These strategies span across cognitive, motivational, social, and affective domains, reflecting various facets of SRL in language learning.

Semi-structured interviews

To gain a deeper understanding of the experimental group students' perspectives on using Google Assistant for L2 learning. This qualitative approach aimed to explore their attitudes, experiences, and perceived benefits and challenges associated with integrating the tool into their learning journey. Fourteen volunteer students from the experimental group participated in individual semi-structured interviews. These participants were chosen to ensure a diverse range of experiences within the group. Each interview was conducted in a private and comfortable setting to encourage open and honest dialogue. The interviews ranged from 20 to 30 min in duration, allowing for in-depth exploration of each participant's perspective. A semi-structured interview guide with open-ended questions (see the Appendix) served as a framework for the discussion, while allowing flexibility to pursue emerging themes or topics raised by the participants.

Google assistant

The cornerstone of the intervention for the experimental group was Google Assistant, a virtual assistant application developed by Google that served as the IPA tool in this study. Accessible on a variety of devices like smartphones, tablets, and smart speakers, Google Assistant allows users to interact through voice commands or text input. But what made Google Assistant particularly well-suited for L2 learning were its functionalities that fostered a dynamic and interactive learning environment.

Participants could engage in dynamic practice sessions by asking Google Assistant questions, issuing commands, and receiving spoken or visual responses. This functionality mimicked a natural conversation-like environment, allowing for simulated dialogues and personalized language practice. Also, Google Assistant's language translation feature served as a valuable tool for understanding and producing foreign language content. Participants could utilize translation for pronunciation practice or to clarify specific vocabulary within dialogues, ultimately enhancing their comprehension and fluency in English.

Information retrieval capabilities extended beyond basic web searches. Participants could access resources like weather updates or set reminders, potentially aiding in creating context-driven language practice scenarios. Imagine practicing phrases related to ordering food by asking about the weather in a specific city. This functionality allowed learners to practice language in a more realistic and engaging context. While limited, Google Assistant's customization options allowed participants to personalize their experience and preferences to some degree. This element of control could contribute to a more engaging and user-friendly learning environment, making the practice sessions more enjoyable and potentially increasing learner motivation.

The experimental group was instructed to leverage these functionalities for specific language learning activities. By practicing pronunciation, receiving feedback on spoken English, and engaging in basic dialogues with Google Assistant, participants benefitted from an interactive and accessible platform to support their English speaking practice. Google's powerful speech recognition and translation capabilities embedded within Google Assistant played a key role in facilitating this learning experience, providing immediate feedback and fostering active language interaction. It's important to note that this study focused solely on the functionalities relevant to L2 learning and did not explore the broader features or functionalities offered by the Google Assistant application.

Procedures

This section details the procedures followed by both the experimental and control groups throughout the study (see Fig. 1). To ensure a fair comparison of outcomes, both groups received the same amount of instructional time (10 weeks, 60 min per session) and engaged in similar learning activities. The key difference lay in the experimental group's use of Google Assistant as a language learning tool.

The experimental group

The experimental group's journey began with comprehensive training on using Google Assistant for L2

learning. This included familiarizing them with the application's interface, voice commands, and functionalities specifically designed for language acquisition. Equipped with these skills, participants embarked on various tasks utilizing Google Assistant.

- **Pronunciation Practice:** Participants honed their pronunciation by reading aloud sentences and paragraphs, receiving immediate feedback on accuracy and intonation. Google Assistant's speech recognition and evaluation capabilities provided a valuable tool for self-correction and improvement.
- **Dialogue Practice:** To enhance conversational skills, students participated in simulated dialogues with Google Assistant. They took turns posing and responding to questions on various topics, creating a safe and interactive environment for language practice.
- **Vocabulary Building:** Expanding vocabulary became an interactive adventure. Participants used Google Assistant to look up new words, listen to their pronunciations, and practice using them in sentences, solidifying their understanding and retention.
- **Self-Assessment Activities:** Google Assistant also guided participants through self-assessment exercises, prompting them to reflect on their learning progress and identify areas for continued development. This self-awareness fostered a sense of ownership over the learning process.

The experimental group participated in 10 weekly sessions, each lasting 60 min. These sessions, integrated seamlessly within the regular class schedule, ensured equal instructional time compared to the control group. However, to encourage independent practice and exploration, participants were encouraged to utilize Google Assistant for additional language learning activities outside of class time. The amount of time spent using the application beyond the scheduled sessions was not formally monitored.

The control group

The control group received clear instructions on the established learning methods they would be employing throughout the study. These methods included:

- **Engaging in Teacher-Led Activities:** Group discussions, role-playing exercises, and presentations led by the instructor provided opportunities for interactive learning and receiving feedback from the teacher.
- **Completing Individual Practice Exercises:** Dedicated time was allocated for participants to

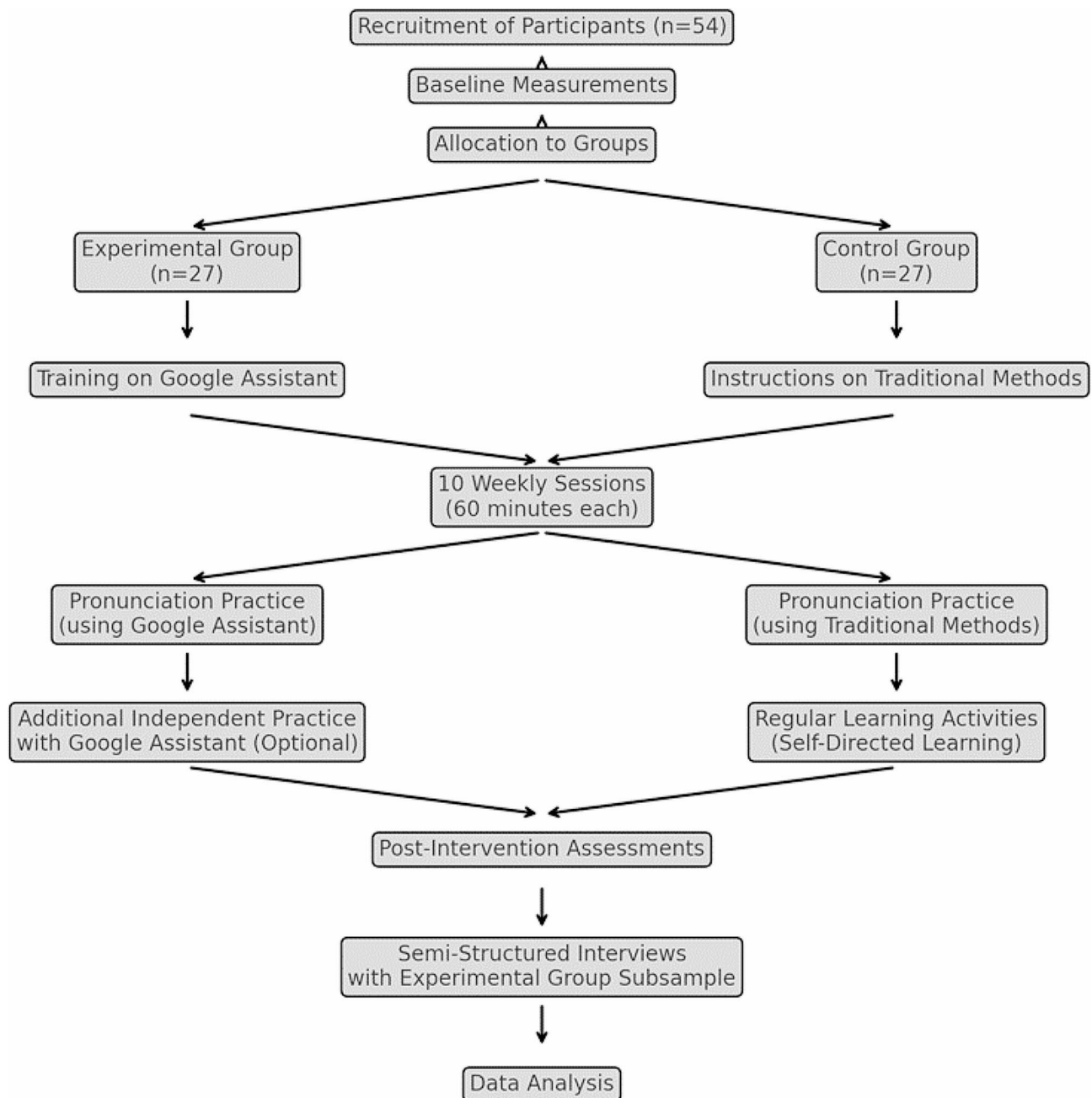


Fig. 1 Study Procedure Flowchart

work independently on exercises from the course textbook and other assigned materials, solidifying their understanding of concepts covered in class.

- **Peer Interaction:** Collaborative learning was fostered through peer-to-peer interaction activities. Participants received feedback and support from classmates, creating a dynamic learning environment.

To ensure similarity with the experimental group's tasks, the control group engaged in activities that mirrored

those utilizing Google Assistant, but without the technological support.

- **Pronunciation Practice:** Participants practiced reading aloud assigned texts in class, receiving feedback from the teacher and peers on pronunciation accuracy and intonation. This provided valuable guidance for pronunciation improvement.
- **Dialogue Practice:** Real-world conversation skills were honed through role-playing activities with

classmates. These simulated conversations allowed participants to practice language exchange and social interaction.

- **Vocabulary Building:** Traditional methods like flashcards, textbook definitions, and teacher-led explanations formed the foundation for vocabulary development. Participants actively learned new words and practiced using them in context.
- **Self-Assessment Activities:** Individual self-assessment quizzes and exercises helped participants reflect on their learning progress and identify areas for improvement. This self-awareness encouraged ownership over their language learning journey.

The control group participated in the same schedule of 10 weekly sessions, each lasting 60 min, focusing on the traditional learning methods outlined above. As with the experimental group, their regular language learning routines outside of class likely included activities like studying course materials, completing assigned homework, and engaging in self-directed learning. The researchers aimed to minimize potential bias by encouraging both groups to maintain their regular routines, although the specific amount of time spent on these activities outside of class was not formally monitored or controlled.

Maintaining comparability

As described, both groups received the same amount of instructional time and engaged in similar learning activities. The crucial distinction lay in the experimental group's integration of Google Assistant as an L2 learning tool. This approach ensured that any observed differences in learning outcomes between the groups could be attributed specifically to the intervention, not to variations in instructional time or activity types. While out-of-class activities were not formally controlled, the researchers strived to minimize potential bias by encouraging both groups to maintain their regular language learning routines outside of class.

Reliability and validity analysis

To establish the trustworthiness of the research findings, reliability and validity analyses were conducted. The internal consistency of the L2 Motivation scale (five items) was assessed using Cronbach's alpha coefficient, resulting in a value of 0.88, which indicates strong internal consistency. Similarly, the Scale of Strategic Self-Regulation for Speaking English as a Foreign Language (S2RS-EFL), consisting of 52 items, demonstrated high reliability with a Cronbach's alpha of 0.90.

For the Oral Proficiency Interview (OPI) measuring L2 Speaking Performance, inter-rater reliability was ensured through a meticulous process. Both raters underwent rigorous training to ensure consistent application of the OPI

scoring criteria, including calibrating their assessments using established OPI sample responses. Additionally, a subset of approximately 20% of the OPI recordings was double-rated by both raters. The Intraclass Correlation Coefficients (ICCs) were then calculated to assess the agreement between the raters, ensuring robust inter-rater reliability.

Validity analyses further reinforced the credibility of the instruments. Content validity for the L2 Motivation scale and the S2RS-EFL was ensured through a comprehensive review by a panel of experts in the field of language education. These experts evaluated the items to confirm that they comprehensively covered the constructs being measured. Construct validity for the L2 Speaking Performance measure was supported by aligning the OPI scores with the ACTFL proficiency guidelines, accurately reflecting true speaking abilities.

Convergent validity of the L2 Motivation scale was assessed by correlating it with another established measure of language learning motivation, specifically the L2 motivation scale by Piniel and Csizér [47]. This yielded a significant correlation ($r=0.72$, $p<0.01$), thus confirming its convergent validity. Furthermore, the instruments were pilot tested with a small sample similar to the study participants. Feedback from the pilot test was utilized to refine the items, ensuring clarity and relevance, thereby enhancing the overall validity of the instruments.

Data analysis

Descriptive statistics such as means, standard deviations, frequencies, and percentages were calculated to describe the central tendencies, variability, and distribution of the data for each group on the respective dependent variables. All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) version 26.0.

One-way analysis of covariance (ANCOVA) was used to compare the performance of the experimental and control groups on the L2 Speaking Performance, L2 Motivation, and L2 Self-regulation measures at the post-intervention stage. This approach was chosen because it allows controlling for a potential confounding variable, in this case, baseline performance on the respective dependent variable (measured before the intervention). The pre-intervention scores were used as covariates in the ANCOVA models. This helped to isolate the true effect of the intervention (using Google Assistant) on the outcomes, while accounting for any potential pre-existing differences between the groups in terms of their baseline performance.

The data collected through the semi-structured interviews conducted with the experimental group was analyzed using thematic analysis, a rigorous method well-suited for identifying recurring patterns and key

Table 1 Descriptive statistics

Variable	Group	Pre-Test (M ± SD)	Post-Test (M ± SD)
L2 Speaking Performance	Experimental	30.2 ± 4.1	34.8 ± 3.7
	Control	30.5 ± 3.8	32.9 ± 4.2
L2 Motivation	Experimental	52.4 ± 5.6	56.1 ± 4.8
	Control	51.8 ± 5.2	54.2 ± 5.5
Self-regulation	Experimental	28.7 ± 3.4	31.2 ± 2.9
	Control	28.1 ± 3.1	29.8 ± 3.7

Table 2 One-way ANCOVA results for L2 speaking performance, L2 motivation, and self-regulation

Variable	Source	df	F	p-value	η^2
L2 Speaking Performance	Group	1	4.23	0.043	0.12
	Covariate	1	35.78	<0.001	0.77
	Error	52			
L2 Motivation	Group	1	2.84	0.097	0.05
	Covariate	1	21.56	<0.001	0.59
	Error	52			
L2 Self-regulation	Group	1	5.12	0.027	0.09
	Covariate	1	27.45	<0.001	0.69
	Error	52			

themes within qualitative data sets [48]. The interviews were audio-recorded with participant consent and transcribed verbatim to ensure accuracy.

Thematic analysis involved a systematic process of coding the transcripts. Initially, we employed an inductive approach, openly coding the data for significant phrases, ideas, and experiences related to the participants' perspectives on using Google Assistant for L2 learning. We then iteratively grouped these codes into categories and subsequently into higher-order themes that represent the core findings of the study. To enhance trustworthiness, this process was conducted by two independent researchers, with discrepancies resolved through discussion and consensus building [49]. This collaborative approach helped to mitigate potential researcher bias and ensure the credibility of the thematic analysis.

Results

Table 1 summarizes the descriptive statistics for the experimental and control groups on three key measures: L2 speaking performance, L2 motivation, and L2 self-regulation. The table shows both the mean scores (M) and standard deviations (SD) for each group at the pre-test and post-test stages. Looking at the L2 speaking performance scores, we see that both groups showed improvement from pre-test to post-test. The experimental group's average score increased by 4.6 points (30.2 to 34.8), while the control group's average score increased by 2.4 points (30.5 to 32.9).

Similarly, both groups exhibited gains in L2 motivation (measured using the MLLS). The average score for the experimental group increased by 3.7 points (52.4 to 56.1), while the control group's average score increased by 2.4 points (51.8 to 54.2). Finally, the data suggests a positive trend in speaking self-regulation for both groups. The experimental group's average score increased by 2.5 points (28.7 to 31.2), and the control group's average score increased by 1.7 points (28.1 to 29.8).

One-way ANCOVA were conducted to compare the performance of the experimental and control groups on the L2 Speaking Performance, L2 Motivation, and Self-regulation measures collected at the post-intervention stage. Pre-intervention scores on the respective dependent variables were included as covariates in the models to control for potential baseline differences between the groups.

The results in Table 2 indicate a statistically significant difference ($p=0.043$) between the experimental and control groups in L2 Speaking Performance (OPI) after controlling for pre-intervention scores. The effect size (η^2) of 0.12 suggests a small to moderate effect of the intervention on speaking performance. This suggests that the use of Google Assistant in the experimental group may have led to a small to moderate improvement in their L2 speaking skills compared to the control group.

The results for L2 Motivation show a non-significant difference ($p=0.097$) between the groups after adjusting for the covariate. Although the F-statistic suggests a slight trend towards a difference, it does not reach the conventional level of significance ($p<0.05$). Therefore, we cannot conclude a definitive effect of the intervention on L2 motivation based on this quantitative analysis.

The results for Self-regulation reveal a statistically significant difference ($p=0.027$) between the groups after controlling for pre-intervention scores. The effect size (η^2) of 0.09 suggests a small effect of the intervention on self-regulation. This indicates that the use of Google Assistant may have had a small positive impact on the self-regulatory skills of the learners in the experimental group compared to the control group.

Concerning the qualitative results, the thematic analysis of the semi-structured interviews conducted with the experimental group participants revealed rich insights into their experiences using Google Assistant for L2 learning (see Table 3). Three key themes emerged, capturing both the perceived benefits and challenges associated with this virtual language learning tool.

Theme 1 *Empowering Learning through Personalized Practice.*

Participants highlighted several advantages of using Google Assistant. A prominent benefit was the ability to improve pronunciation. Google Assistant's real-time

Table 3 Themes and sub-categories of Google Assistant's Use for L2 Learning

Main Category	Sub-category	Description (with Participant Quotes)
Empowering Learning through Personalized Practice	Improved Pronunciation	- Real-time feedback allows identification and correction of errors (Participant 2). - Fosters self-directed learning (Participant 2).
	Increased Speaking Practice	- Enables frequent spoken interaction (Participant 5). - Reduces hesitation and builds confidence (Participant 5). - Enhances motivation and engagement through interaction (Participant 1).
	More Engaging Learning Experience	- Shifts learning from textbook-based to interactive (Participant 1). - Makes learning more fun (Participant 1).
Navigating Limitations and Fostering Continued Use	Voice Recognition Accuracy Issues	- Occasional misunderstandings disrupt learning flow (Participant 3).
	Limited Functionality for Advanced Tasks	- Difficulty handling complex sentence structures (Participant 7). - Not suitable for advanced topics (Participant 7).
	Maintaining Consistent Usage	- Difficulty integrating into regular routines (Participant 4). - Requires additional strategies for sustained engagement (Participant 4).
Envisioning the Future: Feature Enhancements and Personalized Learning	Advanced Dialogue Practice Features	- Desire for functionalities to practice context-specific conversations (Participant 6).
	Personalized Feedback on Pronunciation and Fluency	- Need for more specific feedback beyond right/wrong (Participant 8). - Interest in feedback on improving fluency (Participant 8).

feedback mechanism allowed learners to identify and rectify pronunciation errors, as exemplified by Participant 2: *"I liked how Google Assistant could point out my mistakes when I pronounced something wrong. It helped me learn the correct way to say the words."* This immediate feedback loop fostered a self-directed learning environment, empowering participants to actively engage in pronunciation practice.

Beyond pronunciation, Google Assistant provided valuable opportunities for increased speaking practice. The ability to engage in frequent spoken interactions, as Participant 5 expressed, *"It was helpful to practice speaking English with Google Assistant because I could do it anytime, even when I was alone. It felt less stressful than talking to a real person."* This feature addressed the common challenge of overcoming hesitation and gaining confidence in speaking the target language. The interactive

nature of practicing with Google Assistant further contributed to enhanced motivation and engagement. Participant 1 echoed this sentiment: *"Using Google Assistant made learning English more fun and interactive. It felt more like a conversation than just studying from a textbook."* This shift towards a more engaging learning experience potentially translated into increased perseverance and a more enjoyable learning journey.

Theme 2 Navigating Limitations and Fostering Continued Use.

While participants acknowledged the benefits of Google Assistant, they also identified certain challenges. One concern centered on voice recognition accuracy. Participant 3 highlighted the occasional frustration caused by misunderstandings: *"Sometimes Google Assistant didn't understand what I was saying, which was annoying. It could be confusing when it gave me feedback on the wrong pronunciation."* Inaccurate voice recognition could potentially disrupt the learning flow and hinder the effectiveness of the practice session.

Another limitation identified was the restricted functionality for specific language learning tasks. As Participant 7 noted, *"While Google Assistant was helpful for practicing basic phrases and pronunciation, it couldn't really help me with more advanced topics or complex sentence structures."* The current functionalities might not be fully equipped to address the intricacies of grammar or support open-ended discussions.

Finally, participants acknowledged the challenge of maintaining consistent usage outside of the structured classroom environment. Participant 4's experience reflects this: *"I found it difficult to use Google Assistant consistently outside of class because I was often busy with other activities and didn't always have the time or motivation to practice on my own."* Integrating Google Assistant into regular learning routines might require additional strategies to support sustained engagement beyond the classroom setting.

Theme 3: Envisioning the Future: Feature Enhancements and Personalized Learning.

Despite the identified limitations, participants offered valuable suggestions for improvement. A key recommendation was to incorporate more advanced dialogue practice features. Participant 6 proposed, *"It would be great if Google Assistant could have more advanced conversation features where we could practice different types of dialogues, like ordering food or asking for directions."* This highlights the desire for functionalities that cater to practicing context-specific conversations and real-world scenarios.

Furthermore, participants expressed a need for personalized feedback on pronunciation and fluency. Participant 8 suggested, *"I think it would be helpful if Google*

Assistant could give more specific feedback on my pronunciation, not just tell me if it's right or wrong. It would be nice to know what I can do to improve my speaking fluency as well." Incorporating more nuanced feedback tailored to individual needs could enhance the learning experience and provide learners with actionable strategies for improvement.

In conclusion, the qualitative analysis revealed that Google Assistant holds promise as a tool for L2 learning. Participants reported benefits in pronunciation practice, increased speaking opportunities, and enhanced motivation. However, challenges related to voice recognition accuracy, limited functionality for advanced tasks, and maintaining consistent use were also identified. By incorporating features for practicing complex dialogues, providing personalized feedback, and fostering continued engagement outside the classroom, Google Assistant has the potential to become an even more effective tool for supporting L2 learners on their language learning journeys.

Discussion

This mixed-methods study delves into the potential of Google Assistant as a tool for enhancing L2 speaking performance, motivation, and self-regulation among Chinese EFL learners. The findings contribute significantly to the special issue's focus on technology-assisted LOA practices by offering insights into how IPAs can promote learner engagement with feedback mechanisms.

The observed improvement in speaking proficiency aligns with the concept of reduced anxiety in L2 learning environments facilitated by IPAs [50], a key factor for effective feedback as highlighted by Woodrow [51]. By fostering a low-pressure environment, Google Assistant may encourage more frequent speaking opportunities, ultimately improving fluency. Thematic analysis further revealed that participants valued the real-time pronunciation feedback provided by Google Assistant (Theme 1). This aligns with the emphasis on immediate and actionable feedback within LOA frameworks [10]. Receiving immediate feedback allows learners to actively adjust their speaking and solidify correct pronunciation patterns, promoting a dialogue between learner and technology.

Unlike traditional pronunciation practice methods confined to classrooms, Google Assistant allows learners to practice anytime, anywhere [4]. This flexibility caters to busy schedules and removes geographical limitations, potentially leading to more consistent practice and improved fluency. The findings also resonate with Tai's [8] research, where learners appreciated the interactive nature of IPA interaction. Unlike static resources, IPAs provide a dynamic environment that encourages active participation and reinforces learning through real-time

responses and prompts. The current study sheds light on both the potential and limitations of Google Assistant for L2 motivation. While the Assistant offers valuable feedback and practice opportunities, it may not be a stand-alone solution for motivation, as evidenced by the lack of a statistically significant difference between groups. This aligns with Dörnyei's [52] model, which emphasizes intrinsic factors like personal goals and enjoyment. Thematic analysis (Theme 1) suggests Google Assistant increased interactivity, potentially contributing to enjoyment. However, enjoyment alone might not be enough [25]. Future iterations could integrate features that allow learners to set personalized goals, connect with native speakers, or utilize gamification elements to bridge the gap between the technology and learner aspirations [27, 53, 54]. Social interaction and a sense of community are also crucial for L2 motivation [26]. While Google Assistant allows for some interaction, it currently lacks the collaborative and social aspects found in online learning communities. Strategically integrating Google Assistant with existing learning practices that address these aspects could be a fruitful avenue for future research [28].

The positive impact of Google Assistant on self-regulation aligns perfectly with the growing emphasis on fostering learner autonomy in L2 learning [37]. By providing opportunities for independent practice, immediate feedback, and the ability to adjust learning pace, Google Assistant aligns with the paradigm shift from passive to proactive engagement emphasized in LOA practices [9]. This fosters learner autonomy and empowers learners to take ownership of their learning journey, a key aspect of self-regulation [30]. Features like self-assessment activities (Theme 1) actively encourage learners to monitor their progress, a cornerstone of effective self-regulated learning (SRL). This ownership fosters the development of autonomous learners [37]. The current study further strengthens the established link between SRL and L2 proficiency [31, 32]. Google Assistant, by promoting self-assessment and independent practice (Theme 1), empowers learners to take an active role in managing their learning, a skill directly linked to achieving language learning goals [33]. While Google Assistant offers valuable tools for individual SRL development, future iterations could integrate features that allow learners to share practice sessions with peers or receive feedback from native speakers, further enriching the SRL experience [34]. Additionally, exploring ways to integrate metacognitive strategies could further aid learners [35, 36]. While Google Assistant does not currently address emotional regulation directly, the sense of accomplishment gained through self-directed practice and positive feedback can contribute to a more positive emotional learning experience [37]. Additionally, exploring ways to integrate peer feedback or interaction with native speakers could add

a valuable social dimension to the SRL experience facilitated by IPAs [39].

The qualitative data provided valuable insights for improving Google Assistant's functionalities for L2 learning. The perceived benefits, such as personalized pronunciation practice and increased speaking opportunities (Theme 1), resonate with the affordances of IPAs identified in previous research [19]. However, the identified challenges regarding voice recognition accuracy and limitations in handling complex topics (Theme 2) point towards areas for improvement. These insights can inform developers to create more sophisticated voice recognition systems and incorporate functionalities that cater to practicing advanced language skills, such as open-ended discussions or scenario-based dialogues. The suggestions for improvement gleaned from the qualitative data (Theme 3) offer valuable direction for the future development of IPAs for language learning. Students expressed a desire for features that target complex dialogues (Theme 3). Incorporating functionalities that provide personalized feedback on fluency, grammar, and vocabulary could significantly enhance the learning experience. Additionally, the study underscores the need for strategies to promote consistent use outside of the classroom setting (Theme 2). Integration with learning management systems or gamification elements could be fruitful strategies to explore in future research. Investigating how best to leverage spaced repetition techniques or curate personalized learning pathways within IPAs could further optimize language learning experiences.

This study contributes to the theoretical framework of language learning by exploring how IPAs like Google Assistant can promote self-regulated learning within L2 speaking. The observed improvements in participants' self-regulation strategies suggest that IPAs foster learner autonomy through two key mechanisms. Firstly, by providing immediate feedback, IPAs empower learners to identify and address errors in their speaking, ultimately promoting self-correction and metacognitive awareness. Secondly, the interactive nature of IPAs encourages self-directed practice, fostering learner autonomy and self-regulation in scheduling and conducting speaking activities. These findings align with and contribute to the growing body of research on technology-assisted language learning (TALL), particularly regarding the potential of IPAs to supplement traditional pedagogical approaches and support the development of SRL in L2 speaking. Additionally, the positive impact on pronunciation found in this research aligns with the idea that IPAs can provide accessible and interactive opportunities for pronunciation practice, potentially leading to improved accuracy and fluency.

The study's implications extend beyond theory, holding significant practical value for educators, learners, and

developers of language learning technologies. Educators can strategically integrate Google Assistant into lesson plans, coupled with guidance on its effective use. This allows them to leverage its strengths for pronunciation practice and fostering SRL skills. However, the identified limitations, such as accuracy issues and limited support for complex topics, necessitate careful integration within a broader pedagogical framework that addresses these limitations. For learners, Google Assistant can be a valuable supplementary tool, offering opportunities for self-directed practice through interaction with the IPA. Additionally, learners receive real-time feedback on pronunciation and potentially other aspects of speaking, allowing for self-correction and improvement. Regular interaction with Google Assistant can further encourage learners to take ownership of their learning process and develop self-regulation strategies. However, learners should be aware of potential limitations, such as accuracy issues, and utilize Google Assistant alongside other learning resources and strategies for a well-rounded learning experience.

Finally, the study suggests directions for enhancing IPAs like Google Assistant. Addressing voice recognition accuracy for non-native accents is crucial for wider user adoption. Additionally, incorporating features that cater to complex language skills, such as open-ended discussions or scenario-based dialogues, would significantly improve the utility of IPAs for L2 learners. Furthermore, integrating goal-setting functionalities, reward systems, and the possibility of interacting with native speakers could enhance motivation and create a more holistic and engaging learning experience for L2 learners.

Limitations

The findings of this study should be considered in light of certain limitations. Firstly, the study was conducted with a specific participant pool of Chinese EFL learners, which may limit the generalizability of the results to other populations and learning contexts. Further research with more diverse populations is necessary to validate and extend these findings. Secondly, the study relied on self-reported measures of motivation, which are inherently susceptible to bias. Future research could benefit from including more objective measures, such as tracking user engagement with Google Assistant or analyzing changes in learner autonomy over time, to provide a more comprehensive picture of the tool's impact.

Thirdly, the study design focused on a relatively short intervention period. Longitudinal studies are needed to explore the long-term effects of using Google Assistant on L2 learning outcomes and to investigate how learner behavior and engagement with the technology might evolve over time. A significant limitation of this study is the small sample size, which can impact the statistical

power of the findings and the generalizability of the results. The small sample size limits the ability to detect smaller effects and increases the margin of error, making it difficult to generalize the findings to a broader population. Future studies should aim to include larger sample sizes to enhance the reliability and validity of the results.

Fourth, this study did not explicitly control for factors such as prior language learning experience or learner styles. These variables could potentially influence learners' responses to the intervention and their overall L2 learning outcomes. Future research with a more complex design, such as a multi-group design that considers prior language learning experience levels, could provide a more nuanced understanding of how Google Assistant interacts with individual learner characteristics to impact L2 learning. By exploring these potential interactions, future research can contribute to the development of more targeted and personalized learning experiences using Google Assistant.

Despite these limitations, the current study offers valuable insights into the potential and limitations of Google Assistant as a tool for L2 learning. By addressing the identified limitations and incorporating user-driven suggestions for improvement, Google Assistant has the potential to become an even more effective tool for supporting L2 learners on their language learning journeys. Further research is necessary to explore the long-term impact of IPAs on L2 learning and to identify optimal integration strategies within broader language learning environments.

Conclusion

This mixed-methods study investigated the potential of Google Assistant as a tool for enhancing L2 speaking performance, motivation, and self-regulation among Chinese EFL learners, particularly within the framework of learner-oriented autonomy (LOA). The findings contribute meaningfully to the understanding of how technology can be leveraged to support L2 learning within an LOA framework.

The study demonstrates that Google Assistant has the potential to promote learner engagement with feedback, a critical component of effective LOA. Qualitative data suggests that participants found Google Assistant's interactive nature to be motivating, hinting at its potential to enhance intrinsic motivation (Theme 1). However, statistically significant changes in self-reported L2 motivation were not observed. This underscores the multifaceted nature of motivation and necessitates further research employing a wider range of motivational constructs and methodologies. Additionally, investigating how Google Assistant can be integrated with strategies that target extrinsic motivational factors could yield valuable insights.

The study also identified limitations related to voice recognition accuracy and the inability to handle complex topics (Theme 2). These limitations necessitate further development on the part of technology providers to create a more robust and versatile tool for L2 learners. On a positive note, the study identified Google Assistant's potential to foster self-regulation among L2 learners. Features like self-assessment activities and the anytime, anywhere practice flexibility (Theme 1) were perceived as empowering and contributed to a sense of ownership over the learning process. This aligns with the growing emphasis on learner autonomy in L2 learning and suggests that IPAs like Google Assistant have the potential to equip learners with the skills necessary to become more independent and self-directed language learners. Future research could explore how Google Assistant can be integrated within broader pedagogical frameworks to address identified limitations and further enhance its effectiveness in promoting self-regulation and L2 speaking proficiency. Additionally, investigating the long-term impact of using Google Assistant on learner autonomy and language development would be valuable.

Appendix

Interview Questions

1. Can you describe your experience using Google Assistant for your English learning activities?
2. How did you find Google Assistant helpful in improving your speaking skills?
3. Did you encounter any challenges in using Google Assistant for learning English?
4. In your opinion, how can Google Assistant be further improved to support L2 learners?
5. Do you have any overall thoughts or feedback about using Google Assistant for learning English?

Author contributions

MZ is the sole author and contributor to this research project.

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Data availability

The corresponding author, Meifang Zhang (Email: gzzmfang@sina.com), is happy to share the data upon reasonable request.

Declarations

Ethical considerations

This research was conducted with the utmost respect for ethical principles. The study protocol underwent a rigorous review and was granted approval by the Institutional Review Board (IRB) of the School of Foreign Languages at Guangzhou Institute of Science and Technology (Guangzhou, China, 510540). The IRB confirmed that the research design posed no potential harm to

participants. All participants freely participated in the study after being fully informed. This included providing written informed consent, receiving a clear explanation of the research objectives, and having the opportunity to ask questions. Participants were also assured of their right to withdraw from the study at any point without explanation or consequence.

Consent for publication

This section is not applicable to the current study.

Competing interests

The authors declare no competing interests.

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