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The Effectiveness of Technology-Mediated Oral Corrective Feedback on the Acquisition of English Vowels by Kurdish EFL Learners

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Abstract

Oral corrective feedback (oral CF) has been widely investigated in second language pronunciation research because of its potential to promote more target-like phonological production. However, little is known about how technology-assisted oral CF affects learners' segmental accuracy as measured through acoustic analysis, and no study to date has examined this with Kurdish EFL learners' production of English vowels. For this purpose, sixty Kurdish EFL learners at a university in Kurdistan were randomly assigned to three groups: (a) an explicit oral CF group, receiving oral explanations supported by visual feedback in Praat; (b) an implicit oral CF group, receiving recasts and input enhancement via YouGlish; and (c) a control group, receiving no oral CF. Ten Native American English speakers provided baseline acoustic data for the target vowels. All learners completed a pre-test, post-test, and delayed post-test two months later. Their production of /iː/ and /ɪ/ was elicited through word reading, sentence reading, and picture description. Results showed that the explicit oral CF group achieved significantly greater improvement than both the implicit oral CF and control groups. Furthermore, only the explicit group maintained gains at the delayed post-test, indicating more durable effects of technology-assisted teacher feedback.

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Introduction[1]

Attaining accurate production of L2 sounds is essential for intelligible communication between second language (L2) speakers and listeners (Koffi, 2021; Leis, 2025; Levis, 2018). Among the various components of pronunciation, vowels are particularly problematic, as they often pose persistent difficulties for L2 learners to perceive and produce accurately (Kartushina et al., 2016; Li et al., 2026; Rallo Fabra & Romero, 2012; Reskiawan et al., 2026; Stratton, 2025). Pronunciation has been repeatedly identified as one of the most challenging skills in learning English (Pourhossein Gilakjani, 2016), underscoring the need for effective instructional approaches that target segmental accuracy (Al-Jarf, 2026; Tavakoli, 2026).

In many English as a foreign language (EFL) contexts, learners' difficulties with sound production are shaped by both the influence of their L1 phonological system and the nature of classroom teaching practices (Begum & Hoque, 2016; Li et al., 2026; Reskiawan et al., 2026; Zheng & Liu, 2018). In the Kurdish EFL context specifically, prior research has shown that teaching remains largely teacher-centered, with a strong reliance on traditional methods such as repetition drills and limited opportunities for interactive practice and feedback (Ghafar et al., 2023; Sofi-Karim, 2015). This instructional profile suggests that learners may not receive sufficient or effective feedback on their pronunciation, pointing to a clear need for more communicative and feedback-rich approaches, including oral corrective feedback (oral CF) supported by technological tools (Chiusano & Luchini, 2026; Martin & Sippel, 2026).

Corrective feedback has also evolved with the increasing integration of technology into language teaching and learning. A substantial body of research on Computer-Assisted Pronunciation Training (CAPT) has shown that technological tools can provide immediate, individualized feedback that is difficult to offer consistently in traditional teacher-fronted classrooms (Abdelhalim & Alsehibany, 2025; Liu et al., 2025; Rahim & Apzhaparovna, 2026; Rogerson-Revell, 2021; Rogti, 2025; Toyama & Hori, 2025). For instance, tools such as Praat (Boersma & Weenink, 2022) allow learners to receive visual feedback on their speech by displaying waveforms and formant patterns. Studies have reported that such visual–acoustic feedback can significantly improve learners' segmental production, particularly when their output is compared to native-speaker models and accompanied by targeted feedback (Liakin et al., 2017; Mahmood, 2024b; Ping & Tao, 2025). Likewise, research on High-Variability Phonetic Training (HVPT) has shown that exposing learners to multiple native-speaker voices can enhance the accuracy of their target sound production, with meta-analytic evidence indicating a medium overall effect size for HVPT-based pronunciation training (Thomson, 2018; Uchihara et al., 2025). These findings suggest that oral corrective feedback, when integrated with technology providing visual, acoustic, and authentic input (e.g., Praat, YouGlish), holds

[1] This article reports part of the first author's doctoral thesis, submitted to the University of Wollongong, Australia, in 2026.

considerable promise for improving L2 pronunciation (Abdelhalim & Alsehibany, 2025; Chiusano & Luchini, 2026; Olowoyeye, 2026).

However, despite these promising results, the pedagogical use of such technologies, particularly spectrographic displays and online authentic input tools, has been described as still being in its infancy in terms of classroom application and systematic evaluation (Quintana-Lara, 2014; Walesiak & Talley, 2025). Recent work also indicates that technology-mediated pronunciation instruction depends on coherent task design, teacher mediation, and the affordances and constraints of the instructional setting rather than on technology alone (Chiusano & Luchini, 2026; Lagerlöf, 2026). Moreover, very few studies have compared different types of technology-enhanced oral CF (e.g., explicit visual–acoustic feedback vs. more implicit, input-based feedback) for segmental pronunciation, and, to our knowledge, none have done so in the Kurdish EFL context. To address these gaps, the present study investigates the effects of teacher-provided oral CF supported by Praat-based visual feedback and HVPT through YouGlish on Kurdish EFL learners' production of English vowels.

Literature Review

Oral Corrective Feedback in L2 Pronunciation

In the oral CF literature, a key distinction is drawn between explicit and implicit feedback. Explicit feedback occurs when teachers directly indicate an error and provide the correct form, often with a metalinguistic explanation. Implicit feedback typically takes the form of recasts, where teachers reformulate learners' erroneous utterances without overtly signaling correction, in order to maintain communicative flow (Li, 2013; Liu et al., 2025; Lyster & Ranta, 1997; Martin & Sippel, 2026; Pawlak, 2025; Saito & Lyster, 2012).

Although explicit CF is well established as effective for promoting self-correction in morphosyntax (Ellis, 2017; Lyster & Saito, 2010), its effectiveness for pronunciation remains less conclusive. Some studies have shown that learners often fail to notice phonological recasts because the corrective signal is subtle (Martin & Sippel, 2026; Sheen, 2006). Other research (e.g., Liu et al., 2025; Rogti, 2025; Saito & Lyster, 2012) has found that form-focused instruction combined with explicit CF leads to more durable gains in L2 segmental accuracy than conditions without such feedback, whereas purely implicit CF may not sufficiently direct learners' attention to fine-grained segmental contrasts. Saito (2015) further suggests that recasts may be more effective when learners already possess some awareness of the target form. Overall, the available evidence indicates that although any feedback is preferable to none, explicit oral CF tends to provide greater benefits in improving the accuracy of challenging L2 sounds (Abdelhalim & Alsehibany, 2025; Ammar Hassan Hassan et al., 2025; Martin & Sippel, 2026).

CAPT, Visual Feedback, and HVPT

Computer-Assisted Pronunciation Training (CAPT) has advanced rapidly alongside developments in educational technology for L2 teaching and learning. CAPT tools are designed to support pronunciation practice by offering features such as immediate feedback, visualizations, and playback for self-evaluation (Abdelhalim & Alsehibany, 2025; Lagerlöf, 2026; Levis et al., 2023; Rahim & Apzhaparovna, 2026; Toyama & Hori, 2025). Pennington (2021) argues that such technologies have positively influenced L2 teaching, particularly by enabling timely and consistent corrective feedback. A key advantage of CAPT is its capacity to reduce learners' anxiety by providing extensive opportunities for self-paced, private practice (Abdelhalim & Alsehibany, 2025; Neri et al., 2002). Meta-analytic evidence further indicates that CAPT has a significant positive impact on pronunciation learning when compared with traditional pronunciation instruction and feedback, with especially strong benefits for adult and intermediate learners (Al-Jarf, 2026; Lee et al., 2015; Tavakoli, 2026). A range of CAPT tools has been examined in the literature, including commercial programs (e.g., Pronunciation Power, Rosetta Stone) and research-oriented software such as Praat, as well as newer ASR- and AI-supported systems used for individualized pronunciation practice.

Visual feedback, as a form of nonverbal corrective feedback, has attracted considerable attention in L2 pronunciation research for its ability to make speech visible. Tools such as Praat allow learners to view waveforms, formant plots, and temporal characteristics of their productions, thereby linking abstract phonetic concepts to concrete visual representations. Studies have shown that such visual input can enhance both perception and production: Francophone learners who received visual feedback improved the intelligibility of their consonant and vowel productions more than those without it (Liakin et al., 2017), and learners using Praat developed a clearer understanding of notions such as tongue height, voice onset time, and duration, which promoted greater self-correction (Li et al., 2026; Okuno & Hardison, 2016; Ping & Tao, 2025). These findings suggest that when corrective feedback is combined with audio-visual input, it can better accommodate diverse learning styles and foster deeper processing of L2 pronunciation features (Lagerlöf, 2026; Toyama & Hori, 2025).

Building on this line of research into visual feedback, recent work has also examined easily accessible online platforms as sources of authentic pronunciation input within CAPT. In particular, YouGlish has been used to provide multiple naturally occurring exemplars of target words produced by different speakers in varied contexts (Al-Jarf, 2026; Mahmood, 2024b; Miller, 2019; Olatoye & Olurinola, 2025; Sardegna & Jarosz, 2022; Topal, 2023). When systematically exploited within a High-Variability Phonetic Training (HVPT) framework, YouGlish can offer rich, high-variability input (Quispe-Vargas et al., 2024), thereby supporting both explicit and implicit feedback on learners' segmental production. Crucially, it also exposes learners to diverse accents and speaking styles, a core principle of HVPT (Chiusano & Luchini, 2026; Logan et al., 1991; Thomson, 2018; Uchihara et al., 2025). Current pedagogical reviews emphasize that such CAPT resources are most effective when integrated into instruction to complement, rather than replace, teacher-provided feedback, enabling more precise and individualized pronunciation support (Lagerlöf, 2026; Martin & Sippel, 2026; Rogerson-Revell, 2021; Thomson, 2018; Walesiak & Talley, 2025).

A recent meta-analysis by Mahdi and Mohsen (2024) reported that HVPT has a medium overall effect on pronunciation learning and is particularly beneficial for segmental features among advanced learners, likely because they have sufficient cognitive resources to process complex input and translate it into refined output adjustments. HVPT has been operationalized in various ways: in some studies, learners are exposed to recordings of target segments produced by multiple native speakers and receive feedback on their perception and production; in others, platforms such as YouGlish are used to provide high-variability input, allowing learners to hear and see multiple exemplars of the same target form across a range of speakers and contexts (Mahmood, 2024a, 2024b; Martin & Sippel, 2026; Miller, 2019).

Theoretical Frameworks: Sociocultural and Cognitive Perspectives

This study is grounded in sociocultural theory (SCT) and cognitive perspectives to explain how oral CF and pronunciation training function in technology-mediated contexts. From an SCT perspective, learning is a mediated process in which interaction with a more knowledgeable other (e.g., a teacher or a technological tool) supports movement to higher levels of ability (Huong & Hung, 2021; Lagerlöf, 2026; Vygotsky, 1978). In this sense, CF and technological tools used for pronunciation can be viewed as forms of mediation (Aljaafreh & Lantolf, 1994; Lenkaitis, 2020; Liu et al., 2025; Mahn & John-Steiner, 2012; Rahim & Apzhaparovna, 2026). Adopting this framework allows a more nuanced interpretation of technology-assisted CF and provides a basis for explaining the results in terms of both social interaction and cognitive processing, particularly when feedback helps learners notice, compare, and adjust fine-grained phonological contrasts during practice.

The Study

Despite the growing body of research on oral CF and CAPT, several gaps can be noticed in the literature. Few studies combine explicit and implicit oral CF with visual–acoustic feedback and high-variability phonetic input within a single experimental design, particularly using acoustic measures such as vowel duration and formant values. Research has also focused on widely studied learner populations, leaving under-researched contexts such as Kurdish EFL learners largely unexplored. In addition, studies tend to examine tools such as Praat and YouGlish separately, rather than testing how they work together to deliver different types of feedback across time.

Another limitation concerns the instructional setting. Most studies rely on controlled or face-to-face environments, with less attention to fully online instruction, where feedback delivery, interaction, and learner engagement follow different patterns. This gap matters given the shift toward technology-mediated and online language learning, especially for pronunciation, which increasingly depends on digital tools and remote feedback. Further strength lies in the task design, which reflects how pronunciation develops in real use. The study uses three tasks that move from controlled to spontaneous production. Word reading and sentence reading represent controlled conditions in which learners can focus on accuracy. The picture description task requires spontaneous speech, where learners must manage pronunciation under communicative pressure. This design tests whether gains appear only in controlled settings or transfer to real-time communication, providing a more valid account of pronunciation development.

This study addresses these gaps by examining how technology-assisted explicit and implicit oral CF influence the development and retention of English vowel production among Kurdish EFL learners in an online setting. It combines Praat-based visual feedback, HVPT authentic input through YouGlish, and a controlled longitudinal design to test how feedback type and technology shape segmental learning over time. The study contributes acoustic evidence from an underrepresented context and captures both immediate change and delayed retention in pronunciation development. Specifically, the study addresses the following research questions:

RQ$_1$: Does technology-assisted explicit oral CF lead to greater improvement in the production of /iː/ and /ɪ/ than technology-assisted implicit oral CF or no oral CF?

RQ$_2$: Are there any gains from these types of oral CF maintained over time?

Method

Context

This study was conducted in Iraqi Kurdistan, at the English Department, College of Education, Salahaddin University-Erbil, during the 2023-2024 academic year. The participants were second-year undergraduates enrolled in a four-year bachelor's degree in English language. In the first year of the program, students complete foundational English courses in grammar, communication, speaking, listening, reading, and writing. By the second year, their proficiency typically falls between B1 and B2 on the Common European Framework of Reference for Languages (CEFR). All learner participants were native speakers of Central Kurdish (Sorani) and shared broadly similar educational backgrounds.

The local EFL context is relevant to the design of the study because English instruction in Iraqi Kurdistan has traditionally relied on teacher-centered classroom practice, repetition, and limited opportunities for interactive pronunciation feedback (Ghafar et al., 2023; Sofi-Karim, 2015). Recent curricular reforms have introduced English earlier in schooling and have promoted more interactive materials; however, university learners still vary in the amount and quality of pronunciation-focused feedback they have received before entering higher education. This contextual profile supports the need to test whether teacher-mediated, technology-supported oral CF can improve Kurdish EFL learners' production of English vowel contrasts.

To address possible mediating variables, the study kept the learner context as constant as possible: all Kurdish participants came from the same department, year level, institutional setting, L1 background, and broadly similar age and proficiency range. Group assignment was random, group size was equal, and the intervention conditions differed only in the type and focus of feedback provided on the target vowels. None of the learner participants reported speech or hearing impairments, and none had received prior pronunciation training focused on the target vowels.

Participants

Sixty Kurdish EFL learners were recruited through a formal invitation circulated in the English Department at the College of Education, Salahaddin University-Erbil. Students who wished to participate completed a registration form and then provided consent before joining the study. They were second-year undergraduate students enrolled in a four-year bachelor's degree in English language in the 2023-2024 academic year. All participants were native speakers of Central Kurdish (Sorani), aged 18-25, with a mean age of approximately 19 years. Students were randomly assigned to one of three equal groups (n = 20 per group): an explicit oral CF group, an implicit oral CF group, and a control group. This random allocation supported balanced distribution across the experimental and control conditions.

Table 1

Kurdish EFL Participants' Demographic Information

Group	Number	Age Range	Mean Age	SD	Total
Explicit oral CF	20 (8 M, 12 F)	18-25	19	1.81	60
Implicit oral CF	20 (13 M, 7 F)	18-25	19	2.17	
Control	20 (9 M, 11 F)	18-25	19	1.94	
Location	Iraqi Kurdistan				

A fourth group comprised 10 native speakers of American English from the Los Angeles area in California. They were recruited through the first author's personal contacts established during his two-year residence and master's study in California. This baseline group was included because American English is prominent in the Kurdish EFL context through exposure to films, television programs, and popular music. All baseline speakers had lived in the region for most of their lives and reported no history of speech or hearing disorders. The group was gender-balanced (five males and five females), with an age range of 18-40 years ($M = 36, SD = 1.57$). They completed the same speech tasks as the Kurdish EFL learners, and their recordings were used as a baseline for evaluating the stability and direction of learners' vowel production before and after the oral CF intervention.

Table 2
American English Baseline Speakers' Demographic Information

Gender	Number	Age range	Mean age	SD	Total
Male	5	18-40	37	1.33	10
Female	5	18-40	35	1.79	
Location	Los Angeles, California, USA				

Training Interventions
After random assignment, the three groups differed in the type and focus of oral CF they received. The explicit oral CF group received teacher-led metalinguistic feedback on the target vowels. Praat was used to provide visual-acoustic feedback by displaying learners' vowel productions and comparing them with the baseline productions. YouGlish was also used to expose learners to authentic examples of the target vowels in different speakers' productions. During this condition, the teacher explicitly directed learners' attention to the phonetic differences between their productions and the baseline patterns.

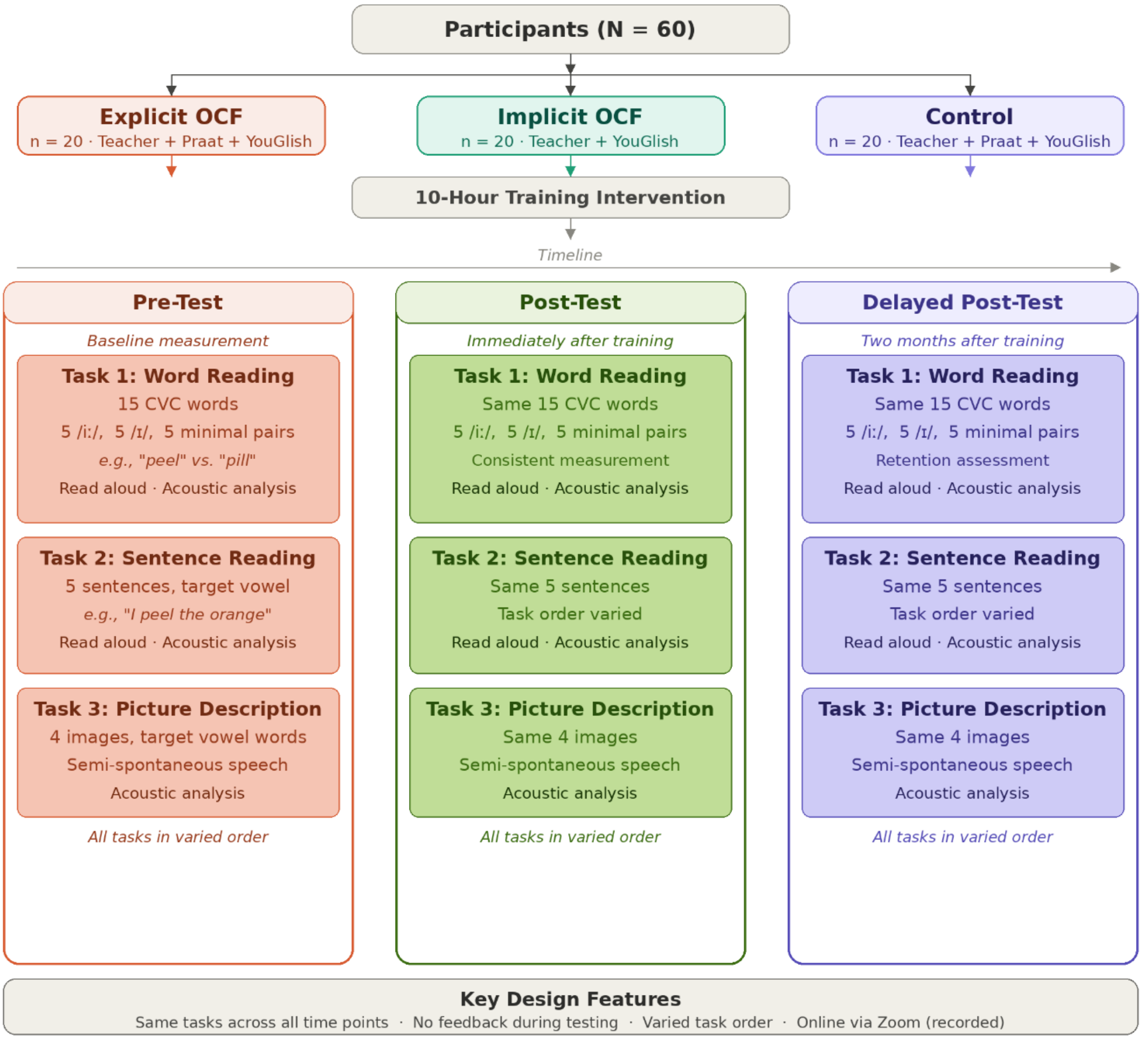
The implicit oral CF group received recasts during pronunciation exercises and teacher-student interaction. They did not receive visual feedback through Praat and did not receive explicit metalinguistic explanation of the target vowel contrasts. The teacher selected YouGlish videos containing words with the target vowels, but learners were not explicitly guided to compare their productions with the baseline. In this condition, learners were expected to notice the relevant phonetic differences through exposure and recasts.

The control group did not receive feedback on the target vowels. To keep classroom attention comparable while avoiding treatment on the target contrasts, the control group received general pronunciation feedback on other features of English pronunciation. This design allowed the study to compare explicit oral CF, implicit oral CF, and no target-vowel CF while holding the institutional context, learner population, and assessment procedure constant.

Tasks and Procedure
This study used three speech-production tasks to collect comparable pronunciation data: (1) reading words in isolation, (2) reading sentences containing the target vowels, and (3) completing a picture description task. The first two tasks elicited controlled production, while the picture description task elicited more spontaneous speech. The Kurdish EFL learners completed the three tasks at three testing points: pre-test, immediate post-test, and delayed post-test two months later. The American English baseline group completed the same speech materials once. This task sequence allowed the study to examine whether any gains appeared only in controlled reading or also extended to less controlled production. The procedure is summarized in Figure 1.

Figure 1

Assessment Timeline and Task Design for Pronunciation Evaluation



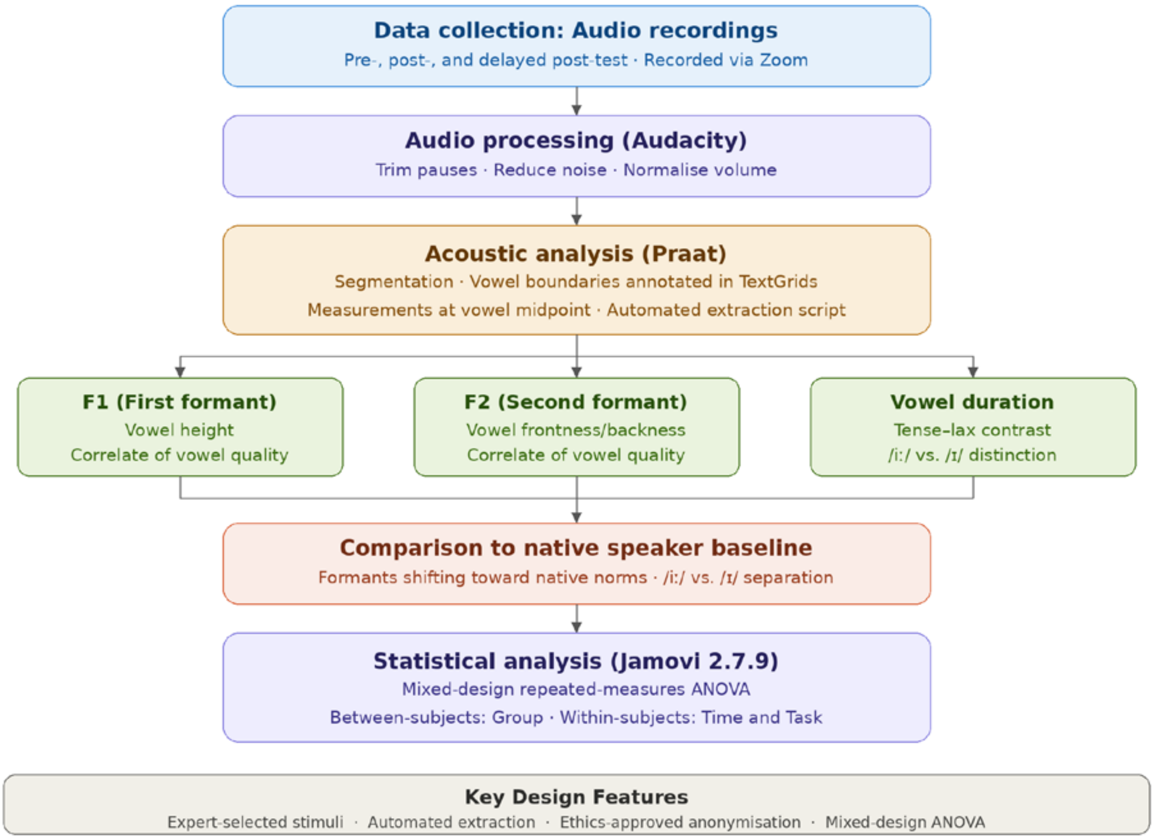
Data Collection and Analysis

All data consisted of audio recordings from the word-reading, sentence-reading, and picture-description tasks. Each recording was anonymized before acoustic analysis. The word lists, sentences, and pictures were selected following expert recommendations in pronunciation research. Recordings were annotated and segmented in Praat (Boersma & Weenink, 2022), using parameter settings established in previous work (e.g., Jacewicz et al., 2009). Vowel measurements were taken at the temporal midpoint to minimize coarticulatory transitions (Wikström, 2013). An automated Praat script (Herrero de Haro, 2023) was then used to extract duration, F1, and F2 values, ensuring consistency and reducing researcher bias.

All data were handled in accordance with ethical guidelines approved by the Social Sciences Human Research Ethics Committee at the University of Wollongong (Ethics Approval No. 2022/344). The resulting dataset was analyzed in Jamovi 2.7.9 using mixed-design repeated-measures ANOVA. This approach was appropriate because the study compared within-participant change across testing times and tasks while also comparing between-group differences across the explicit oral CF, implicit oral CF, and control groups. Similar analytical designs have been widely used in applied linguistics research (Saito & Lyster, 2012; Yang & Lyster, 2010). Details of the analytic procedure are summarized in Figure 2.

Figure 2

Data Collection and Analysis Workflow



Results

This section reports the results for the acoustic analyses for the target vowels /iː/ and /ɪ/ in relation to the two research questions. Repeated-measures ANOVAs examined the effects of group (explicit CF, implicit CF, control), time (pre-test, post-test, delayed post-test), and task (word reading, sentence reading, picture description) on vowel duration and acoustic measures (F1 and F2). Statistical results are summarized in Tables 3–10, and developmental trajectories relative to baseline targets are illustrated in Figures 3–8.

Research Question 1

Vowel duration

Duration of /iː/. The significant time × group interaction, $F(4.04, 88.91) = 2811.37$, $p < .001$, $\eta^2 = .223$ (Table 3), indicates that learners in the three instructional conditions followed different temporal development patterns. Specifically, the explicit CF group demonstrated the largest reduction in /iː/ duration from pre-test to post-test, moving substantially closer to baseline targets. In contrast, the implicit CF group exhibited smaller but consistent reductions, while the control group showed minimal temporal adjustment across testing phases.

The presence of a significant task × group interaction, $F(4.15, 91.35) = 17.51$, $p < .001$, $\eta^2 = .002$, together with a significant time × task × group interaction, $F(4.02, 88.34) = 2.98$, $p = .023$, suggests that the superiority of explicit CF was stable across communicative contexts. The strong between-subjects group effect, $F(3, 66) = 9536.00$, $p < .001$, $\eta^2 = .554$ (Table 4), further confirms systematic differences between instructional conditions. These patterns are illustrated in Figure 3.

Table 3

Repeated Measures ANOVA within Subjects Effects

	Sum of Squares	df	Mean Square	F	p	η²
Time	169304	1.35	125678.1	7990.89	<.001	0.211
Time ✻ Group	178694	4.04	44216.3	2811.37	<.001	0.223
Task	438	1.38	316.5	15.84	<.001	0.001
Task ✻ Group	1453	4.15	349.9	17.51	<.001	0.002
Time ✻ Task	140	1.34	104.5	3.60	0.049	0.000
Time ✻ Task ✻ Group	347	4.02	86.4	2.98	0.023	0.000

Note. Type 3 Sums of Squares

Table 4

Repeated Measures ANOVA between Subjects Effects

	Sum of Squares	df	Mean Square	F	p	η²
Group	444475	3	148158.3	9536	<.001	0.554

Note. Type 3 Sums of Squares

Duration of /ɪ/. For /ɪ/, the significant time × group interaction, $F(6, 132) = 160.93$, $p < .001$, $\eta^2 = .110$ (Table 5), similarly indicates divergent developmental trajectories across feedback conditions. Learners receiving explicit CF exhibited the largest duration reductions and the closest alignment with baseline values across tasks. The implicit CF group demonstrated a moderate temporal difference, whereas the control group remained largely unchanged across testing phases.

Figure 3

Effects of Online Oral CF on the Duration of /ɪ/ among the Three Groups Across Three Tasks in Comparison with the Baseline

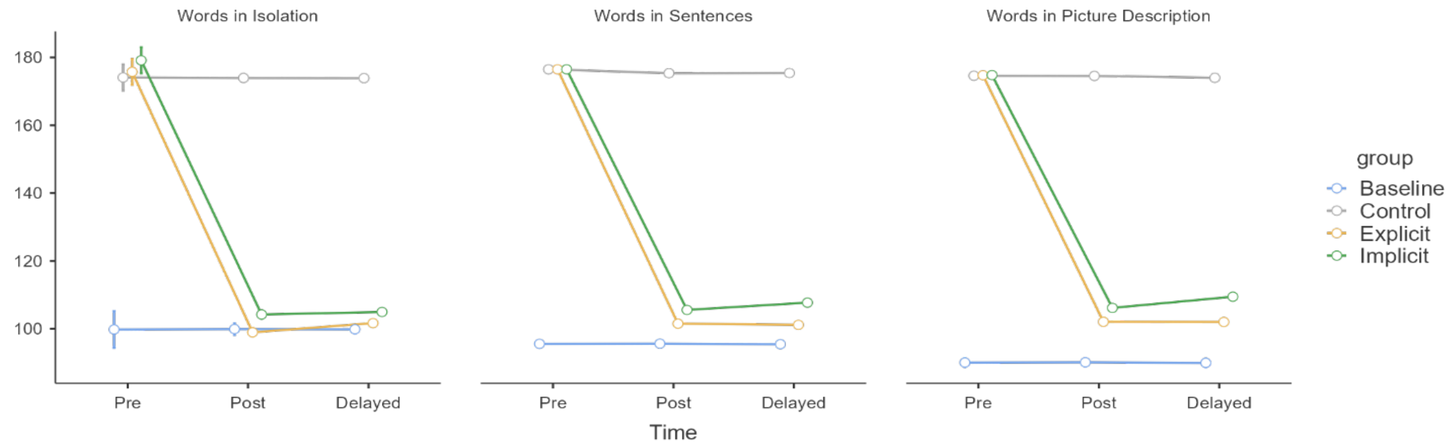


Figure 4

Effects of Online Oral CF on the Duration of /iː/ among the Three Groups Across Three Tasks in Comparison with the Baseline

Additional task-related modulation was reflected in the significant task × group interaction, $F(6, 132) = 76.52$, $p < .001$, $\eta^2 = .024$. The robust between-group effect, $F(3, 66) = 407.00$, $p < .001$, $\eta^2 = .701$ (Table 6), further underscores the magnitude of instructional differences. Group-wise duration trajectories are presented in Figures 3 and 4. Taken together, the duration results indicate that technology-assisted explicit oral CF produced substantially stronger temporal restructuring than implicit oral CF and no-feedback conditions for both target vowels.

Table 5

Repeated Measures ANOVA within Subjects Effects

	Sum of Squares	df	Mean Square	F	p	η^2
Time	10661.7	2	5330.83	396.01	< .001	0.090
Time ✻ Group	12998.0	6	2166.34	160.93	< .001	0.110
Task	28.4	2	14.19	2.29	0.105	0.000
Task ✻ Group	2843.6	6	473.94	76.52	< .001	0.024
Time ✻ Task	76.4	4	19.11	3.23	0.013	0.001
Time ✻ Task ✻ Group	95.4	12	7.95	1.34	0.193	0.001

Note. Type 3 Sums of Squares

Table 6

Repeated Measures ANOVA between Subjects Effects

	Sum of Squares	df	Mean Square	F	p	η^2
Group	82621	3	27540.2	407	< .001	0.701

Note. Type 3 Sums of Squares

Formant Quality (F1 and F2)

Formant measures for /i:/

The significant time × group interaction for F1, $F(4.17, 91.64) = 181.50$, $p < .001$, $\eta^2 = .173$ (Table 7), demonstrates that vowel height adjustments occurred differently across instructional conditions. Learners in the explicit CF group achieved the closest approximation to baseline F1 targets, reflecting improved control of articulatory height. The strong between-subjects group effect, $F(3, 66) = 151.00$, $p < .001$, $\eta^2 = .528$, further confirms these systematic differences.

For F2, significant effects involving time, $F(2, 132) = 6.91$, $p = .001$, $\eta^2 = .004$, and time × group, $F(6, 132) = 5.60$, $p < .001$, $\eta^2 = .010$ (Table 8), indicate group-specific frontness adjustments over time. Moreover, the large task × group interaction, $F(6, 132) = 153.70$, $p < .001$, $\eta^2 = .265$, suggests that explicit CF advantages were consistently expressed across speech contexts. These developments are illustrated in Figure 5 (F1) and Figure 6 (F2). Overall, learners exposed to explicit CF demonstrated the most pronounced formant convergence with baseline targets, whereas the implicit CF group showed weaker but reliable shifts, and the control group exhibited no systematic change.

Table 7

Repeated-Measures ANOVA Summary for F1 of /i:/

Effect	df	*F*	*p*	η^2
Time	1.39, 91.64	477.12	< .001	.152
Time × Group	4.17, 91.64	181.50	< .001	.173
Task	1.68, 110.70	2.36	.108	.001
Task × Group	5.03, 110.70	2.08	.072	.003
Group	3, 66	151.00	< .001	.528

Table 8

Repeated-Measures ANOVA Summary for F2 of /i:/

Effect	df	*F*	*p*	η^2
Time	2, 132	6.91	.001	.004
Time × Group	6, 132	5.60	< .001	.010
Task	2, 132	773.89	< .001	.444
Task × Group	6, 132	153.70	< .001	.265
Time × Task	4, 264	43.55	< .001	.045
Time × Task × Group	12, 264	17.05	< .001	.052

Formant measures for /ɪ/

For /ɪ/, the significant time × group interaction for F1, $F(6, 132) = 23.80$, $p < .001$, $\eta^2 = .099$ (Table 9), indicates that vowel height adjustment differed across instructional conditions. Learners receiving explicit CF displayed the most consistent convergence toward baseline values. This pattern was also observed in F2, where the significant time × group interaction, $F(6, 132) = 7.99$, $p < .001$, $\eta^2 = .032$ (Table 10), reflects differential development of vowel frontness.

The presence of significant task × group interactions for both F1 and F2 further suggests that explicit CF effects generalized across production contexts. These group-specific trajectories are presented in Figures 7 and 8. Collectively, the acoustic analyses corroborate the duration findings by demonstrating that explicit technology-assisted OCF produced stronger segmental restructuring than implicit feedback and no-feedback conditions across both acoustic dimensions.

Table 9

Repeated-Measures ANOVA Summary for F1 of /ɪ/

Effect	df	*F*	*p*	η^2
Time	2, 132	95.38	< .001	.133
Time × Group	6, 132	23.80	< .001	.099
Task	2, 132	11.81	< .001	.017
Task × Group	6, 132	8.75	< .001	.037
Group	3, 66	181.00	< .001	.328

Figure 5

Effects of Online Oral CF on the F1 of /iː/ among the Three Groups Across Three Tasks in Comparison with the Baseline

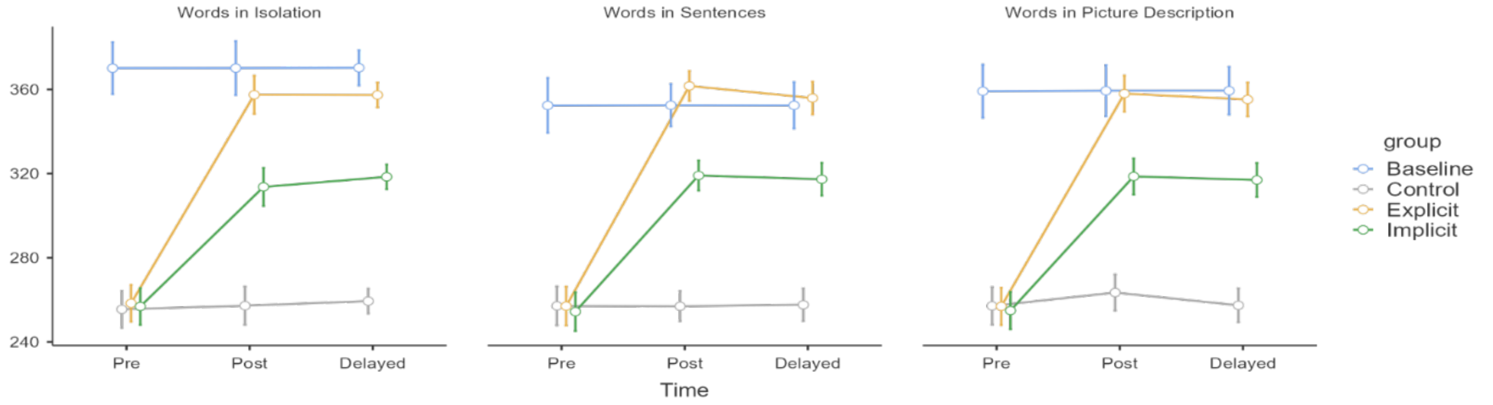


Figure 6

Effects of Online Oral CF on the F2 of /iː/ among the Three Groups Across Three Tasks in Comparison with the Baseline

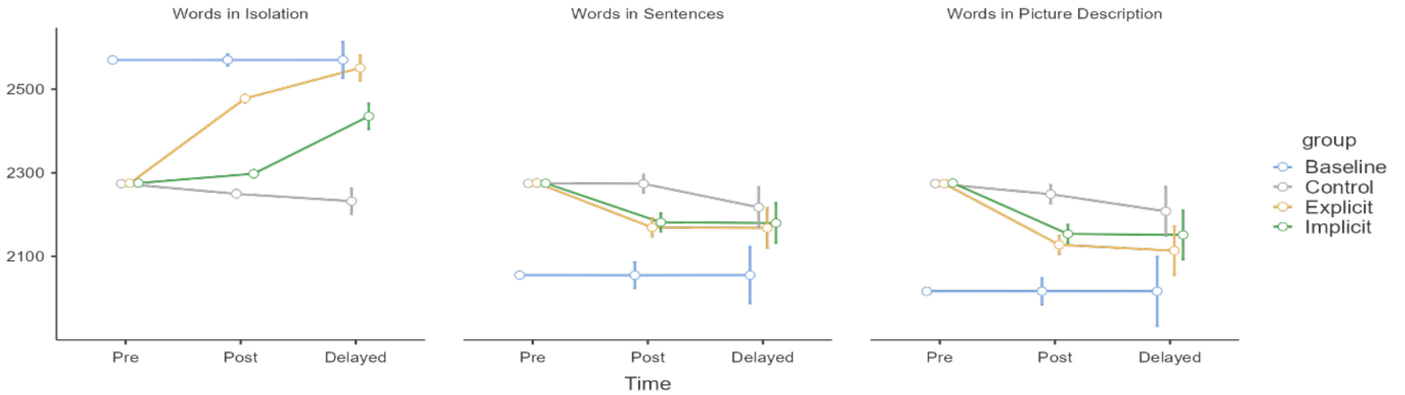


Table 10

Repeated-Measures ANOVA Summary for F2 of /ɪ/

Effect	df	*F*	*p*	η^2
Time	2, 132	64.06	< .001	.086
Time × Group	6, 132	7.99	< .001	.032
Task	2, 132	39.29	< .001	.075
Task × Group	6, 132	31.62	< .001	.181
Group	3, 66	78.10	< .001	.168

Research Question 2

Maintenance effects were examined through comparisons across post-test and delayed post-test measurements. For vowel duration, the significant time × group interactions for /iː/, $F(4.04, 88.91) = 2811.37$, $p < .001$, $\eta^2 = .223$ (Table 3), and /ɪ/, $F(6, 132) = 160.93$, $p < .001$, $\eta^2 = .110$ (See Table 5 above), demonstrate that retention patterns differed systematically across instructional conditions. Inspection of delayed post-test trajectories (See Figures 3 and 4 above) shows that learners in the explicit CF group preserved duration values closely aligned with baseline targets across all tasks. The implicit CF group retained partial gains, whereas the control group did not exhibit meaningful longitudinal change.

Similar maintenance trends were observed for acoustic measures. For /iː/, significant time × group interactions for F1, $F(4.17, 91.64) = 181.50$, $p < .001$, $\eta^2 = .173$ (See Table 5 above), and F2, $F(6, 132) = 5.60$, $p < .001$, $\eta^2 = .010$ (See Table 8 above), indicate sustained group-specific differences at the delayed post-test. For /ɪ/, retention effects were likewise supported by significant time × group interactions for F1, $F(6, 132) = 23.80$, $p < .001$, $\eta^2 = .099$ (Table 9), and F2, $F(6, 132) = 7.99$, $p < .001$, $\eta^2 = .032$ (See Table 10 above). Across both vowels and acoustic dimensions, the explicit CF group consistently maintained phonetic gains over time, demonstrating stable convergence with baseline targets. In contrast, the implicit CF group showed moderate retention, and the control group displayed no durable phonetic development. These findings indicate that technology-assisted explicit OCF can facilitate immediate changes in pronunciation and support longer-term stabilization of segmental accuracy.

Figure 7

Effects of Online Oral CF on the F1 of /ɪ/among the Three Groups Across Three Tasks in Comparison with the Baseline

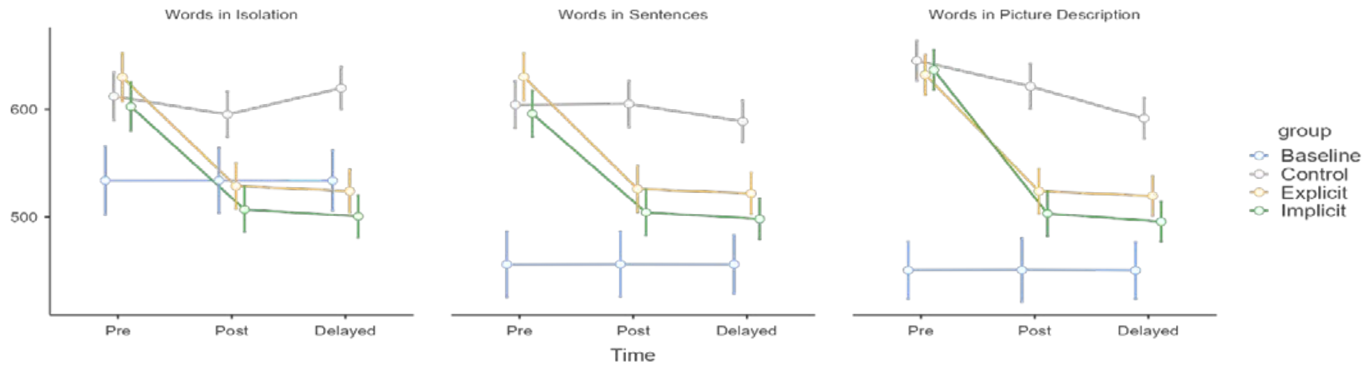
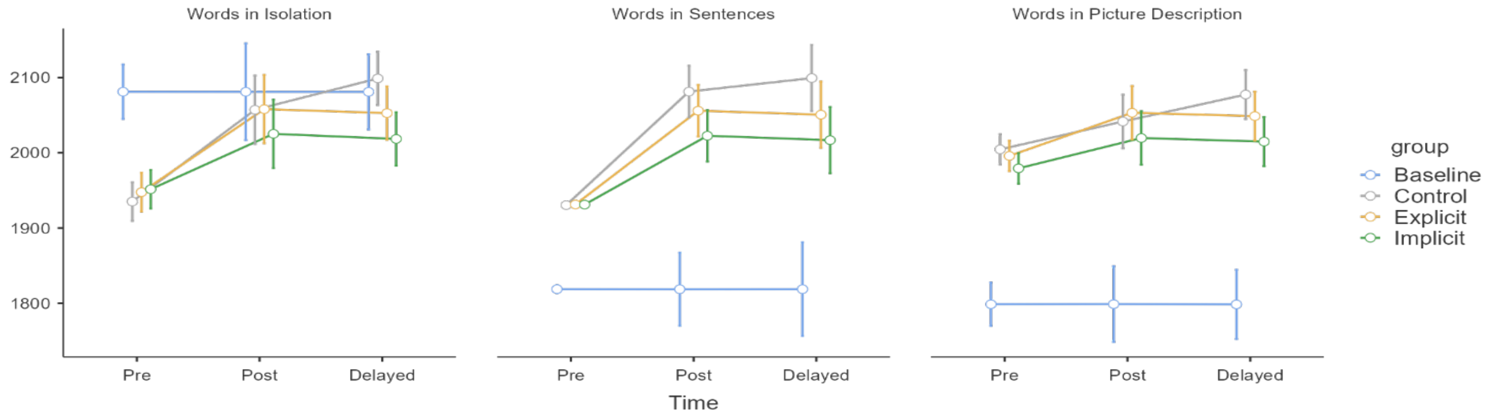


Figure 8

Effects of Online Oral CF on the F2 of /ɪ/among the Three Groups Across Three Tasks in Comparison with the Baseline



Discussion

This study examined the effectiveness of technology-assisted explicit and implicit online oral CF on Kurdish EFL university students' production of English /iː/ and /ɪ/ across three task types during a 10-hour online training program. The findings demonstrate that both feedback conditions facilitated phonetic development; however, explicit oral CF consistently produced stronger and more stable convergence toward baseline targets. The discussion below integrates the findings across both research questions to provide a coherent interpretation of how feedback type, technology, and instructional context jointly shaped pronunciation development. It also situates the findings within the study's sociocultural and cognitive framework, because the central issue is not simply whether technology worked, but how teacher mediation, visual–acoustic evidence, and high-variability input made the target vowel contrast more noticeable and usable for learners.

The results indicate that online oral CF significantly affected vowel production across all three tasks, with the explicit CF group demonstrating the greatest degree of phonetic change (RQ1). In particular, duration and formant measures revealed that learners receiving explicit oral CF consistently produced values closer to baseline targets than those in the implicit and control groups. This difference requires more than a descriptive explanation. The explicit group did not only receive more correction; it received a different quality of mediation. The teacher named the error, explained the contrast, displayed the acoustic difference, and then directed learners back to production. This sequence likely reduced the ambiguity that often weakens pronunciation feedback, especially when the target contrast is small and difficult to hear.

One plausible explanation for this pattern is the role of noticing in second language phonological development. The ability to detect mismatches between one's own production and target-language models has long been considered central to effective learning (Schmidt, 2001, 2010). In the present study, explicit feedback created conditions for noticing by linking three forms of evidence: the teacher's explanation, the Praat display, and the learner's own repeated production. This matters because vowel learning depends on learners' ability to connect acoustic cues such as duration, F1, and F2 with articulatory decisions. Recent work also shows that perception training and immediate CF can support learners' ability to distinguish difficult L2 sound contrasts before stable production develops (Martin & Sippel, 2026).

The present findings align with previous empirical work demonstrating the facilitative role of feedback in pronunciation development (Chen & Li, 2022; Ebadi et al., 2014; Kamali et al., 2025; Nassaji & Kartchava, 2021). Recent classroom-based research further confirms that both explicit and implicit instruction can support segmental development, although their effectiveness may vary depending on task conditions and linguistic complexity (Mahdi & Mohsen, 2024; Quispe-Vargas et al., 2024). Although mixed results have been reported regarding the effectiveness of online oral CF (Inceoglu, 2019; Meritan, 2022), the current findings provide additional evidence that structured online feedback can support segmental development when integrated into guided instructional contexts. The integration of technology appears to have further strengthened these effects. Tools such as Praat enabled learners to visually compare their productions with baseline acoustic models, while YouGlish provided access to authentic phonetic input. Previous studies have reported similar benefits of multimodal phonetic input and visualization (Logan et al., 1991; Melnik & Peperkamp, 2021; O'Brien, 2021; Qian et al., 2018; Shinohara & Iverson, 2018). During training sessions, learners in the explicit CF group received direct explanations, visual representations of their acoustic output, and repeated exposure to native-speaker models. This combination likely enhanced learners' awareness of articulatory and acoustic features and facilitated more precise phonetic adjustment (Imber et al., 2016; Mahmood, 2024b). However, the findings should not be interpreted as evidence that technology alone caused the gains. Recent research on online pronunciation instruction shows that digital tools shape what can be modeled, heard, repeated, and assessed, but their value depends on the pedagogical work that organizes them (Lagerlöf, 2026). Similarly, technology-mediated task-based research with Persian-speaking EFL learners found that technology improved vowel pronunciation when it was embedded in interactive feedback and communicative practice rather than used as an isolated resource (Tavakoli, 2026). The present results, therefore, support a teacher-mediated interpretation: Praat and YouGlish became effective because the teacher used them to make the contrast visible, audible, and repeatedly actionable.

This finding aligns with recent evidence that AI-driven and technology-mediated pronunciation tools can significantly enhance both perception and production of difficult vowel contrasts, even if full native-like attainment is not achieved (Georgiou, 2025). Importantly, these effects appear amplified in the online setting, where visual feedback and replayable input may compensate for reduced face-to-face interaction and allow learners to engage with feedback more intensively and repeatedly, a feature increasingly emphasized in research on ASR- and AI-supported pronunciation learning (McCrocklin & Levis, 2025).

The stronger performance of the explicit CF group was particularly evident for vowel duration. Temporal control is known to play a critical role in intelligibility and perceptual accuracy (Bohn, 2018; Iverson & Evans, 2006; Wheeler & Saito, 2022). The present results suggest that explicit feedback enables learners to more effectively regulate vowel length contrasts, which are especially challenging for learners whose L1 lacks comparable duration-based distinctions. Similarly, improvements in formant measures further indicate that feedback-supported training contributed to more accurate control of vowel height and frontness, two central acoustic correlates of vowel identity (Iverson & Evans, 2006). The pattern is important because it shows that learners did not only shorten or lengthen vowels mechanically; they also adjusted acoustic quality. This suggests a deeper restructuring of phonetic categories rather than a surface-level imitation of duration alone. Recent experimental evidence further indicates that sensory acuity and cross-language phonetic similarity jointly shape L2 vowel production accuracy, which helps explain why different acoustic dimensions may respond unevenly to instruction (Li et al., 2026). Recent experimental evidence shows that explicit phonetic instruction can affect learners' vowel production, particularly in acoustic cues such as duration and formants, when distinguishing between /i:/ and /ɪ/, supporting the role of explicit feedback in refining phonetic categories (Zheng & Wonnacott, 2026). Overall, the findings suggest that online oral CF becomes particularly effective when embedded within technology-mediated pronunciation instruction.

Regarding retention (RQ2), the results indicate that learners who received explicit oral CF maintained phonetic improvements more consistently than those in the implicit and control conditions. This pattern was observed across both vowels and acoustic dimensions, suggesting that explicit feedback not only facilitates immediate phonetic restructuring but also supports longer-term stabilization. One explanation for these maintenance effects relates to the nature of explicit instruction and form-focused feedback. A substantial body of research has demonstrated that explicit pronunciation instruction promotes durable learning outcomes (Couper, 2003, 2006, 2013; Trofimovich et al., 2022). When learners are provided with direct explanations and visual representations of phonetic targets, they are better able to internalize phonological contrasts and apply them across contexts. This interpretation is consistent with Nakatsukasa and Loewen's (2017) observation that explicit feedback enhances both learner understanding and retention of linguistic targets. From a cognitive perspective, these findings also reflect the interaction between explicit knowledge and its gradual proceduralization into more automatized pronunciation performance, as emphasized in recent work on L2 pronunciation knowledge development (Pawlak, 2025). In other words, the delayed post-test results suggest that explicit feedback did not remain only as declarative knowledge about the contrast; repeated guided practice appears to have helped learners convert that knowledge into more stable production routines. From a sociocultural perspective, the maintenance of gains can also be interpreted through the concept of mediation. According to SCT, learning occurs through guided interaction and scaffolded assistance provided by more knowledgeable others (Frawley & Lantolf, 1985; Vygotsky, 1978). In the present study, explicit oral CF functioned as a mediational tool that supported learners' movement beyond their current developmental level. The integration of HVPT input (Thomson, 2018; Uchihara et al., 2025), visual acoustic feedback, and authentic speech models further strengthened this mediational process by providing multiple layers of support. As Nassaji and Swain (2000) argue, corrective feedback becomes more effective when it is responsive to learners' developmental needs and embedded within meaningful interaction.

Although implicit oral CF also produced measurable gains, retention effects were weaker and more variable. This finding aligns with previous research suggesting that recasts, while beneficial, may require high levels of learner engagement and perceptual sensitivity to be fully effective (Gao, 2022; Saeli et al., 2021). The weaker maintenance of implicit feedback is, therefore, not surprising. Recasts preserve communicative flow, but they can leave the corrective intention under-specified. In a vowel contrast such as /iː/–/ɪ/, where the difference involves fine temporal and spectral cues, learners may hear the teacher's reformulation as confirmation of meaning rather than correction of sound form. This interpretation also explains why the implicit group improved but did not reach the same stability as the explicit group: input alone created exposure, but it did not consistently force analytic comparison between the learner's output and the target. Recent classroom-based studies confirm that recasts can facilitate phonological development, particularly through temporal adjustments such as vowel duration, although their effects may be more limited or context-dependent than those of explicit feedback (Parlak et al., 2025; Pawlak, 2025). Meta-analytic evidence further suggests that implicit feedback can enhance long-term phonological accuracy, but often to a lesser extent than explicit forms of feedback (Goo, 2012).

Learners' L1 phonological background may also have influenced retention patterns. Central Kurdish (CK) lacks the vowel /ɪ/ as a distinct phonemic category (Fattah, 1997; Xoshnaw, 2014). According to Flege's (1987, 1995) Speech Learning Model, new phonetic categories may be acquired more easily than similar ones that overlap with existing L1 categories. This may explain why some learners in the implicit CF group showed selective gains in/ɪ/, potentially relying on perceptual sensitivity rather than on explicit analytical processing. At the same time, the L1 explanation should not be overstated. The results show that instruction changed production, but they do not show how individual learners perceived the contrast or which learners had stronger auditory or articulatory sensitivity. For this reason, L1 transfer provides a plausible account of group-level difficulty, while individual-level perceptual and sensory factors remain an empirical question. Overall, while both feedback types supported pronunciation development, explicit oral CF produced more robust and durable learning outcomes. These findings reinforce the importance of aligning corrective feedback strategies with task demands, phonetic targets, and learner profiles. They also support broader claims in instructed SLA that pronunciation development depends on how instructional conditions are systematically designed and mediated (Crowther & Loewen, 2025).

A further point concerns the role of task type in interpreting these findings (RQ1). The consistent advantage of explicit oral CF across word reading, sentence reading, and picture description suggests that phonetic gains were not restricted to controlled production but extended to more spontaneous speech. This pattern strengthens the argument that technology-assisted explicit feedback supports not only accuracy under focused conditions but also transfers to communicative use, which remains a central challenge in pronunciation instruction.

Nevertheless, the three tasks placed different demands on learners. Word and sentence reading allowed greater attention to form, whereas picture description required learners to manage pronunciation while planning meaning. The continued advantage of the explicit group in the picture description task therefore suggests partial transfer, but it should be interpreted with caution because the task was still elicited within an assessment context and did not fully capture natural interaction. This aligns with recent classroom-based research showing that feedback effects can vary across controlled and spontaneous tasks, with stronger and more durable gains emerging when learners successfully transfer forms into communicative production (Dong et al., 2025). Recent work with Spanish-speaking learners similarly suggests that technology-mediated pronunciation gains are strongest when instruction foregrounds functional contrastiveness, learner reflection, and listener-oriented clarity rather than imitation alone (Chiusano & Luchini, 2026). Finally, the pedagogical implication is that teachers should strategically select feedback types based on instructional goals and learner needs. While implicit feedback may support fluency-oriented practice, explicit feedback—particularly when integrated with visual and technological resources—appears more effective for promoting stable segmental accuracy. At the same time, individual differences in motivation, proficiency, and perceptual sensitivity must be taken into account when designing pronunciation-focused interventions (Ammar & Spada, 2006).

The findings offer several practical implications for pronunciation teaching in Kurdish EFL and comparable university contexts. First, teachers should not treat technology as a substitute for instruction. Praat, YouGlish, ASR tools, and other CAPT resources should be embedded in teacher-guided sequences that move from explanation to perception to controlled production and then to communicative use. Second, explicit oral CF appears especially useful when the target sound contrast is acoustically subtle and easily confused, as in /iː/–/ɪ/. Teachers can use simple visual displays of duration and formants to help learners see what they cannot yet reliably hear. Third, implicit recasts should be used selectively. They may help preserve interactional flow, but they should be supplemented with more explicit contrastive feedback when the instructional goal is stable segmental accuracy. Fourth, pronunciation tasks should be sequenced from word-level practice to sentence-level production and then to picture description or other meaning-focused tasks so that learners gradually transfer phonetic control into communication. Finally, the Kurdish EFL context would benefit from teacher training in low-cost CAPT integration, particularly since existing classroom traditions often offer limited individualized pronunciation feedback.

Conclusion

This study examined the effects of teacher feedback assisted with technology-assisted explicit and implicit online oral CF on Kurdish EFL learners' production of the English vowels /iː/ and /ɪ/. The findings show that both feedback conditions supported segmental development, but explicit oral CF produced stronger and more stable movement toward the American English baseline across task types and acoustic measures. This advantage indicates that learners benefited most when teacher explanation, visual-acoustic feedback, and high-variability input worked together to make the vowel contrast visible, audible, and available for repeated practice. Implicit oral CF also contributed to pronunciation development, but its effects were more selective and less stable, suggesting that recasts alone may not provide sufficient salience for subtle vowel contrasts.

The study contributes to L2 pronunciation research by showing that online pronunciation instruction can support measurable acoustic change when feedback is theoretically grounded and pedagogically mediated. The findings also extend research on oral CF by demonstrating that feedback type matters for immediate gains and for retention and transfer across controlled and less controlled tasks. In the Kurdish EFL context, where pronunciation-focused instruction and individualized feedback remain limited, the study provides evidence for integrating teacher-led explicit oral CF with accessible tools such as Praat, YouGlish, and HVPT-based input. Overall, the findings support a balanced approach to pronunciation pedagogy: explicit oral CF should be prioritized for difficult segmental contrasts that require conscious attention to acoustic and articulatory cues, while implicit feedback can still support communicative practice when used strategically. Future research should test longer interventions, include measures of perception and learner-reported data, and examine whether similar effects occur with other target sounds, proficiency levels, instructional modes, and English varieties.

Several limitations and delimitations should be acknowledged. The study was deliberately delimited to two English vowels, /iː/ and /ɪ/, one Kurdish EFL university context, three task types, and an American English baseline. These choices allowed close acoustic analysis of a difficult segmental contrast but limit the extent to which the findings can be generalized to other vowels, consonants, suprasegmental features, proficiency levels, or English varieties. The study also combined several instructional components, teacher feedback, Praat-based visualization, YouGlish input, HVPT principles, and online delivery, so the design cannot isolate the independent effect of each component. In addition, the study measured production acoustically but did not include perception tests, learner interviews, stimulated recall, or systematic measures of how learners processed the feedback. This limits claims about the internal mechanisms that led to change. Future research should, therefore, examine perception–production links, compare teacher-mediated technology with technology-only and teacher-only conditions, include longer delayed post-tests, and test whether gains transfer to freer interaction. Further studies should also investigate learner variables such as motivation, perceptual sensitivity, phonological awareness, and prior digital experience, because these variables may explain why some learners benefit more from explicit or implicit feedback than others.

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Ethics Declarations
World Medical Association (WMA) Declaration of Helsinki–Ethical Principles for Medical Research Involving Human Participants
This study was conducted in accordance with the ethical principles of the World Medical Association Declaration of Helsinki. Ethical approval was obtained from the Research Ethics Committee of the University of Wollongong (Approval No. 2022/344). All participants provided informed written and oral consent prior to participation, and participation was voluntary.

Competing Interests

The authors declare that they have no competing interests.

Data Availability

The data are not publicly available because they contain confidential participant information. Access to the data is restricted to protect participant privacy and comply with the ethical conditions under which the study was approved.

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