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Assessing the Impact of Blended Learning and Technology-Enhanced Pronunciation Instruction: A Mixed Methods Graphic Approach Incorporating Student Feedback

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ABSTRACT

This paper investigates the effectiveness of blended learning and technology-enhanced pedagogy in improving pronunciation within a tertiary education context. This research builds on prior action research documented in "Driving Digitalization: Action Research to Innovate Pronunciation Pedagogies by Building a Virtual Voice Laboratory". The current study featured a 7-day pronunciation improvement plan utilizing the digital platform VirtualVoiceLab.com as part of an elective language course during the 2024-25 academic year. A mixed methods approach was employed, combining quantitative data from a post-course survey with qualitative feedback from student reflections in the staff-student consultation meetings. A total of 161 undergraduate students participated, with 123 completing the survey to provide insights into their experiences. Additionally, graphic comparisons of students' voice charts were analyzed to assess pronunciation improvements. The results revealed overwhelmingly positive responses, with students reporting notable enhancements in pronunciation, fluency, and overall confidence in spoken English. The incorporation of VirtualVoiceLab.com facilitated a flexible, interactive, and self-paced learning environment, complementing in-class activities and encouraging independent practice beyond traditional classroom settings. Students expressed appreciation for the visualized sound charts and audio-visual materials offered by the platform. This study underscores the potential of integrating innovative technology into language pedagogy to improve learning outcomes and student engagement. The findings contribute to the expanding body of research on blended learning in higher education and offer practical insights for educators aiming to implement technology-enhanced teaching methods. This paper will elaborate on the survey findings, discuss pedagogical implications, and provide recommendations for optimizing blended learning strategies in language education.

Keywords: Blended Learning, Technology-Enhanced Pedagogy, TESOL, E-Learning, Higher Education, Mixed Methods, Research-Enhanced Instructional Design

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1 Background

In recent years, the landscape of language education has transformed significantly, driven by advancements in digital technology and an increasing demand for innovative pedagogical approaches. Blended learning, which combines traditional face-to-face instruction with online learning components, has emerged as a powerful framework for enhancing language acquisition. This approach not only accommodates diverse learning styles but also fosters greater flexibility and accessibility for students in higher education settings (Graham, 2013). This paper investigates the effectiveness of blended learning and technology-enhanced pedagogy in improving pronunciation within a tertiary education context. Building on prior action research documented in "Driving Digitalization: Action Research to Innovate

Pronunciation Pedagogies by Building a Virtual Voice Laboratory" (Fan, 2024), this study explores innovative approaches to language instruction. Central to the research is a 7-day pronunciation improvement plan that leverages the digital platform VirtualVoiceLab.com, integrated into an elective language course during the 2024-25 academic year.

Employing a mixed methods approach allows for a comprehensive analysis of student outcomes by combining quantitative data from a post-course survey with qualitative feedback gathered during staff-student consultation meetings. The choice of a mixed methods approach in this study significantly enhances the reliability and rigor of the research findings. By integrating both quantitative and qualitative data, a more comprehensive evaluation can be achieved to understand student experiences and outcomes in pronunciation improvement. This approach allows for the collection of diverse data types; quantitative data from post-course surveys provides measurable insights into student perceptions of their pronunciation skills, fluency, and confidence, while qualitative feedback gathered during staff-student consultation meetings offers deeper insights into the personal experiences and challenges faced by students. This triangulation of data sources helps to validate findings and mitigate potential biases associated with relying solely on one method (Creswell & Plano Clark, 2017). The combination of quantitative and qualitative data enriches the interpretability of the results. While surveys can quantify improvements in student confidence and pronunciation, qualitative reflections elucidate the reasons behind these improvements. For instance, students may articulate how specific features of the VirtualVoiceLab.com platform contributed to their learning, providing context to the numerical data and enhancing the overall narrative of the research.

Additionally, the inclusion of graphic comparisons of students' voice charts serves as a robust and objective assessment tool. Voice charts visualize students' pronunciation performance, highlighting specific areas of improvement in sound production. By analyzing these charts alongside survey data, students' subjective reports of improvement can be correlated with tangible evidence of their progress. This dual-layered assessment strengthens the validity of the findings, as it combines subjective perceptions with objective measurements (Levi & Inbar-Lourie, 2019). Furthermore, the analysis of voice charts allows for detailed examinations of individual learning trajectories. Patterns of improvement can be identified across different students and subsequently correlated with specific instructional strategies or features of the digital platform used. This nuanced analysis can inform educators about which elements of the blended learning approach were most effective, facilitating targeted improvements in pedagogy. Hence, employing a mixed methods design enhances the rigor and credibility of the research. By drawing on multiple sources of evidence, the study's conclusions are more robust and defensible. This methodological triangulation not only strengthens the findings but also aligns with best practices in educational research, where the complexity of learning processes often requires multifaceted investigation (Graham, 2013). In summary, the combination of mixed methods and voice chart analysis provides a powerful framework for investigating the effectiveness of blended learning and technology-enhanced pedagogy, offering valuable insights for educators aiming to improve pronunciation instruction in language education.

A total of 161 undergraduate students participated in the study in Term 2 2024-25, with 123 completing the survey, providing meaningful perspectives regarding their experiences of blended learning. Additionally, graphic comparisons of students' voice charts were analyzed to assess pronunciation improvements, offering a reliable method for evaluating progress (Levi & Inbar-Lourie, 2019). The findings revealed overwhelmingly positive responses from students, who reported significant enhancements in their pronunciation, fluency, and overall confidence in spoken English. The incorporation of VirtualVoiceLab.com facilitated a flexible, interactive, and self-paced learning environment, effectively complementing in-class activities and encouraging independent practice beyond traditional classroom settings (Graham, 2013).

Students also expressed appreciation for the visualized sound charts and audio-visual materials provided by the platform, which contributed to their learning experience.

This study underscores the potential of integrating innovative technology into language pedagogy to improve learning outcomes and enhance student engagement. The insights gained contribute to the expanding body of research on blended learning in higher education and offer practical recommendations for educators seeking to implement technology-enhanced teaching methods. Through this exploration, the paper aims to elaborate on survey findings, discuss pedagogical implications, and provide strategies for optimizing blended learning approaches in language education.

2 Literature Review

2.1 Blended Learning in Language Education

Blended learning, a pedagogical approach that combines traditional face-to-face instruction with online learning, has gained significant traction in language education (Garrison & Vaughan, 2008). This shift is largely attributed to advancements in technology and the increasing demand for flexible learning environments. Blended learning is defined as an educational framework that integrates online digital media with traditional classroom methods. Garrison and Vaughan (2008) emphasize that the essence of blended learning lies in the thoughtful integration of different modes of delivery to enhance learning outcomes. In the context of language education, blended learning can take various forms, including flipped classrooms, online modules, and interactive digital resources (Graham, 2013). This literature review examines the rationale behind the adoption of blended learning in language education and explores effective strategies for its implementation.

2.2 The Rationale for Blended Learning in Language Education

Increased Engagement. One of the primary motivations for adopting blended learning is its potential to increase student engagement (Graham, 2006). Research indicates that students are more likely to participate actively in their learning when technology is integrated into the classroom (Hwang et al., 2015; Lai & Hwang, 2016). The interactive nature of online tools, such as discussion forums and multimedia resources, can stimulate students' interest and motivation, making language learning more appealing. Studies have shown that blended learning models yield higher average engagement scores compared to conventional learning methods (Boelens et al., 2015).

Personalization of Learning. Blended learning offers opportunities for personalized learning experiences. According to Trilling and Fadel (2009), personalized learning is one of the great education challenges of the twenty-first century. Online components allow students to progress at their own pace, revisit challenging concepts, and engage with materials that align with their interests. This adaptability is particularly beneficial in language education, where proficiency levels can vary widely among learners. Adaptive technologies can facilitate a personalized approach to learning, tailoring the learning experience to individual needs (Marsh, 2012).

Development of Digital Literacy. In today’s digital age, proficiency in technology is essential. Blended learning environments cultivate digital literacy, enabling students to navigate online resources effectively. As language education increasingly incorporates digital tools, students develop skills that are crucial for academic and professional success. Lai and Hwang (2016) suggest that this competency not only enhances their language learning but also prepares them for the demands of a technology-driven world.

Collaboration and Communication. Blended learning fosters collaboration and communication among students. Online platforms can facilitate group work and peer-to-peer interactions, which are vital in language learning contexts. Research by Hwang et al. (2015) shows that collaborative activities in blended environments enhance language skills, as students engage in meaningful conversations and practice language use in diverse scenarios. Blended learning unites students as group members, enabling them to cooperate and accomplish assigned tasks (Ali & AlQarni, 2024).

2.3 Effective Strategies for Implementing Blended Learning

Curriculum Design. A well-structured curriculum is crucial for successful blended learning implementation. Educators should design courses that integrate online and face-to-face components seamlessly. This involves identifying the learning objectives that can be best achieved through online resources and determining how in-person activities can complement them (Graham, 2013). For example, grammar lessons may be taught online through interactive exercises, while speaking practice occurs in the classroom. However, in the elective speaking course, blended learning materials and an online self-directed practice platform were implemented to facilitate and maximize learning capacity. Hence, the choice of what course materials to flip and blend, and how and when to flip and blend them required meticulous and strategic curriculum planning.

Selection of Appropriate Technology. The choice of technology plays a significant role in the effectiveness of blended learning. Educators must select tools that align with learning objectives and are accessible to all students. Platforms like Moodle, Google Classroom (Fan & Daly, 2021), and Edmodo offer robust features for language education, including quizzes, discussion boards, and resource sharing. Additionally, mobile applications can facilitate language practice outside the classroom, enhancing learning continuity (Kukulska-Hulme, 2006).

Training and Support for Educators. For blended learning to be effective, educators need adequate training and support. Professional development programs should focus on equipping teachers with the skills to integrate technology into their teaching practices. According to Ali and AlQarni (2024), training is essential for creating engaging digital content and ensuring fair access for all students. Ongoing support is essential for educators to feel confident in using blended learning approaches and adapting to new technologies. When devising the virtualvoicelab.com and creating the blended learning materials during the action research, a plethora of literature review and observation from students' performances and reactions in class were done to perfect the implementation of blended learning in the elective course.

Assessment and Feedback. Assessment strategies must evolve to suit blended learning environments. Formative assessments, which provide ongoing feedback, are particularly useful in language education. Online quizzes and peer assessments can offer insight into student progress and areas needing improvement (Black & Wiliam, 1998). Additionally, providing timely feedback on both online and in-person activities helps reinforce learning and motivates students to improve. By applying for the Teaching Development Grant supported by the University Grant Committee, the action research process was closely monitored and evaluated quarterly. Two pilot studies were conducted, with ten and twenty student participants involved as volunteers to provide user feedback which was referenced to improve the blended learning efficacy in the elective course.

2.4 Recent Developments in Technology-enhanced Learning

The rapid evolution of educational technology has significantly transformed teaching and learning practices, particularly in the realm of language learning. Recent advancements in artificial intelligence (AI), machine learning, and data analytics have enabled the development of adaptive learning platforms that cater to the diverse needs of students. For example, AI-driven tools now offer real-time feedback on pronunciation, grammar, and intonation, providing personalized learning experiences that were previously unattainable (Al-Zahrani & Alasmari, 2024). Additionally, augmented reality (AR) and virtual reality (VR) applications are gaining traction in language education, offering immersive environments where learners can practice communication skills in simulated scenarios (Lin & Wei, 2024), that 'AR games possessed the potential to create a more immersive vocabulary learning environment for individuals without disrupting their learning pace, thus promoting independent learning'(Lin & Wei, 2024, p.5). These innovations have enhanced learner engagement, self-regulation, and accessibility, making language acquisition more interactive and effective.

The incorporation of gamification elements into technology-enhanced learning platforms is another noteworthy development. Immersive engagement via gamification was proved to be effective in improving the students' learning performance, enhancing online social interaction with peers across different study groups, and providing a joyful learning experience (Bai et al., 2022). Furthermore, mobile learning applications have become increasingly prevalent, enabling students to access learning materials anytime and anywhere, thus aligning with the demands of modern, flexible education systems.

2.5 Challenges in Technology-Enhanced Learning Research

Despite these advancements, the integration of technology into learning environments is not without challenges. One significant issue is the digital divide, which poses barriers to equitable access to technology-enhanced learning (TEL) tools. Students from underprivileged backgrounds or regions with limited internet connectivity may struggle to benefit from these innovations, potentially exacerbating educational inequalities (Miras et al., 2023).

One of the most pressing compatibility issues involves platform-specific constraints. For instance, as highlighted in the Virtual Voice Lab (VVL) study, students faced difficulties with audio recording and playback on certain devices, such as Android phones and iPads. These technical limitations are often rooted in disparities among operating systems, hardware specifications, and software versions. According to Chen et al. (2022), cross-platform issues are a common barrier in educational technology, particularly when tools are designed without considering the heterogeneity of devices. Incompatibility can result in incomplete functionality, such as missing features or distorted audio, which detracts from the user experience and reduces the effectiveness of learning platforms.

Another significant challenge stems from the lack of standardized software development practices tailored to educational tools. Many platforms are built with a focus on either iOS or Android, neglecting the need for uniform performance across both systems. Moreover, older devices might not support the latest software updates, creating a gap in accessibility for students who cannot afford to upgrade their devices (Miras et al., 2023). This issue is further exacerbated when educational platforms rely on advanced features, such as augmented reality (AR) or virtual reality (VR), which demand high processing power and modern hardware (Lin & Wei, 2024). In such cases, learners with outdated devices or limited technical knowledge may find it challenging to engage fully with these tools.

Interoperability between systems is also a major concern, especially in institutions that integrate multiple platforms. For instance, students might use a learning management system

(LMS) alongside third-party applications for language learning or simulations. When these platforms lack compatibility, data sharing and integration can become cumbersome, resulting in inefficiencies and frustration for both students and educators. According to Al-Zahrani and Alasmari (2024), the seamless integration of AI-driven tools across diverse platforms is critical for maintaining personalized and adaptive learning experiences. However, achieving such integration requires significant collaboration between software developers and educators, as well as consistent updates to address emerging compatibility issues.

Additionally, connectivity requirements further complicate the use of advanced TEL platforms. Real-time tools, such as AI-based pronunciation feedback or virtual classrooms, demand stable internet connections, which can be a challenge in regions with poor infrastructure. Even when connectivity is available, slow internet speeds can disrupt platform performance, leading to delays, buffering, or incomplete tasks. This issue disproportionately affects learners in underserved areas, perpetuating the digital divide and limiting equitable access to TEL tools (Miras et al., 2023).

The reliance on self-directed learning in technology-enhanced environments poses further challenges for students with low self-regulation or time-management skills. While high-performing students often thrive in such settings, lower-performing students may require additional scaffolding and support to stay engaged and achieve meaningful outcomes (Hachey et al., 2015). This underscores the need for targeted interventions and blended models that combine technology with traditional, instructor-led approaches to ensure all students can benefit.

In conclusion, compatibility issues pose significant challenges to the adoption and effectiveness of technology-enhanced learning platforms. These challenges, ranging from device-specific constraints to interoperability and connectivity issues, highlight the importance of inclusive and adaptable design practices. By addressing these barriers, stakeholders can ensure that TEL tools deliver equitable and meaningful learning experiences for all students.

2.6 Enhanced Solutions to Address Compatibility Issues

Addressing compatibility issues in technology-enhanced learning (TEL) platforms requires leveraging advancements in mobile app development, particularly in cross-platform development approaches. As highlighted by Xanthopoulos and Xinogalos (2013), native mobile apps, while offering optimal user experience, performance, and full access to platform-specific hardware, are increasingly inefficient due to the growing number of mobile platforms. Developing native apps for multiple platforms necessitates separate implementations for each, leading to increased development time and maintenance costs—a problem known as fragmentation. To combat this, cross-platform development frameworks have emerged as a viable solution. These frameworks allow developers to write a single application codebase that can run on multiple platforms while maintaining a native-like user experience. Among the various approaches, hybrid and interpreted apps are particularly promising for TEL platforms because they utilize widely adopted web technologies like JavaScript, reduce the need for detailed platform-specific knowledge, and are supported by production-ready tools such as PhoneGap and Titanium. However, challenges remain, including limited hardware access and dependence on the development environment to support new platform-specific features. By adopting cross-platform frameworks, TEL platforms can address compatibility challenges while ensuring scalability, cost-efficiency, and accessibility for diverse learners.

Integrating cloud-based solutions offers a promising way to address compatibility challenges by reducing reliance on device hardware and enabling universal access. Cloud-based platforms allow the offloading of computational tasks to remote servers, which ensures that even users

with older or less capable devices can effectively utilize technology-enhanced learning (TEL) tools. As noted by Eljak et al. (2024), cloud computing in e-learning environments significantly enhances accessibility, scalability, and cost efficiency by providing centralized resources that are easily accessible via web browsers regardless of the user's device or operating system. Moreover, cloud-based solutions offer seamless updates and maintenance, eliminating the need for users to manually upgrade software or hardware. This ensures that TEL platforms remain functional and up-to-date across a wide range of devices. However, Eljak et al. (2024) also emphasize the importance of addressing challenges such as data security, privacy concerns, and the need for robust internet connectivity to fully leverage the potential of cloud-based learning environments. By adopting secure and scalable cloud solutions, educational institutions can ensure compatibility and equitable access while minimizing technical barriers for students.

The incorporation of standards for interoperability plays a pivotal role in addressing challenges related to the integration of multiple platforms. For example, the Learning Tools Interoperability (LTI) standard, developed by IMS Global Learning Consortium, allows seamless data sharing and integration between learning management systems (LMS) and third-party educational applications (DeMonner, 2022). By adopting such standards, institutions can ensure that diverse tools work cohesively, reducing the fragmentation of digital learning environments. Research by Salminen et al. (2022) highlights that institutions employing LTI-based integrations experience fewer technical disruptions and greater user satisfaction compared to those utilizing proprietary or non-standardized systems.

Lastly, providing technical support and user training is another essential component of overcoming compatibility challenges. Institutions can address this by offering workshops, creating comprehensive user guides, and implementing 24/7 technical support systems to assist users in resolving compatibility-related problems. Incorporating artificial intelligence (AI)-driven adaptability into technology-enhanced learning (TEL) platforms offers a transformative solution to compatibility challenges. AI algorithms can dynamically adjust platform functionality to accommodate the specific device, operating system, and network conditions of each user. As Strielkowski et al. (2024) emphasize, AI-driven adaptive learning systems can analyze user behavior and environmental variables in real-time to deliver tailored educational experiences. For instance, these systems can optimize performance by compressing large data files for users with slower internet connections or simplifying the interface for learners using older devices. Such adaptability ensures that TEL platforms remain accessible and efficient, even in diverse technological contexts. Furthermore, Strielkowski et al. (2024) highlight that AI-driven adaptability promotes sustainable educational transformation by making learning tools more inclusive and equitable across socioeconomic and geographic divides. By leveraging AI, TEL platforms can address technical barriers while enhancing user engagement and overall learning outcomes.

2.7 Blended Learning in Language Education – A Single Case Context

At Lingnan University, the context of higher education reflects a unique demographic landscape where the majority of student intake consists of local and mainland Chinese students. These students exhibit a wide range of English-speaking proficiency, which poses both challenges and opportunities for language educators. To address these variances, an action research initiative was conducted to incorporate blended learning into an elective course. This approach aimed to create a more inclusive and effective learning environment that could cater to diverse language abilities.

The current evaluation proposes a holistic approach to assess the incorporation of blended learning and visualization of the learning process taken place in the action research. The process of the action research which involved two pilot studies funded by the University Grant Committee from 2023 to 2025 was documented in the journal article by Fan (2024): "Driving digitalization: Action research to innovate pronunciation pedagogies by building a virtual voice laboratory," published in the *International Journal of Second and Foreign Language Education*. This action research focused on the implementation of a Virtual Voice Laboratory (VVL) platform, which facilitated blended learning and allowed students to engage in self-directed practice.

Following this, a comprehensive evaluation of the action research was undertaken through a mixed-methods approach, which included both qualitative and quantitative data collection. To visualize the impacts brought by blended learning, graphic comparisons of voice charts were used. These charts illustrated changes in student engagement levels and language proficiency over the course of the semester. The results indicated a positive correlation between the use of blended learning strategies and improvements in students' language skills, affirming the effectiveness of this pedagogical approach in a diverse educational setting.

3 Materials and Methods

3.1 Justification for Mixed Methods Approach

The adoption of a mixed methods approach for this study is grounded in its capacity to integrate quantitative and qualitative data to provide a comprehensive understanding of the research problem. Mixed methods research bridges the strengths of both methodologies, enabling a holistic exploration of the efficacy of blended learning in fostering self-directed learning and enhancing learning outcomes. By combining surveys and voice chart data, this approach provides a nuanced perspective, capturing both numerical trends and the subjective experiences of students.

The quantitative component, comprising two student surveys conducted over the academic year 2024-25, allows for statistical analysis of the impact of the blended learning model across 11 sections in the spring semester (202 students) and 9 sections in the fall semester (161 students). The qualitative component, including student feedback from consultation meetings and the analysis of voice charts, complements the quantitative data by offering insights into students' perceptions, experiences, and challenges with the blended learning approach. This triangulation of data strengthens the reliability and validity of the study by cross-verifying findings across multiple sources.

3.2 Literature Review on Mixed Methods

The mixed methods approach aligns with established practices in educational research, particularly in studies exploring the implementation of blended learning models. Scholars such as Creswell and Plano Clark (2017) emphasize the value of mixed methods in addressing complex research questions that cannot be sufficiently answered through a single methodological lens. In the context of higher education, mixed methods have been widely adopted to evaluate innovative teaching strategies, as they allow researchers to capture both the measurable outcomes (e.g., grades, participation rates) and the contextual factors (e.g., student engagement, motivation) that influence these outcomes.

Blended learning, which combines face-to-face teaching with digital resources, has been extensively studied for its potential to enhance self-directed learning. Studies by Garrison and Kanuka (2004) highlight how blended learning fosters autonomy by enabling students to tailor

their learning experiences to their individual needs and schedules. However, this autonomy can also be a source of anxiety for some students, particularly when assessments are heavily critiqued. By employing a "completion-based" grading system, as outlined in this study, the research aligns with the findings of Ryan and Deci (2000), who argue that reduced emphasis on critique can enhance intrinsic motivation and lower anxiety levels, leading to better learning outcomes. Self-determination theory (SDT) posits that competence, autonomy, and relatedness are essential for psychological growth and well-being (Ryan & Deci, 2000).

3.3 Justification for the Methodology of Adding the Voice Chart Section to Supplement the Mixed Methods

The inclusion of a voice chart section in this study's methodology is a deliberate enhancement to the mixed methods approach, designed to provide a detailed and individualized understanding of students' progress in blended learning environments. Voice charts act as both a diagnostic and pedagogical tool, offering insights that complement the quantitative data collected from surveys and the qualitative feedback gathered during consultation meetings.

3.3.1 Supporting Self-Directed Learning and Personalized Feedback

Voice charts provide a tangible representation of students' performance, particularly in areas such as pronunciation, intonation, and fluency. For students, this visual tool enables self-assessment, empowering them to identify and address specific areas of improvement during independent study. This aligns with research emphasizing the importance of self-regulation and self-directed learning in blended learning environments (Garrison & Kanuka, 2004). By visualizing their progress, students are not only more motivated but also better equipped to allocate their study time effectively, reinforcing the autonomy that blended learning aims to cultivate (Ryan & Deci, 2000).

The tailored feedback provided alongside the voice charts further enhances their utility. For example, in the case of Student 1 (Grade A-), the instructor's comments focused on nuanced aspects of pronunciation, such as vowel length and voiced consonants, reflecting the student's higher level of proficiency. Conversely, for Student 2 (Grade C), the feedback emphasized foundational issues like linking, plosives, and schwa articulation, which aligned with their struggles as a non-native speaker. This differentiation in feedback demonstrates how voice charts can facilitate personalized learning pathways, addressing each student's unique needs and fostering targeted improvements.

3.3.2 Bridging the Gap Between Online and In-Person Learning

In the blended learning model, where students engage with both online and face-to-face components, continuity between these two modes is essential for a cohesive learning experience. Voice charts serve as a shared reference point, ensuring alignment between students and instructors. They provide instructors with a data-driven basis for identifying patterns in student performance, such as recurring pronunciation errors or issues with word linking, which can then be addressed during in-person sessions. For instance, Student 1's slight elongation of vowels and Student 2's choppy intonation were highlighted through their respective voice charts, enabling the instructor to focus on these specific issues during subsequent interactions.

This methodology is particularly valuable in a context where students may have varying levels of engagement with online materials. As demonstrated by Student 2, who missed the first four weeks of lectures but sought help later, the voice chart provided a means to diagnose and address gaps in their learning, despite their inconsistent attendance. This adaptability

underscores the role of voice charts in supporting both struggling students and high achievers, ensuring that all learners benefit from the blended learning approach.

3.3.3 Enhancing the Reliability and Credibility of Mixed Methods

By integrating visual voice charts into the mixed methods framework, the study enhances the reliability and depth of its findings. Quantitative data from surveys can indicate general trends in student engagement and outcomes, while qualitative feedback provides contextual insights. The voice charts bridge these two dimensions, offering evidence-based, individualized data that supports and validates the broader findings. For example, the automatic awarding of completion marks for voice chart submissions ensures consistent participation, while the instructor's tailored comments provide qualitative depth, capturing the variability in student experiences and outcomes.

This triangulation of data strengthens the study's credibility, as it allows for cross-verification of findings across multiple sources. Moreover, the use of voice charts aligns with best practices in blended learning research, which advocate for the integration of technology to support personalized learning and targeted interventions (Garrison & Vaughan, 2008).

3.3.4 Contribution to Blended Learning Research

The methodological addition of visual voice charts contributes to the growing body of research on blended learning by addressing key challenges such as fostering autonomy, providing timely feedback, and bridging the gap between online and in-person components. By enabling students to visualize their progress and instructors to deliver targeted feedback efficiently, voice charts enhance the overall effectiveness of the blended learning model. This methodology not only supports the study's aim of evaluating the impact of blended learning on self-directed learning and course outcomes but also offers a replicable framework for future research in similar contexts.

3.3.5 Voice Charts Collection and its Significance

The collection of voice charts was a critical component of the study, designed to capture students' progress and engagement in self-directed learning. Similar to the practice by Wilson (2009) using Praat and Moodle, students taught by the researcher were required to submit both a screenshot of their voice chart and the corresponding audio recording as evidence of completion on Moodle. This submission process was tied to a 2% participation mark, which was awarded on the basis of completion rather than quality. The rationale for this assessment method was to reduce students' anxiety and foster a positive learning environment, as supported by self-determination theory (Ryan & Deci, 2000).

The voice chart data further supplemented the feedback collected during staff-student consultation meetings (SSCM) held at the end of each semester. Since students could select the best performance to share with their instructors, the stress and anxiety level could be largely reduced. This practice correlated to the feedback shared by the student representatives in the SSCM. These meetings provided an open forum for student representatives to share their opinions on the course structure, assessment methods, and the utility of VirtualVoiceLab.com. This feedback was instrumental in contextualizing the quantitative findings from the surveys and voice charts, ensuring that the study captured the full spectrum of student experiences.

3.4 Applicability Across Cultural Contexts

The integration of mixed methods with graphic comparison, such as voice charts, can significantly enhance the applicability of research across diverse cultural contexts by offering

both quantitative and qualitative insights that are adaptable to varying educational and linguistic environments. In multicultural settings, where differences in language proficiency, learning styles, and academic expectations are prevalent, this approach provides a comprehensive framework to address these complexities.

Voice charts, as a visual and diagnostic tool, enable instructors and researchers to identify culturally specific patterns in pronunciation, intonation, and fluency, which may stem from linguistic backgrounds or phonological influences. For instance, in contexts where students are non-native speakers of English, common challenges like linking, elision, or assimilation may vary based on their first language phonetic structures. A comparative analysis of voice charts from students of different cultural backgrounds can reveal these trends, offering valuable insights into how pronunciation difficulties are shaped by linguistic and cultural factors. This understanding allows for the development of targeted interventions that are culturally sensitive and tailored to address the specific needs of diverse student populations.

Moreover, the visual nature of graphic comparisons transcends language barriers, making it an effective tool for cross-cultural communication. Students from different cultural contexts may find it easier to interpret graphical feedback and voice chart patterns, as these provide clear, non-verbal representations of their progress. This approach aligns with principles of universal design for learning (UDL), ensuring accessibility and inclusivity in educational practices. Additionally, instructors can use graphic comparisons to address culturally influenced differences in learning attitudes, such as varying levels of self-regulation or reliance on instructor feedback, by tailoring their guidance to foster autonomy while respecting cultural norms.

Mixed methods further enhance the applicability of this approach by triangulating data across cultural contexts. Quantitative measures, such as completion rates or survey responses, can identify broad trends in blended learning engagement across cultures, while qualitative feedback from voice charts and consultation sessions provides deeper contextual insights. For example, in cultures where high power distance exists, students may hesitate to seek help or question feedback. Voice charts and graphic comparisons offer an alternative, non-confrontational medium for feedback delivery, empowering students to self-assess and take ownership of their learning.

Ultimately, the application of mixed methods with graphic comparisons across cultural contexts fosters a more equitable and adaptable approach to blended learning. By addressing the diverse linguistic, cultural, and pedagogical needs of students, this methodology ensures that blended learning models remain inclusive and effective in promoting self-directed learning and skill development on a global scale.

4 Findings

This section presents an in-depth exploration of the findings from the implementation of the Virtual Voice Lab (VVL) in the elective course LUE3003 during Term 2 of the 2024-25 academic year. Utilizing a mixed methods approach, the analysis combines quantitative survey data with qualitative feedback to evaluate the effectiveness of the VVL in enhancing English pronunciation skills through blended learning. The findings highlight the strong reception of key features, such as the 7-day self-learning plan and sound charts, while also identifying areas for improvement, including technical functionality and interactivity. Additionally, a graphical comparison of voice charts submitted by students with differing academic performances illustrates the personalized impact of targeted feedback and self-directed learning. This mixed-methods analysis underscores the pedagogical value of the VVL and its potential to foster self-

regulation, improve pronunciation, and bridge the gap between online and in-person instruction.

4.1 Quantitative Data Collection and Analysis

This empirical investigation examines learner perceptions of the Virtual Voice Lab (VVL) platform implemented within the LUE3003 elective course during Term 2, 2024-25 at Lingnan University. Utilizing a cross-sectional survey design (n=123), the study evaluated this blended learning intervention designed to enhance English phonological competence through self-directed practice. Quantitative and qualitative methodologies were employed to assess engagement levels, pedagogical efficacy of platform features (including the 7-day learning plan and phonemic charts), and areas requiring technical and pedagogical refinement. The subsequent analysis systematically addresses participant receptivity, feature effectiveness, and developmental recommendations based on empirical findings.

4.2 Survey Instrumentation and Analytical Approach

A structured questionnaire comprising ten items (incorporating both closed and open-response formats) was administered to evaluate key VVL dimensions. Primary metrics included initial perceptions of the 7-day learning architecture, perceived efficacy in phonological skill development, utility of specific features (e.g., phonemic charts, model recordings), and net promoter sentiment. Quantitative data underwent descriptive statistical analysis (frequencies, central tendency measures), while qualitative responses were subjected to thematic analysis to identify recurrent patterns and substantive insights (Braun & Clarke, 2006).

4.3 Results and Interpretive Analysis

Initial Perceptions of Pedagogical Structure. Participant receptivity toward the 7-day learning framework was predominantly favorable. Quantitative analysis revealed 50.4% (n=62) expressed moderate positivity, while 24.4% (n=30) reported strong endorsement. Marginal negativity was observed (4.1%, n=5), with no instances of extreme disapproval. This distribution suggests broad acceptance, potentially attributable to the scaffolded design and perceived usability (Means et al., 2013).

Perceived Efficacy of Learning Intervention. A significant majority (69.1%, n=85) rated the intervention as moderately to highly effective for phonological development, with 29.3% (n=36) indicating maximal efficacy. Limited critique emerged, with only 6.5% (n=8) reporting marginal effectiveness. These metrics substantiate the framework's pedagogical utility, particularly its contextual alignment with course objectives and provision of structured practice opportunities.

Feature Utility for Phonological Acquisition. Participant valuation of thematic content revealed notable variation. Foundational prosodic elements proved most impactful: linking/pausing (Day 1) was prioritized by 52% (n=64), followed by lexical stress patterns (Day 3; 43.9%, n=54). Segmental features (vowels/consonants; Days 4-5) received moderate engagement (35.8-37.4%), while consonant clusters (Day 6) demonstrated lowest utility perception (26%, n=32). This hierarchy suggests immediate applicability of suprasegmental features influences perceived relevance (Derwing & Munro, 2005).

Model Recording Efficacy. Audio exemplars received consistently high evaluation across parameters. Clarity (M=4.39, SD=0.73) and pacing (M=4.38, SD=0.76) on a 5-point Likert scale indicated strong consensus regarding their instructional value. Minimal dispersion metrics further reflect homogeneity in positive assessment, underscoring the critical role of high-fidelity auditory models in pronunciation pedagogy (Thomson, 2017).

Participant Endorsement Metrics. Net promoter sentiment was markedly positive, with 93.5% (n=115) indicating moderate to high recommendation likelihood. Neutral disposition (12.2%, n=15) and negative inclination (2.4%, n=3) were statistically negligible. This robust endorsement reflects perceived instrumental value in phonological skill development.

Practice Duration Patterns. Temporal investment data revealed that 67.3% (n=101) engaged in daily practice sessions of 15-30 minutes duration, suggesting an optimal balance between feasibility and pedagogical effectiveness. Extended engagement (30-60 minutes) was reported by 23.8% (n=36), while only 4% (n=6) exceeded 60 minutes. This distribution indicates that focused, time-efficient practice aligns with learner capacity for sustained implementation.

4.4 Qualitative Data Collection and Analytical Methodology

This hermeneutic analysis examines learner experiences derived from a Staff-Student Consultation Meeting (SSCM) conducted virtually for the LUE3003 course during Term 2, 2024-25. Utilizing purposive sampling, 14 student representatives engaged in semi-structured discourse regarding course design, individualized consultations, and the 7-Day Plan's implementation. Sessions employed pseudonymization to ensure confidentiality and lasted approximately 60 minutes, with participants providing unstructured feedback on pedagogical components. Data collection followed established ethical protocols for learner voice research (Bovill, 2020). Thematic analysis revealed significant congruence with prior pilot study findings (Fan, 2024), indicating persistent patterns across implementation cycles. This systematic categorization identifies emergent pedagogical implications through inductive coding (Saldaña, 2009).

4.5 Emergent Themes and Pedagogical Implications

Systematic Skill Sequencing and Adaptive Implementation. Participants consistently valued the 7-Day Plan's structured phonological progression, noting its explicit segmentation of suprasegmental and segmental features. The modular design enabled differentiated practice targeting individual competency gaps (e.g., vowel articulation, connected speech). As articulated:

“Overall, the course is so good and (so is) the interactive teaching method (is) and blended learning about the 7 Day Plan that allow us to practice at home while we don't have anything to do. And after the course. We can also keep the materials for our further learning. So I really love the 7 Day Plan.” (Student 5, Appendix, 41:41- 41:50)

This pedagogical flexibility demonstrated efficacy in promoting self-regulated learning behaviors, aligning with Zimmerman's (2002) model of learner autonomy.

Reinforced Cognitive Engagement. The scaffolded daily objectives facilitated sustained engagement with phonological content beyond formal instruction. Participants reported enhanced knowledge retention through incremental skill-building:

“I really love this course. And then I really appreciate the 7 Day Learning plan as it breaks down the pronunciation in manageable steps, and I also think this kind of approach really made our learning process more effective and less overwhelming, and, moreover, I find the individual consultation extremely valuable. I really really love it” (Student 9, Appendix, 23:14).

This finding corroborates cognitive load theory principles in pronunciation pedagogy (Kalyuga, 2011), suggesting distributed practice scaffolds metacognitive awareness.

Formative Assessment Mechanisms. Individualized consultations emerged as a critical success factor, with diagnostic feedback enabling precise gap identification. Participants emphasized its role in developing metalinguistic awareness:

"And and I think another particularly very good point is that after each assignment the tutor will give feedback, and I can see my own problems and make improvements in the next assignment." (Student 11, Appendix, 26:46)
"So I really love the individual consultations, because I think they help me see exactly where I'm struggling with my pronunciation. So without this one-on-one feedback I might never notice where my mistakes are, so I think it's super helpful, and really boost my confidence in my assessment. So I think this is the activity that really need to keep." (Student 9, Appendix, 49:40)

These findings substantiate Hattie's (2009) meta-analysis on feedback efficacy, particularly for covert phonological processes.

Affective Learning Dimensions. Gamified in-person activities (e.g., the "spy game") significantly reduced phonological anxiety through collaborative engagement. Participants noted:

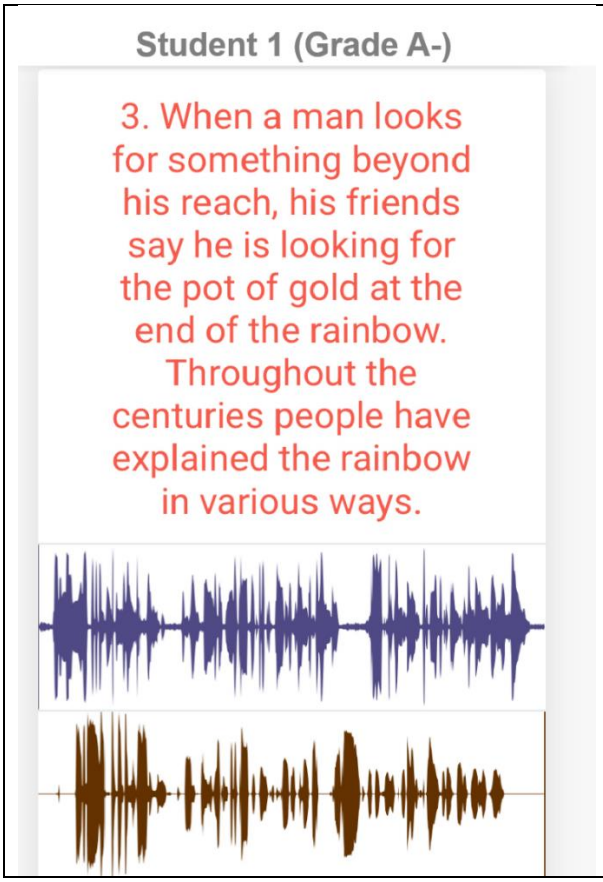
> "I really like the spy game, actually, because we can. Not only learn how to pronounce word, and also we can use we can think of killer. I think it's quite interactive for us to communicate (with) other students. It would be very interesting to join these activities. Thank you." (Student 2, Appendix, 37:57)

This affective scaffolding appears instrumental in sustaining engagement with subsequent asynchronous components, supporting Krashen's (1982) affective filter hypothesis regarding language acquisition barriers.

Triangulated Validation. The consistency of these themes across both SSCM data and prior pilot studies (Fan, 2024) demonstrates robust pedagogical validity. The recurrent emphasis on structured flexibility, diagnostic feedback, and affective support establishes a framework for effective pronunciation pedagogy in blended environments.

4.6 Comparative Analysis of Phonological Development Using Visual Mediation

This section examines how visual voice charts facilitate differentiated instruction in blended learning environments through two representative cases (Figure 2-3). Student 1 (L1 English speaker, Grade A-) demonstrated advanced phonological control but exhibited hyperarticulation tendencies affecting naturalness. Student 2 (L2 English speaker, Grade C) displayed marked challenges with consonant voicing, prosodic continuity, and schwa articulation despite remedial efforts.



Instructor's comments to the student:

A very good read. There are only two words to note -

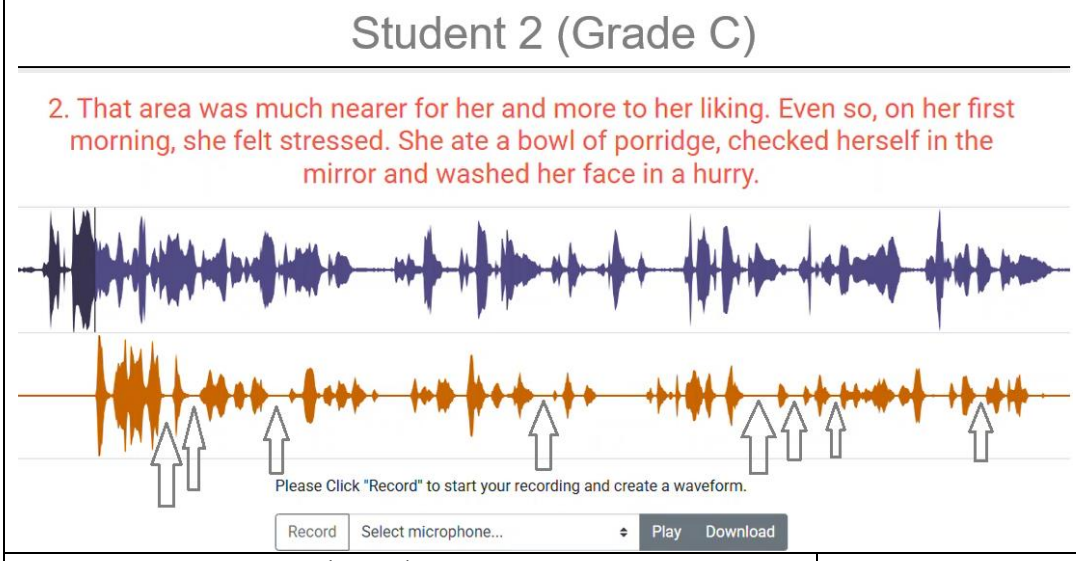
1. reach - it is a long vowel, unlike 'rich' which is a short vowel.

2. various - the beginning sound is a voiced consonant. Please make sure the vibration is there and not replaced by the /f/

Scan the QR code to listen to the recording.

Figure 2. Voice Chart by Student 1 (Grade A-)

Note: Figure 2 shows the voice chart submitted by the student on Moodle. Completion mark was awarded automatically, and the instructor would listen to the recording and give tailored comments. Student 1 was randomly selected from the students who obtained an overall grade A or A- in Term 2, 2024-25.



Instructor's comments to the student:
Good effort! This recording displays commendable effort which clearly shows how careful you tried to utter each word with care. To improve further, you may want to work harder on the voiced and unvoiced consonant, be more mindful of the plosives (blocking and releasing of air), practice the articulation of schwa, and reduce the pausing by linking the words. To link the words more fluently, try to apply the techniques learnt in class such as catenation, intrusion, assimilation, and geminates. Currently, the emphatic (over stress) utterances may lead to choppiness which impairs the intonation. Please watch the video about linking on VVL here:
https://virtualvoicelab.com/index.php?page=linking

Scan the QR code to listen to the recording.

Figure 3. Voice Chart by Student 2 (Grade C)

Note: Figure 3 shows the voice chart submitted by student 2 on Moodle and was randomly selected from the students who obtained an overall grade C+ or C in Term 2, 2024-25.

4.7 Diagnostic and Pedagogical Functions of Visual Voice Charts

The following table provides a functional analysis of the use of visual voice charts within blended learning environments. It outlines how these charts serve as critical tools for both students and instructors, facilitating metacognitive development, formative assessment, and pedagogical continuity. By mapping out the unique benefits for each group, the table highlights the multidimensional role voice charts play in supporting phonological awareness, targeted feedback, and the alignment of instructional strategies across different phases of learning.

Table 1: Functional Analysis of Voice Charts in Blended Learning

Function	Student Benefits	Instructor Benefits
Metacognitive Scaffolding	Enhances self-monitoring of phonological features (Derwing & Munro, 2005)	Identifies recurrent error patterns across cohorts
Formative Assessment	Enables benchmarking against acoustic models	Facilitates evidence-based intervention targeting
Continuity Mechanism	Creates longitudinal skill trajectory mapping	Synchronizes online/offline instructional alignment

4.7.1 Mechanistic Efficacy

Visual voice charts play a multifaceted role in phonological instruction by externalizing covert processes and enabling learners to independently diagnose both segmental distinctions, such as voiced and unvoiced sounds, and suprasegmental features like prosodic continuity (Wilson & Gick, 2014). Inspired by Wilson's use of Praat and Moodle (2009), the author combined the voice charts with Moodle submission to facilitate students' self-learning process. These charts facilitate targeted remediation by structuring feedback around specific linguistic parameters, for instance, prompting learners to "reduce plosive over-aspiration" as illustrated in Figure 3. This directs attention to discrete phonological features rather than offering broad, subjective impressions. Importantly, within blended learning environments, visual voice charts serve as transactional artifacts that bridge asynchronous practice with synchronous instruction, ensuring pedagogical coherence and maintaining continuity across different learning modalities (Garrison & Vaughan, 2008).

4.7.2 Theoretical and Pedagogical Implications

This single case study demonstrates how visual mediation transforms abstract phonological concepts into actionable learning pathways. As shown in Figure 3, Student 2's progression from fragmented utterances to controlled connected speech (evidenced in subsequent submissions) validates the tool's capacity to scaffold interlanguage restructuring through focused attention allocation.

The pedagogical framework leveraged instructor feedback utilizing connected speech diagnostics, specifically targeting features such as catenation, intrusion, assimilation, and geminates, to address individual phonological challenges, while visual annotations provided precise scaffolding for suprasegmental development areas including prosodic continuity and lexical stress. Concurrently, demonstrative recordings facilitated multimodal self-assessment by enabling learners to benchmark their oral production against model utterances, thereby creating an integrated diagnostic-practice loop that bridged theoretical instruction with applied skill refinement.

4.8 Pedagogical Efficacy of Visual Voice Charts in Blended Learning

Visual voice charts serve as multidimensional scaffolds within blended learning ecosystems, enhancing phonological awareness through multimodal representation. These instruments mediate between asynchronous self-directed learning and synchronous instruction by facilitating metacognitive development through externalization of abstract phonological features such as voice-onset time and formant structures into visual schemata. This process enables learners to self-monitor suprasegmental elements including prosodic continuity and lexical stress, promoting evidence-based self-assessment through benchmark comparisons (Derwing & Munro, 2015). Concurrently, the charts optimize instructional diagnostics by providing objective performance analytics that identify persistent error patterns, such as final-obstruent devoicing or vowel centralization. This diagnostic capability streamlines feedback delivery through visual reference points, enabling precise remediation strategies during face-to-face interventions (Hattie & Timperley, 2007). Furthermore, these tools ensure pedagogical continuity by creating shared referential frameworks that align learner-instructor expectations across distributed learning phases, supporting longitudinal skill trajectory mapping while reducing transactional distance between modalities (Garrison & Vaughan, 2008).

Table 2: Functional Taxonomy of Visual Voice Charts

Dimension	Learner Benefits	Instructor Benefits
Cognitive	Enhanced metalinguistic awareness	Pattern recognition across cohorts
Behavioral	Self-regulated practice adjustment	Evidence-based intervention targeting
Transactional	Reduced transactional distance	Synchronized instructional alignment

4.9 Longitudinal Analysis of Academic Performance and Engagement

Analysis of academic performance across Term 1 and Term 2 (AY 2024-25) reveals significant competency-based engagement patterns. As quantified in Table 2, high-performing students (grades A/A-/B+) maintained near-perfect completion rates (99.3% to 98.1%), demonstrating robust self-regulation capabilities. Mid-tier students (B/B-) exhibited a marked 10.7% engagement decline, while low performers (C+/C) showed critical disengagement (-20.0%). F-grade students maintained universal non-participation (0% both terms), indicating a negative feedback loop where declining engagement exacerbates competency gaps.

Table 3: Academic Performance and Blended Learning Completion (AY 2024-25)

Grade Band	Term 1 Completion (%)	Term 2 Completion (%)	Δ Completion
High (A/A-/B+)	99.3 (n=64)	98.1 (n=54)	-1.2
Mid (B/B-)	93.3 (n=104)	82.6 (n=86)	-10.7
Low (C+/C)	77.1 (n=28)	57.1 (n=20)	-20.0
Fail (F)	0.0 (n=3)	0.0 (n=1)	0.0

These quantitative patterns are further elucidated in Table 3, which demonstrates a strong positive correlation between grade attainment and completion rates ($r = .89$, $p<.01$). The bell-curve distribution confirms maximal engagement occurs at median competency levels (B grade band), with sharp divergence among lower performers. The B- threshold emerged as a critical inflection point, where completion rates plummeted to 63% in Term 2. This differential attrition suggests lower-performing students require enhanced scaffolding for self-regulated learning, particularly in managing blended learning's dual demands. The sustained high performance among top-quartile students validates the model's efficacy for autonomous learners, while the terminal disengagement at failure levels necessitates early interventions targeting motivational and metacognitive barriers (Zimmerman, 2002).

5 Discussion

This section synthesizes key findings on the relationship between academic performance, blended learning engagement, and pedagogical design. Analysis reveals how self-directed learning efficacy varies across proficiency tiers, the impact of communication strategies on participation, and feedback's role in bridging learning modalities. These insights inform actionable recommendations for optimizing blended learning to equitably address diverse learner needs.

5.1 Performance-Engagement Correlation

A robust positive correlation exists between academic standing and blended learning completion ($r = .89$, $p<.01$), revealing critical divergence in self-regulated learning capacity. High performers (A/A-/B+) maintained near-perfect completion (Δ −1.2%), leveraging autonomy to reinforce phonological skills. Conversely, low performers (C+/C) exhibited acute disengagement (−20.0% completion decline), signaling deficits in metacognitive scaffolding (Zimmerman, 2002). This bifurcation necessitates tiered interventions: structured timelines for struggling learners while preserving autonomy for advanced students. Notably, low-performing completers demonstrated significant skill gains (e.g., Student 2's connected speech progression), validating blended learning's potential when strategically supported.

5.2 Communication Efficacy and Accountability

Communication clarity directly influenced participation, as evidenced by differential incompletion rates across instructors (Table 4). Despite repeated reminders from Teachers A and C, Term 2 saw a 50% rise in non-completion (n=24 vs. n=16 in Term 1), with Teacher B's section reporting unawareness of the 2% participation mark. This indicates uniform communication protocols are necessary but insufficient alone. Cohort dynamics (e.g., Term 2's lower collective motivation) and external factors (e.g., workload intensity) likely compounded disengagement. Multifaceted strategies including centralized announcement systems and workload calibration are essential to mitigate contextual barriers.

Table 4: Blended Learning Incompletion by Instructor

Instructor	Term 1 Incompletion	Term 2 Incompletion
Teacher A	3/90 (3.3%)	8/72 (11.1%)
Teacher B	10/36 (27.8%)	9/18 (50.0%)
Teacher C	3/76 (3.9%)	7/71 (9.9%)

5.3 Moderating Factors in Engagement Trends

The grading policy, while effective in reducing student anxiety through completion-based assessment, inadvertently disadvantaged low-performing students who lacked intrinsic motivation. High-achieving students thrived under the autonomy provided by this approach, whereas struggling learners required additional quality-based incentives, such as partial credit for iterative submissions, to recognize the value of completing tasks. Furthermore, cohort variability played a significant role, as Term 2's students demonstrated lower baseline motivation, as evidenced by institutional data, which amplified disengagement. Implementing pre-term diagnostic assessments could help identify at-risk groups, enabling proactive support measures. Additionally, external pressures, such as workload imbalances, disproportionately affected Term 2 students, further hindering their engagement. To address these barriers, modular task design and timely technical assistance could be introduced to alleviate the challenges associated with workload and technical difficulties

5.4 Feedback as a Pedagogical Catalyst

Instructor feedback served as a critical bridge between online and in-person learning, employing differentiated approaches to meet the diverse needs of students. All participants who completed the blended learning program received personalized feedback from instructors, a key factor that enhanced the program's effectiveness, as evidenced by both quantitative and qualitative findings. For high performers, such as Student 1 (Grade A−), feedback focused on concise refinements, such as improving vowel length distinctions, which preserved their motivation and reinforced their advanced skills. In contrast, low-performing students, like Student 2 (Grade C), benefited from granular, targeted feedback addressing foundational gaps, such as plosive control and schwa articulation. This feedback was often supplemented with resource links and specific exercises aimed at promoting self-regulated improvement.

In addition, digitally augmented feedback such as audio annotations or hyperlinks directing students to blended learning materials within the Virtual Voice Lab further personalized guidance, reinforcing resource utilization and encouraging independent practice. This approach aligns with Hattie and Timperley's (2007) framework, emphasizing the importance of actionable, relevant, and goal-oriented feedback in driving student progress. Crucially, feedback explicitly linked task completion in the online environment to tangible skill gains, increasing its perceived relevance across all proficiency levels. For high achievers, this connection reinforced their advanced learning objectives, while for struggling learners, it

highlighted the value of incremental progress and reduced the gap between their current performance and desired outcomes. Together, these strategies ensured that feedback not only addressed individual needs but also empowered students to navigate the blended learning environment with greater autonomy and confidence.

5.5 Limitations and Strategic Implications

To optimize blended learning efficacy, institutions should implement stratified scaffolding that segments support by self-regulation capacity, providing low performers with structured timelines and progress monitoring while offering advanced learners challenge tiers, alongside integrating motivational positive reinforcement through quality-based incentives (e.g., badges for iterative improvement) to complement completion marks. Currently, the challenges posed by compatibility issues remain unresolved due to limited resources. With sufficient funding support, blended learning online platforms should embed AI-driven diagnostic feedback within asynchronous modules to deliver real-time guidance before summative assessments, cross-platform development and cloud-based platform which requires additional costs could address interoperability, while pre-term workshops tailored to cohort profiles should build foundational resilience through time-management and technical-navigation training. Collectively, these evidence-based reforms position blended learning as an adaptive ecosystem capable of narrowing equity gaps through responsive pedagogical design that anticipates learner variability.

6 Conclusion: Advancing Blended Language Learning Through Visual Feedback and Adaptive Pedagogy

This study demonstrates that visual voice charts significantly enhance blended learning environments by serving as pivotal tools for both students and instructors. These charts provide visual representations of phonetic elements—such as voiced/unvoiced consonants, vowel duration, and prosodic features—enabling students to self-monitor progress and target specific areas for improvement (e.g., linking techniques or stress patterns). Instructors leverage these visualizations for data-driven diagnostics, facilitating tailored interventions aligned with individual proficiency levels, as evidenced by the contrast between feedback strategies for Grade A- and C learners. Empirical validation from the Virtual Voice Lab (VVL) implementation further substantiates these benefits: 93.5% of students endorsed the structured 7-day plan, highlighting its efficacy in addressing core pronunciation challenges like linking/pausing (52% perceived utility) and syllable stress (43.9%).

Pedagogically, this research underscores two critical principles. First, differentiated feedback functions as a scaffolding mechanism, optimizing cognitive load and motivation across proficiency levels—concise refinement cues for advanced learners versus granular, resource-supported guidance for struggling students. This aligns with Vygotsky's (1978) Zone of Proximal Development, positioning feedback as dynamic instructional scaffolding. Second, visual voice charts operationalize self-regulated learning theory (Zimmerman, 2002), transforming abstract phonological concepts into actionable metrics. The VVL survey corroborates this, with 69.1% of students reporting enhanced skill retention through structured 15–30-minute daily sessions anchored to visual benchmarks.

Despite these strengths, limitations warrant consideration. Technical constraints, particularly cross-platform compatibility issues (e.g., Android/MacOS audio uploads), intermittently disrupted user experiences. Students also indicated gaps in interactivity, requesting features like AI-driven real-time feedback and adjustable-speed demo recordings. Furthermore, longitudinal evidence of skill transfer to spontaneous speech remains under-explored.

Future research should prioritize four key directions: (1) developing AI-enhanced personalization through machine learning algorithms to auto-detect errors (e.g., plosive inaccuracies) and generate predictive feedback; (2) integrating voice charts into gamified or immersive contexts (e.g., VR simulations), as suggested by 22% of VVL respondents; (3) investigating cross-modal feedback by combining visual analytics with haptic or augmented reality interfaces; and (4) conducting longitudinal analyses to evaluate sustained impacts on phonological awareness across diverse learner demographics. In synthesis, visual voice charts crystallize the symbiosis between metacognitive autonomy and instructor expertise in blended ecosystems. Their capacity to democratize pronunciation mastery—validated by high recommendation rates (93.5%) and adherence to structured practice—positions them as indispensable for equitable, data-informed language acquisition. Subsequent innovations embracing AI and immersive design will amplify their transformative potential. Studies should also explore strategies for addressing the digital divide, such as leveraging low-bandwidth solutions or providing offline access to learning materials. Furthermore, longitudinal research is needed to assess the long-term impacts of technology-enhanced learning on student outcomes, particularly in diverse cultural and socio-economic contexts. By addressing these challenges and leveraging recent developments, technology-enhanced learning can continue to evolve as a powerful tool for fostering equitable and effective education.

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Appendix

2024-25 Staff-student Consultation Meeting Full Transcript is available here:
Appendix_Transcript.docx