

# Enhancing Engagement in Speech Rehabilitation through Gamified Interaction and Emotional Design

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**Abstract:** Speech rehabilitation systems often suffer from low user engagement due to repetitive training processes and limited emotional support. To address this issue, this study proposes an integrated interaction design framework combining gamification, emotional design, and multisensory compensation mechanisms for speech rehabilitation. Based on User-Centered Design (UCD) principles and Norman's emotional design theory, a mobile application named Yinshu was developed, incorporating gamified tasks, adaptive difficulty adjustment, AI emotional companion interaction, and a "visualizing sound" feedback mechanism. To evaluate the system, 40 participants completed a customized short-form User Engagement Scale (UES) questionnaire after using the application. The results showed positive evaluations across all dimensions, with mean scores above 4.0 on a 5-point Likert scale. Gamified rewards improved motivation and self-efficacy, while emotional companion interaction reduced feelings of isolation and enhanced psychological engagement. In addition, the visual feedback system effectively improved users' understanding of pronunciation accuracy and reduced cognitive barriers during training. The findings suggest that integrating gamification and emotional design can effectively enhance engagement in speech rehabilitation, providing practical insights for future digital rehabilitation system design.

**Keywords:** Speech Rehabilitation; Gamification; Emotional Design; Human-Computer Interaction; User Engagement.

## 1. Introduction

Speech rehabilitation is a critical component in the recovery process for individuals with speech impairments caused by neurological disorders, developmental conditions, or acquired injuries. With the rapid advancement of digital health technologies, mobile-based rehabilitation tools have emerged as scalable and accessible solutions, enabling continuous training beyond clinical settings. However, despite their functional advantages, many existing digital speech rehabilitation systems remain limited in their ability to sustain long-term user engagement, often resulting in low adherence and suboptimal therapeutic outcomes.

One of the primary challenges in current rehabilitation systems lies in their overly task-oriented and monotonous interaction design. Traditional approaches tend to emphasize repetitive pronunciation exercises with limited feedback modalities, which can increase cognitive fatigue and reduce user motivation over time. Furthermore, these systems frequently neglect the emotional and psychological needs of users, particularly those experiencing frustration, anxiety, or stigma associated with speech impairments. The absence of emotionally supportive interaction mechanisms may further diminish users' willingness to engage consistently in rehabilitation activities.

Recent studies suggest that integrating gamification and emotional design into health-related applications can significantly enhance user engagement and experience. Gamification introduces motivational affordances such as points, badges, and leaderboards, which have been shown to improve behavioral participation and self-efficacy in various rehabilitation contexts. Meanwhile, emotional design—grounded in Norman's three-level framework (visceral, behavioral, and reflective)—emphasizes the importance of

affective interaction in shaping user experience and long-term engagement. Despite these advances, there remains a lack of systematic integration between gamified interaction, emotional design, and speech rehabilitation mechanisms, particularly in terms of how these elements jointly influence both behavioral engagement and psychological participation.

To address these gaps, this study proposes an integrated design approach that combines gamified interaction strategies, emotional design principles, and multisensory compensation mechanisms within a speech rehabilitation context. Specifically, a mobile application named Yinshu is developed based on a user-centered design (UCD) framework. The system introduces a "visualizing sound" mechanism to compensate for auditory limitations, incorporates adaptive difficulty adjustment informed by flow theory, and embeds an emotionally responsive virtual companion to support users throughout the rehabilitation process.

The primary objective of this study is to investigate how the integration of gamification and emotional design can enhance user engagement in speech rehabilitation. To this end, both behavioral and psychological dimensions of engagement are examined through empirical evaluation. The study aims to answer the following research questions: (1) how multisensory interaction affects cognitive load during rehabilitation tasks, (2) how gamification influences user motivation and self-efficacy, and (3) how emotional design contributes to users' affective experience and sustained participation.

This research makes three main contributions. First, it proposes a novel interdisciplinary framework that integrates gamification, emotional design, and speech rehabilitation within a unified interaction design model. Second, it develops and implements a functional prototype system that operationalizes these design principles in a real-world

application context. Third, it provides empirical evidence on the effectiveness of this approach in improving user engagement, offering both theoretical insights and practical guidelines for the design of future digital rehabilitation tools.

## **2. Related Work and Theoretical Framework**

### **2.1. Speech Rehabilitation and Digital Interventions**

Speech rehabilitation has traditionally relied on therapist-guided interventions, emphasizing repetitive articulation training and auditory feedback mechanisms. With the proliferation of digital technologies, mobile and computer-assisted rehabilitation systems have been increasingly adopted to extend therapy beyond clinical environments. These systems provide flexibility, accessibility, and opportunities for continuous practice, which are essential for patients requiring long-term intervention.

However, existing digital speech rehabilitation tools often prioritize functional training while overlooking user experience and engagement. Many systems rely heavily on auditory feedback, which may not be sufficient for users with severe impairments or those who struggle with auditory processing, leading to heightened communication frustration. Additionally, the lack of adaptive interaction and personalized feedback can lead to cognitive overload or disengagement, ultimately reducing the effectiveness of rehabilitation programs. These limitations highlight the need for more user-centered and interaction-driven design approaches in speech rehabilitation systems.

### **2.2. Gamification in Rehabilitation Contexts**

Gamification has emerged as a powerful strategy to enhance user engagement in health-related applications by incorporating game-design elements into non-game contexts. Common mechanisms include points, badges, leaderboards, and progress tracking, which can stimulate extrinsic motivation and reinforce positive training behaviors.

In rehabilitation contexts, gamification has been shown to improve adherence and increase the frequency of training activities. By transforming repetitive tasks into interactive and goal-oriented experiences, gamified systems can reduce boredom and enhance user persistence. Furthermore, gamification can support the development of self-efficacy by providing users with a sense of achievement and a clear roadmap of their progression. Despite these advantages, current applications in speech rehabilitation are often superficial, focusing primarily on reward systems without integrating deeper emotional needs, resulting in limited long-term effectiveness when not combined with broader engagement-enhancing strategies. Despite these advantages, current applications of gamification in speech rehabilitation are often superficial, focusing primarily on reward systems without integrating deeper interaction mechanisms or aligning with users' emotional needs. As a result, the long-term effectiveness of gamification remains limited when not combined with other engagement-enhancing strategies.

### **2.3. Emotional Design in Human-Computer Interaction**

Emotional design plays a crucial role in shaping user experience by addressing users' affective responses during interaction. According to Norman's three-level model,

emotional design can be understood across visceral, behavioral, and reflective levels, each corresponding to different aspects of user perception and experience.

At the visceral level, design focuses on immediate sensory appeal, such as visual aesthetics and interface attractiveness (e.g., the use of low-saturation color schemes to mitigate user anxiety). At the behavioral level, usability and interaction efficiency are emphasized, ensuring that users can achieve their training goals intuitively. At the reflective level, design influences users' self-perception and emotional attachment to the system, which is often facilitated by companion agents or social feedback. In healthcare, emotional design is a key factor in reducing negative emotions such as anxiety, frustration, and stigma. However, many existing systems lack mechanisms to address these emotional dimensions, resulting in a gap between functional performance and the user's psychological well-being.

### **2.4. Theoretical Integration: UCD, Flow Theory, and Multisensory Interaction**

To address the limitations identified in prior studies, this research integrates multiple theoretical perspectives into a unified design framework.

First, User-Centered Design (UCD) emphasizes the importance of involving users throughout the design process to ensure that systems align with their needs, preferences, and abilities. UCD has been widely applied in healthcare design to improve usability and accessibility.

Second, Flow Theory provides a theoretical basis for understanding user engagement. According to this theory, optimal engagement occurs when there is a balance between task difficulty and user skill level. Adaptive difficulty mechanisms can help maintain this balance, preventing both boredom and frustration [7,11].

Third, multisensory interaction offers an alternative approach to traditional auditory-based rehabilitation by incorporating visual and other sensory modalities. The "visualizing sound" strategy enables users to perceive speech characteristics through visual feedback, reducing reliance on auditory processing and lowering cognitive barriers.

The integration of these theories allows for a more holistic approach to interaction design, addressing not only functional performance but also cognitive and emotional aspects of user experience.

### **2.5. Research Gap**

Although prior research has explored digital speech rehabilitation, gamification, and emotional design independently, several critical gaps remain.

First, there is a lack of integrated frameworks that systematically combine gamification and emotional design within speech rehabilitation contexts. Existing studies tend to focus on isolated design elements rather than their synergistic effects.

Second, limited attention has been given to the dual dimensions of engagement, namely behavioral engagement (e.g., participation frequency) and psychological engagement (e.g., motivation, emotional involvement). Most studies emphasize performance outcomes while neglecting users' internal experiences.

Third, the potential of multisensory interaction, particularly visual compensation mechanisms, remains underexplored in speech rehabilitation systems. This represents an important opportunity to enhance accessibility

and reduce cognitive load for users with diverse needs.

In response to these gaps, this study proposes an integrated design framework that combines gamification, emotional design, and multisensory interaction to enhance engagement in speech rehabilitation. The following sections detail the system design, methodology, and empirical evaluation of this approach.

### 3. System Design and Methodology

#### 3.1. System Design of the “Yinshu” Application

This study developed a gamified speech rehabilitation application named Yinshu, which integrates emotional design, multisensory interaction, and adaptive rehabilitation mechanisms into a unified mobile interface. Guided by User-Centered Design (UCD) principles and Norman’s emotional design theory, the system aims to improve both behavioral engagement and emotional participation during speech rehabilitation training.

As illustrated in Figure 1, the application mainly consists of three integrated modules: (1) gamified rehabilitation tasks, (2) AI emotional companion interaction, and (3) visualized pronunciation feedback. Instead of separating each interface into independent figures, the core interaction interfaces were combined into one composite figure to provide a clearer overview of the system structure and reduce visual redundancy within the manuscript.

The first module adopts gamification strategies including daily tasks, level progression, achievement rewards, and leaderboard mechanisms. Users gain heart points and virtual growth rewards after completing pronunciation or breathing exercises, thereby enhancing motivation and long-term adherence through reward-driven interaction. The interface design uses rounded geometric components and a soft Morandi-inspired color palette to reduce visual fatigue while creating a warm and emotionally friendly rehabilitation environment.

The second module introduces an AI virtual companion named “Yinhu,” which provides conversational guidance and emotional encouragement throughout the rehabilitation process. Through supportive dialogue and positive reinforcement feedback, the virtual companion aims to reduce users’ feelings of loneliness, anxiety, and rehabilitation fatigue. This interaction mechanism corresponds to the reflective level of emotional design by strengthening emotional attachment and psychological support.

The third module applies a “visualizing sound” strategy to provide multisensory compensation during pronunciation training. Real-time waveform visualization and pronunciation indicators allow users to perceive pronunciation accuracy visually rather than relying solely on auditory feedback. This approach reduces cognitive barriers in speech correction tasks and improves interaction clarity, especially for users with difficulties in auditory perception.



Fig. 1 Integrated Interface Design of the Yinshu Application

#### 3.2. Methodology

To evaluate the effectiveness of the proposed interaction framework, a user evaluation study was conducted involving 40 participants after experiencing the Yinshu application. Following the interaction session, participants were invited to complete a customized short-form User Engagement Scale (UES) questionnaire.

The questionnaire adopted a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) and was developed based on the core interaction features of the system, including multisensory compensation, emotional companion interaction, adaptive difficulty adjustment, and gamified motivation mechanisms.

As summarized in Table 1, the questionnaire consisted of four dimensions: Aesthetic Appeal (AE), Perceived Usability

(PU), Reward Factor (RW), and Focused Attention & Emotional Support (FA/ES). Representative items from each dimension were retained in the main text, while the complete bilingual questionnaire was prepared as supplementary material to maintain the conciseness of the manuscript.

The Reward Factor dimension examined whether gamified elements such as badges, daily tasks, and leaderboards enhanced users’ motivation and self-efficacy. Meanwhile, the Focused Attention and Emotional Support dimension investigated the impact of the “Yinhu” virtual companion and encouraging feedback on emotional engagement and immersive rehabilitation experiences.

The collected questionnaire data were analyzed descriptively to examine participants’ perceptions of engagement, usability, and emotional interaction within the proposed rehabilitation system.

**Table 1.** Customized UES Questionnaire Structure

Dimension	General
Aesthetic Appeal (AE)	1. The interface design of the "Yinshu" app is visually attractive (e.g., the soft Morandi color scheme).
	2. The layout and rounded geometric elements of the app are aesthetically pleasing.
Perceived Usability (PU)	3. The real-time waveform and pronunciation indicators help me understand my speech accuracy clearly.
	4. I feel in control of my training pace when using the adaptive difficulty features.
	5. Correcting my pronunciation using the visual feedback system is straightforward and efficient.
Reward Factor (RW)	6. Earning rewards like the "Encounter With You" medal makes me feel a sense of achievement.
	7. The gamified daily tasks and leaderboards motivate me to continue my rehabilitation training.
	8. Using the "Yinshu" app for speech practice is rewarding and worthwhile.
Focused Attention & Emotional Support (FA/ES)	9. I easily lose track of time when I am immersed in the vocal practice mini-games.
	10. The companion agent "Yinhu" makes the rehabilitation environment feel warm and less isolating.
	11. The encouraging feedback (e.g., "Almost made it!") helps me stay focused even when I fail.

## 4. Results and Discussion

To evaluate the effectiveness of the proposed gamified and emotional rehabilitation framework, descriptive statistical analysis was conducted based on the responses of 40 participants who completed the customized short-form UES questionnaire after using the Yinshu application.

### 4.1. Results Analysis

As shown in Table 2, all questionnaire items achieved mean scores above 4.0, indicating generally positive user perceptions toward the system's visual design, usability, gamification mechanisms, and emotional interaction experience.

The findings suggest that the gamified reward system effectively enhanced users' motivation and self-efficacy. In particular, achievement-related items received the highest average scores ( $M = 4.30$ ), indicating that badges, rewards, and progress feedback positively influenced continued participation in rehabilitation tasks.

The visualized pronunciation feedback system also demonstrated positive usability performance. Participants reported that the real-time waveform and pronunciation indicators helped them understand speech accuracy more clearly, supporting the effectiveness of the "visualizing sound" multisensory compensation strategy.

Furthermore, emotional interaction mechanisms contributed positively to users' rehabilitation experiences. The virtual companion "Yinhu" and encouraging feedback reduced feelings of isolation and maintained users' attention

during training tasks, reflecting the importance of emotional support in rehabilitation-oriented interaction design.

**Table 2.** Descriptive Statistics of the UES Questionnaire

Dimension	Representative Item	Mean
Aesthetic Appeal (AE)	Visual attractiveness of the interface	4.18
Aesthetic Appeal (AE)	Rounded layout and visual comfort	4.25
Perceived Usability (PU)	Real-time waveform improves pronunciation understanding	4.18
Perceived Usability (PU)	Adaptive difficulty improves training control	4.08
Perceived Usability (PU)	Visual feedback is intuitive and efficient	4.15
Reward Factor (RW)	Achievement badges increase accomplishment	4.30
Reward Factor (RW)	Daily tasks and leaderboards improve motivation	4.18
Reward Factor (RW)	Rehabilitation training feels rewarding	4.30
Focused Attention (FA)	Immersion in vocal mini-games	4.13
Emotional Support (ES)	Yinhu reduces loneliness during rehabilitation	4.15
Emotional Support (ES)	Encouraging feedback maintains focus after failure	4.30

### 4.2. Discussion

The results indicate that integrating gamification and emotional design into speech rehabilitation can improve both behavioral engagement and psychological participation. Compared with traditional rehabilitation systems that primarily focus on repetitive training tasks, the Yinshu application provided a more immersive and emotionally supportive interaction experience.

From a behavioral perspective, gamified task structures and reward mechanisms encouraged continuous participation and reinforced users' sense of progress. This finding is consistent with previous studies suggesting that reward-driven interaction can enhance rehabilitation adherence and user motivation.

From an emotional perspective, the AI companion "Yinhu" played an important role in reducing psychological pressure during rehabilitation. The emotional support mechanism helped transform rehabilitation from a purely functional process into a more socially and emotionally engaging experience.

However, several limitations should also be acknowledged. Although users responded positively to the adaptive difficulty mechanism, its mean score ( $M = 4.08$ ) was relatively lower than other dimensions. This suggests that some users may still require more personalized training adjustments or clearer progression guidance. In addition, this study mainly relied on short-term questionnaire-based evaluation, and long-term behavioral data were not included.

Overall, the findings demonstrate that the combination of multisensory interaction, gamification, and emotional design can effectively improve user engagement in speech rehabilitation contexts, providing valuable insights for future digital rehabilitation system design.

## 5. Conclusion

This study explored how gamified interaction and emotional design strategies can enhance user engagement in

speech rehabilitation contexts through the development of the Yinshu application. By integrating multisensory compensation mechanisms, adaptive rehabilitation tasks, and AI emotional companion interaction, the proposed system aimed to improve both behavioral participation and psychological engagement during rehabilitation training. The findings indicate that visualized pronunciation feedback effectively reduced cognitive barriers, while gamified reward systems enhanced users' motivation and sense of achievement. In addition, the emotional companion "Yinhu" contributed positively to users' emotional support and immersive rehabilitation experiences. Although the study was limited by a relatively small sample size and short-term evaluation, the results demonstrate the potential of combining gamification, emotional design, and multisensory interaction in digital rehabilitation systems. This research provides both theoretical insights and practical design references for future speech rehabilitation applications and emotionally adaptive healthcare interfaces.

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