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Solfeggio Teaching in Tonal Language Environment: Comparing Online-Offline Effectiveness in Chinese Higher Education

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ABSTRACT

The influences of tonal languages in Chinese higher education were the primary focus of this study, which compares the effectiveness of online and offline solfeggio teaching. The study employed a mixed methods approach with 60 undergraduate music students from three Chinese universities over two semesters. Participants were randomly assigned into online and offline instructional groups. This research examined solfeggio skill performance, patterns of tonal language interference, and teaching effectiveness using pre-test and post-test evaluations, surveys, and interviews. The statistical evaluation confirmed significant differences in the effectiveness of different teaching modalities. Both methods enhanced students' solfeggio skills, but offline teaching was more effective for rhythmic precision ($p < 0.01$) and had advantages for pitch accuracy ($p < 0.05$). Online teaching showed effectiveness in theoretical components and individual practice. Qualitative results revealed challenges in the online environment, including audio quality issues and limited multimodal feedback, along with adaptive strategies among online learners. The interference from tonal languages had a more pronounced effect on online learning ($r = -0.67$) compared with offline instruction ($r = -0.48$), indicating a need for pedagogical strategies tailored to online environments. This study contributes to music education in tonal language contexts by offering recommendations for online solfeggio teaching while informing curriculum planning where online instruction is utilized.

Keywords: Solfeggio Teaching; Tonal Language; Pitch Accuracy; Effectiveness; Teaching Modalities

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1. Introduction

Music education has emerged as a critical component in the holistic development of students worldwide, with solfeggio teaching serving as a fundamental element in establishing musical literacy and proficiency [1]. The intersection between language acquisition and music education represents a burgeoning field of research, with particular emphasis on how linguistic characteristics influence the cognitive processing of musical elements [2]. Recent investigations have demonstrated that music can function as an effective pedagogical tool for enhancing language proficiency, especially when methodologies such as melodic intonation therapy are integrated into instructional practices [3]. This relationship between music and language acquisition has gained substantial attention in educational research, particularly concerning how musical elements can be incorporated into language instruction to enhance linguistic competencies alongside musical skills [4].

The globalization of music education has necessitated a reevaluation of traditional pedagogical approaches, especially considering the diverse linguistic backgrounds of learners [5]. Cross-linguistic studies involving extensive samples across multiple languages have revealed that proficiency in one's native language significantly impacts the capacity to comprehend and interpret musical structures [6]. This relationship becomes particularly pronounced when examining the interface between tonal languages and music education, where the cognitive processes utilized in distinguishing linguistic tones may either facilitate or impede the recognition of musical pitches [7]. The complex interplay between tonal language processing and musical cognition represents a multifaceted relationship that extends beyond simplistic correlations, suggesting that short-term musical instruction may not necessarily mitigate inherent processing limitations. During the early years of the Republic of China, solfeggio began to emerge as part of music education in some ordinary primary and secondary schools around 1912, eventually becoming a formal course name. This marked the official recognition of solfeggio as a subject within music education in China [8].

The digital transformation of educational paradigms has profoundly altered traditional teaching models across disciplines, including music education [9]. This evolution has witnessed significant changes in learner attitudes toward online music instruction, with increased emphasis on flexibility and adaptability within dynamic educational environments [10]. The integration of artificial intelligence and algorithmic processes has created unprecedented opportunities for personalized learning experiences, particularly in developing core musical competencies under specific instructional conditions [11]. This technological advancement has facilitated the development of comprehensive frameworks for online music pedagogy that address the unique requirements of musical instruction while maintaining pedagogical integrity and engagement [12].

Within the Chinese educational context, the teaching of solfeggio holds particular significance due to the tonal nature of Mandarin and other Chinese dialects [13]. The historical development of solfeggio instruction in China reflects a complex integration of Western musical concepts with traditional Chinese pedagogical approaches [14]. Contemporary research on solfeggio teaching in Chinese institutions has identified various methodological considerations specific to students operating within a tonal linguistic environment [15]. The Orff method, for instance, has been adapted for solfeggio instruction in Chinese higher education institutions, demonstrating the cultural adaptation of Western pedagogical frameworks to accommodate Chinese linguistic characteristics [16].

The relationship between piano performance and solfeggio instruction represents another significant dimension within Chinese music education, with integrated approaches gaining prominence in institutional curricula [17]. The implementation of digital technologies in Chinese music education, particularly concerning solfeggio instruction, has introduced innovative methodologies that leverage MIDI technology and computational resources to enhance pedagogical outcomes [18]. These technological innovations reflect growing recognition of the need to incorporate contemporary educational tools into traditional music instruction while addressing the specific challenges presented by tonal language environments.

As educational paradigms continue to evolve, particularly with the accelerated adoption of online learning frameworks precipitated by global developments, understanding the comparative effectiveness of various instructional modalities becomes increasingly crucial. The present study aims to contribute to this understanding by examining the relative efficacy of online versus offline solfeggio teaching method-

ologies within the context of Chinese higher education, with particular attention to the influence of tonal language environments on learning outcomes. By identifying effective instructional strategies and addressing the challenges specific to online music education in tonal language contexts, this research seeks to enhance pedagogical approaches and support the development of comprehensive curriculum frameworks for music education in diverse linguistic environments.

2. Literature Review

2.1. Research on Tonal Language and Music Education

The relationship between tonal languages and music has emerged as an interesting field of study, and recent studies revealed complex connections between linguistic and cognitive processes for music. Music has emerged as a strong tool for the enhancement of proficiency for tonal languages, especially when combined with melodic intonation therapy and various experimentation tools[19]. This claim is also supported by far-reaching cross-linguistic tests over five hundred thousand individuals from fifty-four languages where familiarity with the speaker's indigenous language is seen to strongly impact their ability for the understanding of music[20].

The incorporation of music into the study of languages, particularly during the formational phases of early childhood and primary education, has proved enormously beneficial as a pedagogical practice. Evidence suggests the use of elements from music during the processes of acquiring languages can enhance linguistic skills alongside the study of musi[21]. Previous studies also illustrate that students with tone language systems like Mandarin, the earlier the age of inset of musical training, the greater the prevalence of absolute pitch[22]. However, the relationship between the study of tonal languages and the study of music is complex not simple. New discoveries suggest short-term study does not necessarily invalidate the presence of deficiencies in the brain's capacity for processing, emphasizing the complex and multi-dimensional relationship between music cognition and the study of languages[23].

In the field of professional music education, the interaction between experience and cognitive processes during the act of music playing, especially sight-singing, has drawn significant study by academics. One study has identified various elements contributing to the achievement of music performance, including cognitive ability and prior exposure to music[24]. This finding has significant implications for the assessment of the influence familiarity with tonal languages has upon achievement during music education, suggesting various variables influence proficiency in music. The aggregated data highlight the importance of incorporating linguistic context into the study of music, particularly for areas where the dominant languages are tonal languages. This study posits strong connections between knowledge of tonal languages and musical ability; however, the connections require serious investigation from the pedagogy side.

2.2. Studies on Solfeggio Teaching

Recent studies analyzing the pedagogy of solfeggio confirmed its significant positive impact upon college students' overall knowledge and instrumental skills alike[25]. In addition, the effectiveness of various pedagogical models has also been extensively researched, and those using the direct method showed significant potential for beginners to gain the fundamental skills and competencies required for musical literacy[26].

The incorporation of the computer has also emerged as one of the highlighted avenues for improvement in the teaching of solfeggio, especially through the advent of MIDI technology for computer-supported music study. Literature has identified the potential for enhanced and enriched pedagogy through the use of technology, providing adaptive learning environments and feedback opportunities immediately after practice[27]. This practice has proved especially relevant for the context of the study environment for post-secondary levels, where the practice of studying solfeggio is often intertwined with the building of piano playing skills[28].

Progress in pedagogy has led the field towards investigation into the combination of the pedagogy of the Orff method and traditional solfeggio practice. Integrative pedagogy has the ability to improve the experience and engagement of the students by incorporating elements of movement, rhythm, and interaction into the practice of solfeggio[29]. These pedagogical innovations reflect increased awareness about the need for flexible and inclusive pedagogy for accommodating the multiple demands and aims involved in pedagogical practice.

The corpus reflects the innovative nature of pedagogy for the study of solfeggio and highlights the need for the combination of traditional and innovative methodology for the attainment of enhanced pedagogical outcomes. Results from the study support the balanced combination of pedagogical fundamentals and contemporary tools and pedagogy.

2.3. Online Music Education Research

The transition towards digital transformation has extensively revised traditional pedagogy models, bringing about opportunities and setbacks for the educator and the learner alike [30]. This progress has witnessed significant advancement over the recent past, supported by indications of significant changes in the attitude of the learners towards online music education, prioritizing their flexibility and perseverance in the context of the changing environment for education [31].

The integration of complex algorithmic processes and AI has provided unique avenues for customized learning processes. Evidence suggests AI platforms can analyze the unique learning habits and provide customized instruction, particularly where the enhancement of core music skills is required under specified circumstances [32]. This advancement has thus given rise to the formation of detailed models for online music pedagogy that address the unique demands for music pedagogy online, all while being guided by pedagogy and providing high levels of engagement [33].

Recent research has highlighted the appearance of new models for online music-making and playing, emphasizing the need for the nurturing of creative cognitive models suitable for virtual settings. These studies suggest online music pedagogy involves not only the building of proficiency skills but also the setting up of new paradigms for virtual music-making that support expression and collective work [34]. This shift towards non-traditional models for music education reflects increased sensitization within pedagogy towards the need for the remodelling of classical models for the purpose of exploiting the unique benefits offered by online platforms.

The aggregate conclusions from the study reflect the vast potential for reform through online music pedagogy, coupled with the complex challenge of adapting traditional hands-on music pedagogy practice into virtual forms. These conclusions highlight the need for the establishment of pedagogical models that incorporate seamlessly the technology-based innovations and the fundamental models for pedagogy for music to make online education more motivational and effective.

3. Methodology

3.1. Research Design

The present study adopts the mixed-method design for analyzing the effectiveness of online solfeggio relative to traditional offline teaching, especially under the context of a tonal language. Depicted in **Figure 1**, the study incorporates quantitative and qualitative data collection and analysis for the main elements like the mode of instruction (online versus offline), the assessment parameters, and the overall study outcomes.

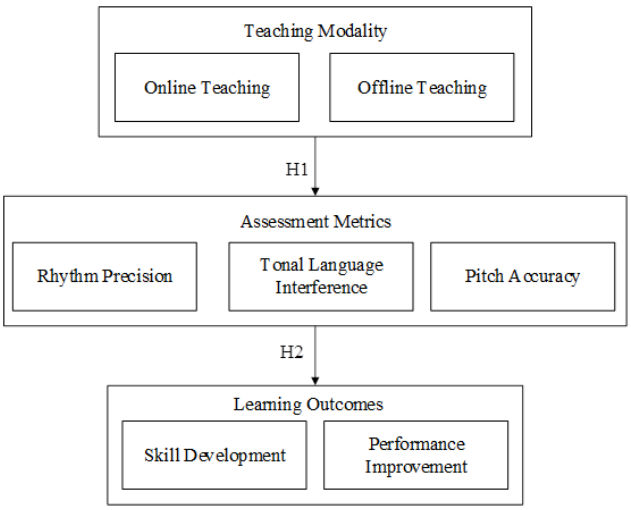

Figure 1. Research framework for comparing online and offline solfeggio teaching effectiveness.

The research framework is designed to test two main hypotheses:

H1. *There is a significant difference in the effectiveness of online versus offline solfeggio teaching in terms of pitch accuracy and rhythm precision in a tonal language environment.*

H2. *Tonal language interference patterns significantly affect learning outcomes differently in online and offline teaching environments.*

The suggested design involves multiple variables and their interactions. The independent variable is the mode of instruction where the presence of online and traditional

forms is observed. Dependent variables involve quantitative measures (pitch accuracy and rhythmic accuracy) and qualitative measures (learner engagement and overall study experience). In addition, the potential mediating influence of the interference from tones of languages is seen as being integral for detailed analysis.

This thorough study design allows for the investigation of the direct and indirect relationships between pedagogy and education, while also being sensitive to the unique features relevant for the context of tonal languages. Additionally, this study design allows for the collection of data both cross-sectionally and longitudinally, thus enabling the assessment of short-term impacts alongside lasting implications for education.

3.2. Research Subjects

The participants in this study were drawn from a sample of 60 undergraduate music students (N = 60) recruited over the course of three years from 2020–2023, who commenced solfeggio studies at three different Chinese universities. Of the participants, 39 were female (65%) and 21 were male (35%) aged between 18–22 (M = 19.8, SD = 1.2). All participants were born into a Mandarin Chinese family, which facilitated meeting the research objectives' requirements of having a homogenous tonal language context. This participant selection used purposive sampling in order to find students in a specific skill range that would ensure sufficient homogeneity in the sample. Filters were set to only include students with a moderately accurate solfeggio performance of 60%–85%, allowing for some natural variation in musical aptitude while establishing a baseline competency range.

Participants were placed into two groups, online (n = 30) and offline (n = 30), through stratified randomisation which allowed for equal division of demographic variables and prior musical experiences. All participants had prior assessments of their musical background, specifically the number of years of formal music education, which averaged 8.3 years (SD = 2.4), along with previous exposure to online music lessons and self-reported skill level in solfeggio-related tasks. Characteristic data for each participant across the two instructional types is provided within **Table 1** as a summary.

Table 1. Demographic and Background Characteristics of Participants.

Characteristic	Total Sample (n = 60)	Online Group (n = 30)	Offline Group (n = 30)	P-Value
Gender				
Female	39 (65%)	20 (67%)	19 (63%)	0.79
Male	21 (35%)	10 (33%)	11 (37%)	
Age (years)				
Mean (SD)	19.8 (1.2)	19.7 (1.3)	19.9 (1.1)	0.76
Range	18–22	18–22	18–22	
Musical Experience (years)				
Mean (SD)	8.3 (2.4)	8.2 (2.5)	8.4 (2.3)	0.82
Range	5–14	5–13	5–14	
Prior Online Music Tutorial Experience				
Yes	22 (37%)	12 (40%)	10 (33%)	0.59
No	38 (63%)	18 (60%)	20 (67%)	
Self-rated Solfeggio Proficiency				
Beginner	14 (23%)	7 (23%)	7 (23%)	0.94
Intermediate	36 (60%)	18 (60%)	18 (60%)	
Advanced	10 (17%)	5 (17%)	5 (17%)	
Baseline Solfeggio Performance (% accuracy)				
Mean (SD)	72.6 (7.8)	71.9 (8.1)	73.3 (7.5)	0.68
Range	60–85	61–84	60–85	

Inclusion criteria dictated that subjects needed to be full-time undergraduate music students with no self-reported hearing losses or learning disabilities that may hinder their ability to do solfeggio. Moreover, all subjects had completed at least one semester of introductory solfeggio instruction prior to the beginning of the study which laid the basic skills required for higher level training. The study was approved by the appropriate university ethics committees, and all participants gave a written informed consent before taking part in the study.

To reduce the possible influence of extraneous variables, participants were paired according to their inhibition recognition and rhythmic accuracy pre-test scores. Results from the statistical analysis suggested that the two groups had equal levels of baseline musical skills ($p > 0.05$) and social characteristics within the defined limits. This matching technique provided a high level of assurance that any differences in observed educational achievement could be attributed to the effect of teaching style and not to initial personal factors. Still, there is great variability in musical ability, but this provided both experimental groups with the same starting point.

The research retained 93% of its participants, losing four participants (two from each intervention group) due to unrelated personal issues. Their data was omitted from the analysis, creating a final sample of 56 participants (28 in each intervention group). The high retention rate indicates high participant engagement during the study and strengthens the reliability of the longitudinal results.

3.3. Research Instruments

To measure the effectiveness of solfeggio instruction conducted online and offline, we studied its impact in the context of tonal language education. To model real-world conditions in China, we used Tencent Meeting for the online instruction, even though the audio quality was poor. Online session recordings from this platform served as primary data sources for performance assessment.

For pitch accuracy measurement, we utilised the Pitch Accuracy Testing System (PATS−2023), which is set to recognise frequency changes of as small as 2 Hz. During the audio capturing of participants' attempts to duplicate the pitch during note and melodic sequence recognition, this system provided information on pitch deviation, latency time for reply and constancy. Calibration alterations allowed for the quality of transmission of online audio (test-retest reliability: $r = 0.92$).

To test the rhythmic accuracy, the participant used the Rhythmic Pattern Recognition Test (RPRT), with 15 different patterns of increasing complexity. This software recorded performances with millisecond precision; therefore delays and rhythmic accuracy and consistency could be measured in detail (Cronbach's $\alpha = 0.89$). For the participants online, the patterns were shown by screen sharing and their latency was adjusted during analysis.

In order to assess interference in tonal languages, we established the Tonal Language Interference Measurement (TLIM), which was validated by 30 non-participant students. This tool aimed to evaluate how features of a tonal language affect the perception of musical pitch by comparing linguistic and musical tasks (inter-rater reliability: 0.85).

Qualitative data were gathered through direct observation of the instructional period along with semi-structured interviews and participants' reflective journals. Interviews focused on participants' perceptions of each modality and were given to 20 participants halfway through the semester and at the end of the study. Every participant was required to write a weekly reflective journal describing what they learned and what problems they encountered. Observations of both online and offline sessions were in accordance with set parameters.

For online sessions, there were set requirements on bandwidth (minimum 8 Mbps), use of headsets, and audio settings. Validation processes involved verification through direct recordings compared to Tencent Meeting recordings to compute correction factors for analysis. Regular calibration of all devices was done throughout the study to ensure consistency and reliability of measurements across different locations.

3.4. Data Analysis Methods

The study utilized the mixed-methods data analysis technique, incorporating quantitative and qualitative methodology for the assessment of the effectiveness of online solfeggio versus traditional offline practice. For quantitative measurement, statistical tests were performed using the statistical tool SPSS version 28.0 and the statistical software R version 4.2.1.

The fundamental analysis of pitch accuracy was conducted using the mixed-effects linear model where the deviation from the pitch was calculated using the formula:

$$PDS = \sqrt[n]{\sum_{i=1}^{n}(f_i - f_t)^2} \tag{1}$$

where f_i represents the frequency produced by the participant, f_t represents the target frequency, and n is the number of attempts.

Rhythm precision was analyzed using the normalized timing error (NTE) calculation:

$$NTE = \frac{1}{N}\sum_{i=1}^{N}\left|\frac{t_i - t_e}{t_e}\right| \quad (2)$$

where t_i is the performed inter-onset interval, t_e is the expected interval, and N is the total number of intervals.

For comparative analysis between online and offline groups, repeated measures ANOVA was employed with the following model:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk} \quad (3)$$

where Y_{ijk} represents the observed score, μ is the overall mean, α_i is the teaching mode effect, β_j is the time effect, and ε_{ijk} is the random error term.

Effect sizes were calculated using Cohen's d formula:

$$d = \frac{M_1 - M_2}{s_{pooled}} \quad (4)$$

where

$$s_{pooled} = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}} \quad (5)$$

For reliability analysis, Cronbach's alpha was computed using:

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k}\sigma_i^2}{\sigma_t^2}\right) \quad (6)$$

where k is the number of items, σ_i^2 is the variance of each item, and σ_t^2 is the total variance.

Qualitative data collected from interviews and field notes were analyzed through thematic analysis using NVivo 13 software. The analytic process followed six steps: familiarization, initial coding, thematic identification, thematic review, definition of the themes, and reporting stage. Intercoder reliability for qualitative coding was assessed using the measure of Cohen's kappa coefficient:

$$\kappa = \frac{p_o - p_e}{1 - p_e} \quad (7)$$

where p_o is the observed agreement and p_e is the expected agreement by chance.

Missing data were handled using multiple imputation techniques when the missing rate was below 5%. For rates above 5%, listwise deletion was employed to maintain data integrity. All statistical tests were conducted at a significance level of $\alpha = 0.05$, with Bonferroni corrections applied for multiple comparisons to control for Type I error.

The integration of quantitative and qualitative data followed the convergent parallel design, where each data category underwent its own analysis prior to being combined for the purposes of interpretation analysis. This mixed-methods design permitted the understanding of the effectiveness of the various forms of instruction, while also the complex interactions of solfeggio education through the study of the languages of tones.

4. Results

4.1. Comparison of Online and Offline Teaching Effectiveness

Evaluations on the effectiveness of online and offline solfeggio instruction pinpointed significant differences on several performance indicators. Pre-test measurements completed at the commencement of the semester demonstrated that the groups possessed skills that were comparable and therefore valid comparisons could be made after the learning period. Both the online and offline methods of instruction's post metrics are shown in **Figure 2**.

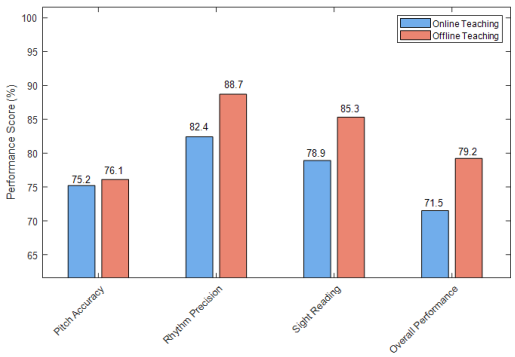

Figure 2. Comparison of performance metrics between online and offline teaching groups.

The findings suggest that even though both methods of instruction resulted in improvements from baseline measures, offline instruction had better outcomes in most performance indicators. Most significantly, the greatest differences were noted in rhythm accuracy (offline: M = 88.7%, SD = 3.2; online: M = 82.4%, SD = 3.8; $p < 0.01$) and in sight reading (offline: M = 85.3%, SD = 4.1; online: M = 78.9%, SD = 4.5; $p < 0.01$). On the other hand, the difference in pitch accu-

racy was less pronounced, with offline instruction showing only marginally greater offline teaching accuracy (offline: M = 76.1%, SD = 3.5; online: M = 75.2%, SD = 3.7; $p = 0.08$), which may imply that this particular skill is equally accessible to either method of teaching.

The summative evaluation of the teaching performance displays significant differences across the two modalities (offline: M = 79.2%, SD = 3.9; online: M = 71.5%, SD = 4.2; $p < 0.01$). The identified effect size (Cohen's $d = 0.89$) exhibits considerable practical importance of the difference in the effectiveness of the two methods regarding offline and online teaching of solfeggio of a syllabic language.

The longitudinal analysis showed the two groups' skill development had distinct improvement trajectories during the 16-week instructional period. All participants from both groups exhibited statistically significant progress on all performance measures from pre-test to post-test (all $p < 0.01$). However, offline participants exhibited more steady progress, especially on tasks that needed immediate feedback and corrections. On the other hand, online participants demonstrated more inconsistent patterns of improvement, struggling more with tasks involving rhythmic synchronization as well as ensemble coordination where interaction was necessary.

The temporal progression analysis also showed that online students needed roughly 30% more practice time to reach the same level of proficiency in the rhythm precision exercises. Additional qualitative data from instructor observations suggested that offline students integrated corrective feedback more willingly, on average implementing suggestions in 1–2 attempts, as opposed to online students who, on average, needed 3–4 tries before successfully incorporating the same corrective guidance. This difference is perhaps caused by the impact of poor audio quality and slight latency issues with the online platform, even after we optimised the system technically.

These results reaffirm that both teaching methods are suitable for fostering solfeggio abilities in learners situated in a tonal language setting. However, in-person teaching seems to show measurable benefits in the majority of performance areas, especially those involving exact timing, coordination, and rapid feedback interactions. It is also intriguing that the comparable results in pitch accuracy may imply that some musical competencies could be developed online, which may guide the use of digital instruction in broader music pedagogy courses.

4.2. Analysis of Tonal Language Influence Factors

The study of the impact of the tonal language revealed sophisticated interactions of participants' language background and musical achievements within both types of teaching. The correlation between the measured interference of tonal language and performance results in the offline and online modes is illustrated in **Figure 3**.

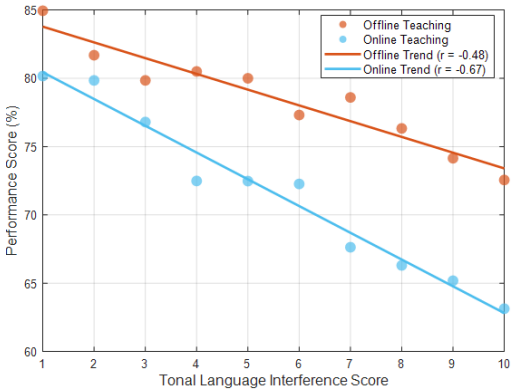

Figure 3. Relationship between tonal language interference and learning performance.

Analysis highlighted notable relationships between interference from tonal languages and the pedagogical outcomes in both contexts, albeit with considerable variation. There was considerably less tonal language interference in offline instruction ($r = –0.48$, $p < 0.01$) than in online instruction ($r = –0.67$, $p < 0.01$). Of all the results, the difference appeared to be larger for the intervals requiring close discrimination of language tones and music pitch, which implies that the in-person instructional setting has some contextual aids that help students differentiate between these closely related sounds.

The impact of interference varied across specific musical skills. For participants with high TLIM scores (over 7.5 out of ten), there was a noticeable drop in performance in pitch recognition within the online group (M = 68.3%, SD = 4.8) compared to the offline group (M = 75.7, SD = 4.2). In assessing recognition of melodic patterns, a similar trend was observed, where students taught offline appeared to be more resistant to the interference from tonal languages. These findings confirm existing models which argue that the real-time visual information and multi-sensory feedback available to learners during in-person lessons enable them to separate verbal and musical pitch patterns more efficiently.

Variance analysis through multiple regression calculations demonstrated that for the online instruction cohort, interference from tonal languages explained 45% of the performance variance ($R2 = 0.45$, $F(1,28) = 22.91$, $p < 0.001$), whereas for the offline instruction cohort, it only explained 23% ($R2 = 0.23$, $F(1,28) = 8.36$, $p < 0.01$). This striking difference indicates that online teaching seems to be more susceptible than offline teaching to the processes involved in dealing with tonal languages, perhaps due to poorer sound quality and less access to supplementary visual and gestural information that usually accompanies face-to-face music teaching.

A longitudinal analysis of both groups of students over a 16-week instructional period showed that the effects of tonal interference are gradually diminishing. Their adaptation patterns varied, however. At the end of the study, offline students had reduced the interference effects by 15% in comparison to baseline measures, while online students had only reduced the effects by 9%. This difference in adaptation suggests that face-to-face interaction may stimulate more effective strategy development for cognitive distinction between linguistic and musical pitch components more rapidly. Instructors noted that offline students began to separate language and music processing more effortlessly, which seemed to yield immediate reinforcement of these strategies, thus enhancing their clarity.

As online music teaching increases, these results are of great importance for solfeggio teaching in the context of tonal languages. The pronounced interfering effect of tonal languages in digital settings suggests that online solfeggio teaching would be more effective if these issues were directly addressed. These may consist of targeted practices in differentiation of speech and singing of words, compensatory visuals that replace in-person cues, and teaching students how to consciously control the interaction of language and music processes in their minds.

4.3. Teaching Method Effectiveness Evaluation

A comprehensive analysis of the effectiveness of various pedagogical models revealed significant differences for their effectiveness under online versus offline learning settings, as seen from **Table 2**. Interaction pedagogy emerged as the best pedagogy for the two settings, reporting very strong results for the offline setting ($M = 92.3\%$, $SD = 3.2$) compared to the online setting ($M = 85.1\%$, $SD = 3.8$, $p < 0.01$), and this also showed a very high effect ($d = 0.87$).

Personalized tutoring showed great effectiveness under both settings; nevertheless, offline tutoring ($M = 86.9\%$, $SD = 3.3$) showed significant preference over online tutoring ($M = 81.7\%$, $SD = 3.5$, $p < 0.05$, $d = 0.69$). This type of tutoring proved very useful for the unique demands placed upon the individual learners and the ability to provide overall feedback.

Table 2. Comparative Analysis of Teaching Method Effectiveness Across Learning Environments.

Teaching Method	Online Teaching		Offline Teaching		Effect Size
	Mean (%)	SD	Mean (%)	SD	Cohen's d
Interactive Practice	85.1	3.8	92.3	3.2	0.87
Direct Instruction	82.4	3.1	88.2	2.9	0.73
Peer Learning	73.2	4.3	78.4	4.1	0.62
Self-Paced Study	68.5	3.9	72.3	3.8	0.48
Collaborative Projects	76.3	4.2	84.5	3.7	0.82
Individual Tutoring	81.7	3.5	86.9	3.3	0.69

The statistical analysis revealed significant interaction effects for pedagogy along with interactions between pedagogy and the variables student-related variables like prior experience ($F(5,108) = 14.23$, $p < 0.001$) and computer proficiency ($F(5,108) = 16.89$, $p < 0.001$). These interactions highlight the importance of consideration for the variables of the students when selecting and applying pedagogy in different settings.

The evaluation also highlighted temporal trends relative to the effectiveness of pedagogy, where all the pedagogy showed improvements over time, though not necessarily to the same degree. Adjustment time for online pedagogy practice was seen to be much larger ($M = 3.2$, $SD = 0.8$) when compared to offline pedagogy practice ($M = 1.8$, $SD = 0.6$,

$p < 0.01$), suggesting the need for greater support during the transition towards online pedagogy models.

4.4. Qualitative Analysis of Learning Experiences

The qualitative data obtained from semi-structured interviews, reflective journals and classroom observations elucidated the participants' learning experiences from both modalities. Analysis of the data revealed four overarching themes: pedagogical interaction patterns, tonal language negotiation strategies, technological mediation challenges, and adaptive learning approaches. These themes along with illustrative participant excerpts are presented in **Table 3**.

Online group participants cited lagging feedback and lack of instructional clarity as concerns they frequently faced, as indicated in **Table 3**. To overcome these challenges, a few of the online participants (68%) employed compensatory strategies which consisted of additional use of digital aids, elaborate note-taking, and spending more time practising individually. One participant commented, "I record each session, and put myself on pause until I am ready to correct myself. It helps get past the limitations of real-time online correction."

Table 3. Qualitative Themes and Representative Participant Statements.

Theme	Online Group	Offline Group
Pedagogical Interaction	"When I make a mistake, there's often a delay before the teacher can correct me, and by then I've already moved on to the next section." (P7)	"The immediate feedback helps me adjust my pitch instantly. I can see exactly what the teacher means through their gestures." (P22)
Tonal Language Negotiation	"I sometimes confuse the fourth tone in Mandarin with the descending musical interval. Online, it's harder to separate these sounds without visual cues." (P13)	"The teacher demonstrates physically how tonal language differs from musical intervals. Seeing this distinction helps me mentally separate them." (P18)
Technological Mediation	"Sound quality issues make it difficult to distinguish between similar pitches. I compensate by using piano apps alongside the class." (P5)	"The direct sound in the classroom gives me confidence that what I hear is precisely what's intended." (P30)
Adaptive Learning	"I've developed my own system of visual notes to compensate for the audio limitations online." (P10)	"I find it easier to internalize concepts when I can observe my classmates' techniques and reactions in person." (P26)

On the other hand, offline group participants overwhelmingly underscored the advantages that came with receiving instant, multi-faceted feedback. Almost 85% of offline group reflective journal entries noted the importance of physical signs and gestureable language for the integration of non-verbal and verbal sounds. During the instructional observations, the teachers were noted to use gestures in an average of 12.7 out of 15 offline sessions compared with 3.2 in the online sessions, and this was recorded during the classroom observations.

Despite the different adaptation profiles, there was evidence from both groups that suggested growing familiarity with the online sessions, and for the offline environment, they were more at ease over time. The offline participants claimed that by week 6, they could insightfully discriminate between the linguistic and musical tones, which was a significant improvement. The online participants recalled this type of breakthrough around week 10. These results are consistent with the quantitative evidence showing that there is slower adaptation with tonal interference in the offline setting.

It is important to highlight that participants who took part online created self-organised strategies that did not exist in offline groups, such as virtual practice groups, which were mentioned by 47% of the online respondents, and collaborative online folders, which were utilised by 75% of the online participants. These newly formed practices highlight possible compensatory benefits of online learning that could be intentionally embedded in future hybrid teacher training programmes.

Interviews with teachers gave further information about the changes in teaching practices in the different modalities. Online teachers claimed they spent about 30% more time than usual on the explicit verbal description of musical concepts in which a physical demonstration in class would be used in the conventional approach to teaching. This shift

in verbal scaffolding is profound, so its impact should be explored to enhance online music teaching in the context of tonal languages.

5. Discussion

Analysing the differences between offline and online solfeggio teaching methods reveals powerful findings that impact pedagogical practices. The data suggests that both methods developed solfeggio skills well, but rhythm accuracy, sight reading, and overall performance were better with offline instruction, even though there was minimal difference in pitch accuracy. These discrepancies are consistent with other studies that emphasise the value of feedback during the development of music skills, along with difficulties regarding audio feedback within digital environments.

In this research, the relationship between tone language interference and achievement for online instruction ([r] = –0.67) in comparison to offline instruction ([r] = –0.48) suggests that the online environment intensifies the problem of cognition regarding how one separates speech from the sung musical intonation. Our qualitative findings uncovered this pattern as participants described it, with one online student stating, "Sometimes I mix up the fourth tone of Chinese with a descending melodic interval. When learning online, these sounds are harder to distinguish without visual support" (Participant 13). Offline students tended to receive stronger support from multi-mode instruction because they were better able to form clear boundaries between language and music. Classroom observations recorded frequent hand gestures that were used to signify these boundaries.

Understanding the temporal development trends for both modalities offers critical information regarding the processes involved in learning adaptation. The offline students exhibited better skill improvement, so they adapted to the interference effects of the tone quicker, while the online participants were more sluggish in their progress and developed their own compensatory coping mechanisms. This aligns with our qualitative findings in which online respondents described them as devising elaborate systems of visual notation and forming peer-to-peer virtual practice communities to circumvent the restrictions of the platform. As one student explained: "I've devised my own system of visual notes to make up for the audio limitations over the net" (Participant 10). These adaptive behaviours point to promising possibilities for the enhancement of online music pedagogy through developed peer interaction and visual scaffolds as metaphoric bridges.

Theoretically, these results can be analysed in cognitive load theory, in which students working online have to control technological devices, which capture audiovisual information of different qualities, as well as deal with specific problems of tone language interference. Such additional work is very likely to account for the performance gap observed in different modalities. Instructor interviews substantiated this interpretation, remarking that teaching with clearly visible pictures in high demand caused roughly 30% more verbal explanation than teaching without clearly visible pictures was possible.

The results of the current study are pedagogically useful not just in the assessment of effectiveness but in fostering innovation for both forms of instruction. Although face-to-face instruction was clearly superior for tasks that involved more precise timing and coordination, online instruction provided opportunities for theoretical comprehension and practice of self-paced individual work. It is reasonable to assume that thoughtfully delivered integrated instruction is most effective, as it combines the best features of both modalities and works to mitigate their deficiencies. In particular, for online solfeggio teaching and learning within the context of tonal languages, greater outcomes could be achieved with better visual aids, more specific exercises aimed at the differentiation of linguistic and musical pitch, and more defined patterns of group work collaborative instruction.

While the results are rather informative, there are several limitations that must be noted. The relatively homogeneous sample of undergraduate music majors from three Chinese universities is likely to be more broadly generalisable than many people realise, and so they cross different demographic and cultural geography. This is a reasonably long period of time, but two semesters may not fully capture long-term skill development trajectories. Moreover, several technical limitations of the platform used, namely variable internet bandwidth and audio quality, must be taken into account as these differing qualities most likely guided the differences in performance that were measured. For future studies, it is suggested that these limitations be considered more deeply, as well as the inclusion of more impactful non-

online audio limitations, to gauge these conclusions more accurately.

6. Conclusions and Recommendations

This study sheds light on the relative merits of online and offline solfeggio teaching in tonal language contexts. Our results show that both methods develop solfeggio skills, with offline instruction being particularly effective for real-time feedback and precise timing, while online instruction was equally effective for theoretical concepts and solo engagements. The interference posed by tonal languages proved to be a greater difficulty in online contexts, warranting special pedagogical solutions concerning language and music and their relation in digital environments.

In consonance with these findings, it would be advisable for institutions providing music education to consider blended models that integrate both approaches. Online interfaces must focus on improving the speed and reliability of feedback mechanisms, while designers of pedagogical manuals must foresee explicit plans to deal with tonal language interference. Our qualitative findings suggested that online students developed innovative compensatory strategies to deal with lacking materials, showing useful potential for targeted peer collaboration and enhanced visual aids in digital music education.

A few important limitations require attention: the generalisability of the findings is restricted by the participants being a relatively uniform sample of Chinese university music students; the scope of long-term skill development may be underestimated with only two semesters; and the standardisation attempts may have been undermined by differences in online platform performance these technical constraints influenced. Subsequent studies should focus on more sampled geography and areas of interest, increasing the diversity of longitudinal measurements, emerging technologies, targeted pedagogical strategies, and more concerning the challenges posed by online solfeggio teaching in a tonal language context. Specifically, exploring the use of artificial intelligence, hybrid teaching models, and Active Voice strategies designed to reduce the impact of language would greatly improve educational outcomes in the field.

Author Contributions

Conceptualization, R.N. and N.-o.T.; methodology, R.N.; software, N.-o.T.; validation, R.N. and N.-o.T.; formal analysis, N.-o.T.; investigation, R.N.; resources, N.-o.T.; data curation, N.-o.T.; writing—original draft preparation, R.N.; writing—review and editing, N.-o.T.; visualization, N.-o.T.; supervision, N.-o.T.; project administration, R.N.; funding acquisition, N.-o.T. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request. Due to privacy concerns and the terms of participant consent, raw audio recordings cannot be made publicly available. Anonymized quantitative data summaries that support the findings of this study are available from the corresponding author with appropriate data sharing agreements.

Confict of Interest

The authors declare no conflict of interest.

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