

Conference Proceedings

CIVAE 2026

8th Interdisciplinary and Virtual Conference on Arts in Education

March 18- 19, 2026

Edited by MusicoGuia

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Ideology and Legacy: How the Cultural Revolution Shaped Modern Chinese Dance Education	140
Liu Yifei	
Classroom-based assessment of speaking in SFL in upper secondary education: a case study in Portugal	145
Isabel de Lurdes Pereira do Cabo	
Teaching Academic Writing in the AI Era: Large Language Models for the Development of English Writing Skills, Digital Literacy, and Critical Thinking	151
Lucía Sanz-Valdivieso	
Ensemble Performance in Digital Environments: Synchronous and Asynchronous Dimensions in Vocal, Piano, and Choral Practice	157
Nataliia Ashykhmina	
A critical view at generative AI images by Arts and Design students	163
Nuria Rey Somoza	
Experiential pedagogy in building skills for evaluating and reusing industrial heritage in the university environment	168
Merciu Florentina-Cristina, Păunescu Cornel, Merciu George-Laurențiu	
Understanding, Shaping, and Reflecting on AI: Experience-Based Learning in Art Museum Contexts	173
Majulie Hofer	
Art as Counter-Media: Pedagogical Mediation, Critical Language and Visual Dissent from a Case Study	177
Gema Rupérez, Raúl Ursúa-Astráin	
Learning the Croatian Language through the Creation of Board Games	182
Ana Tereza Želinski	
Beyond the Image: Ecopedagogy and Public Art Practices	185
Monica Sgrò	
Music and Advertising: Classical Music in its Association with Consumption	190
Nice Vizoso Chao	
Art and social commitment: the activism of Regina José Galindo through her creations	195
María Dolores Villaverde Solar	
Grammar in Motion: Embodied Linguistic Learning Through Dance	198
Diana Travado Amaral	

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Ensemble Performance in Digital Environments: Synchronous and Asynchronous Dimensions in Vocal, Piano, and Choral Practice

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Abstract

Networked technologies are reshaping ensemble performance, requiring vocal, piano, and choral practices to adapt rehearsal, interaction, and presentation to online formats. The objective of this study is to systematically compare synchronous (real-time) and asynchronous (time-shifted) digital modalities in vocal, piano, and choral ensemble practice through an affordance–constraint framework in order to develop evidence-based pedagogical and technological strategies for optimizing rehearsal, performance, and assessment in digital environments. Synchronous settings support co-presence and shared temporal coordination but are constrained by latency, audio quality, and unequal technical resources. Asynchronous workflows offer higher-fidelity recording, flexible scheduling, and possibilities for iterative feedback, while attenuating spontaneity and embodied co-regulation. Hybrid models that combine asynchronous preparation with focused synchronous sessions are increasingly prevalent in educational and professional contexts. The findings suggest that well-structured digital ensemble practices can broaden access, foster creativity, and develop new musical and media literacies when timing, embodiment, social cohesion, and equity are explicitly addressed.

Keywords: digital ensemble, synchronous and asynchronous collaboration, vocal practice, piano ensemble, choral performance.

Interpretación de conjunto en entornos digitales: dimensiones sincrónicas y asincrónicas en la práctica vocal, pianística y coral

Resumen

Las tecnologías en red están redefiniendo la interpretación en conjunto y exigen que las prácticas vocales, pianísticas y corales adapten los ensayos, la interacción y la presentación a formatos en línea. El objetivo de este estudio es comparar de forma sistemática las modalidades digitales sincrónicas (en tiempo real) y asincrónicas (en diferido) en la práctica de conjuntos vocales, pianísticos y corales mediante un marco de análisis de posibilidades y restricciones, con el fin de desarrollar estrategias pedagógicas y tecnológicas basadas en la evidencia que optimicen el ensayo, la interpretación y la evaluación en entornos digitales. Los entornos sincrónicos favorecen la copresencia y la coordinación temporal compartida, pero se ven limitados por la latencia, la calidad del audio y la desigualdad en los recursos técnicos. Los flujos de trabajo asincrónicos ofrecen grabaciones de mayor fidelidad, una programación flexible y posibilidades de retroalimentación iterativa, aunque atenúan la espontaneidad y la correulación corporal. Los modelos híbridos que combinan la preparación asincrónica con sesiones sincrónicas focalizadas son cada vez más frecuentes en contextos educativos y profesionales. Los resultados sugieren que las prácticas de conjunto digital bien estructuradas pueden ampliar el acceso, fomentar la creatividad y desarrollar nuevas alfabetizaciones musicales y mediáticas, siempre que se aborden de manera explícita la sincronización, la corporalidad, la cohesión social y la equidad.

Palabras clave: conjunto digital; colaboración síncrona y asincrónica; práctica vocal; conjunto pianístico; interpretación coral.

Introduction

Digital infrastructures have redefined the spatial and temporal conditions of ensemble music-making. Lockdown measures during the COVID-19 pandemic dramatically reduced in person rehearsals while catalysing a 264% increase in online joint music-making, especially through videoconferencing and file based collaborations (Onderdijk et al., 2021). In parallel, advances in networked music performance (NMP) technologies have sought to support real-time interaction under stringent latency and quality constraints (Rottondi et al., 2016).

For vocal, piano, and choral practices – highly dependent on fine timing, timbral nuance, and complex social coordination – this shift has been both disruptive and generative. Online vocal and piano programmes have demonstrated measurable gains in musical ear development and performance skills when supported by carefully structured digital curricula (Liu, & Ye, 2023; Pike, 2017). Digital tools and platforms have also been shown to stimulate creativity and collaborative exploration in vocal ensembles (Liang, 2024).

This study focuses on ensemble work across three domains – vocal, piano, and choral – analysed through the lens of synchronous, asynchronous, and hybrid digital modalities.

Methodology

Overall approach

The study adopts a practice-based and integrative review design. Evidence is drawn from: empirical studies on NMP latency and temporal coordination (Washburn et al., 2021; Rottondi et al., 2016); surveys and case studies of online ensemble activity during pandemic restrictions (Onderdijk et al., 2021; Ritchie, & Sharpe, 2021); research on online piano and vocal pedagogy (Liu, & Ye, 2023; Pike, 2017); studies of digital collaboration and creativity in vocal ensembles (Liang, 2024); work on ensemble aptitude, social factors, and group functioning (Kawase, 2016; Lim, 2014); practice-based telematic performance experiments with enhanced embodiment technologies (Gurevich et al., 2024).

These sources are combined with reflective analysis of recent practice-based projects (virtual choirs, remote piano duets, online vocal ensembles) in higher education and community settings.

Analytical framework

An *affordance-constraint* framework structures the analysis:

- *Affordances*: Capabilities that a modality makes possible or easier (e.g., flexible timing, high-fidelity recording, large-scale participation).
- *Constraints*: Technological, perceptual, and social limitations (e.g., latency, compression, reduced nonverbal cues).

Modalities are examined across four dimensions: technical (latency, audio quality, monitoring); pedagogical (rehearsal design, feedback, assessment); artistic (expressivity, blend, phrasing, repertoire); social (agency, leadership, cohesion, motivation). Findings are organised by modality and then specified for vocal, piano, and choral practice.

Results and Discussion

1. Technical Conditions of Digital Ensemble Work

Latency is the defining variable distinguishing synchronous from asynchronous digital ensemble formats. Empirical research demonstrates that increasing acoustic transmission delay significantly affects tempo stability and interpersonal synchronization, even among expert pianists (Washburn et al., 2021). Role asymmetries emerge under latency conditions: initiating performers often stabilize tempo, while responding performers exhibit adaptive flexibility.

Despite technical optimization, internet routing variability makes it difficult to ensure latency below perceptual thresholds necessary for rhythmically tight ensemble interaction across long distances (Rottondi et al., 2016). Consequently, during pandemic restrictions, videoconferencing platforms were frequently used for instructional dialogue rather than fully synchronous ensemble performance (Onderdijk et al., 2021).

Asynchronous workflows eliminate real-time latency by shifting coordination to pre-structured reference materials (click tracks, conductor videos). Temporal alignment is achieved in post-production rather than through live negotiation. This relocation of timing agency fundamentally reconfigures ensemble interaction.

Mainstream videoconferencing platforms are optimized for speech, often applying compression, noise suppression, and automatic gain control. These processes compromise dynamic range, articulation clarity, and timbral detail—especially problematic for piano tone and choral blend.

In contrast, asynchronous recording allows higher sampling rates, controlled microphone placement, and detailed mixing processes. In virtual choir production, editing, equalization, and spatialization become central artistic tools (Onderdijk et al., 2021). However, performers often record in isolation without emergent ensemble sound, requiring advanced internal auditory modeling.

Monitoring presents additional challenges. Headphone use alters spatial perception and can distort balance awareness in synchronous contexts. Asynchronous recording requires singers and pianists to align with guide tracks while imagining the final composite result.

2. Pedagogical and Rehearsal Adaptations

Remote instruction during lockdown revealed that students' attitudes toward online formats were largely positive when pedagogical design aligned with disciplinary goals (Ritchie, & Sharpe, 2021). Synchronous instruction preserved relational continuity, whereas asynchronous assignments encouraged self-regulated practice.

Case studies of synchronous piano instruction demonstrate that, with adequate technological support, teachers can effectively address technique, phrasing, and musical interpretation while simultaneously training students in distance pedagogy (Pike, 2017). Similarly, problem-based online vocal-piano programs have demonstrated improvements in ear development and performance competence when structured through coordinated modules and digital interaction (Liu, & Ye, 2023).

These findings suggest that digital ensemble pedagogy does not merely replace traditional rehearsal but redistributes learning phases between individual and collective domains.

Research comparing individual and collaborative rehearsal indicates that alternating solitary preparation and group interaction enhances internalization of musical material. Asynchronous digital formats naturally foreground this alternation: performers must independently refine parts before submission.

Digital collaboration projects demonstrate increased learner agency when students assume distributed roles. In ensemble contexts, roles such as technical coordinator, editing assistant, or section leader support engagement and shared responsibility.

Personality research indicates that extraversion, agreeableness, and openness correlate with ensemble aptitude (Kawase, 2016). In digital settings, intentional role distribution may compensate for reduced embodied co-presence by sustaining interpersonal investment.

Remote assessment experiences highlighted the importance of transparent evaluation criteria (Ritchie, & Sharpe, 2021). For digital ensembles, assessment may distinguish: process competencies (timeliness, recording quality, responsiveness to feedback); product competencies (intonation, rhythm, stylistic coherence); collaborative competencies (leadership, communication, problem-solving)

3. Artistic and Social Dimensions

Vocal Practice. Digital vocal ensembles have explored layering, multimedia integration, and collaborative composition. Active use of digital tools correlates with increased creativity and engagement (Liang, 2024).

Asynchronous vocal ensembles rely on standardized pronunciation guides, conductor modeling videos, and microphone setup instructions to achieve timbral cohesion. Singers must internalize ensemble blend in the absence of real-time feedback.

Synchronous coaching remains essential for immediate correction of resonance, tuning, and expressive nuance (Liu, & Ye, 2023). However, close-harmony a cappella textures remain particularly vulnerable to latency.

Socially, vocal ensembles function as high-performing work groups characterized by mutual sensitivity and collective regulation (Lim, 2014). Structured interaction and small-group digital spaces can help sustain cohesion.

Piano Ensemble. Piano's wide frequency range exposes digital audio limitations. Latency experiments confirm significant coordination challenges in remote duet performance (Washburn et al., 2021).

Synchronous duet work is most viable in low-latency local networks. Clear assignment of initiating roles may enhance stability. Asynchronous recording enables refined control over pedaling, articulation, and dynamics but demands self-recording literacy.

Synchronous online piano teaching projects demonstrate expanded access and meaningful pedagogical outcomes when supported by adequate technological infrastructure (Pike, 2017).

Choral Performance. Choral ensembles experienced acute disruption during lockdown, with widespread adoption of asynchronous "virtual choir" models (Onderdijk et al., 2021).

Hybrid choral workflows commonly include: synchronous sessions for warm-ups and sectional work (often muted); asynchronous recording submission; centralized editing and mixing.

Ensemble performance has been shown to enhance affective engagement compared to solo performance (Labbé et al., 2017). While digital formats may attenuate embodied intensity, many choirs report sustained belonging through shared projects.

Conclusions

Digital ensemble performance fundamentally reconfigures relationships among timing, sound, embodiment, and sociality.

Synchronous modalities preserve live interaction and shared temporal agency but remain constrained by latency and audio limitations. Asynchronous modalities enable high-quality production, flexible scheduling, and creative experimentation, yet attenuate spontaneous interaction. Hybrid models strategically integrate both, combining relational immediacy with technical consolidation.

To leverage digital ensemble environments effectively, educators should: integrate technological literacy into musicianship training, rebalance rehearsal structures between individual and collective phases, implement multidimensional assessment frameworks, address equity, access, and social cohesion as central design considerations.

Digital ensemble practice expands the ecology of musicianship. When intentionally designed, it enables new forms of collaboration, intercultural exchange, and multimodal creativity while redefining how togetherness is cultivated in networked musical spaces.

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