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Role of Digital Technologies in Analysis of Choral Performance: Mechanism of Processing Sound and Musical Piece

O Papel Das Tecnologias Digitais Na Análise da Performance Coral: Mecanismo De Processamento De Som E Peça Musical

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Abstract: Achievement of the quality of a choral piece performance is possible provided that the ensemble sound is maintained, the purity of the structure, the expressiveness of timbres, dynamics, and the technical training of the choir members are achieved. The aim of the study is to determine the impact of digital technologies on the improvement of choral performance, considering methods of sound processing and work on a musical piece. The training of choral performers was implemented using digital technologies – Vocalista (for sound processing) and ChoraLine (for work on a musical piece). The research results demonstrated that the students' choir members were able to achieve a high level of vocal emotionality (4.9 points), an ensemble nature of vocal parts (4.8 points) and performance technique (4.6 points); it has been found that digital technologies had a positive impact on the development of musical ear (4.7 points) and memory (5.0 points). The article's practical significance lies in the possibility of expanding approaches to teaching choir members using digital technologies. Prospects for further research include

comparing the effectiveness of digital and virtual technologies for processing musical sounds and musical pieces in general.

Keywords: ChoraLine. ensemble of vocal parts. emotionality of performance. Vocalista. vocal synchronicity.

Resumo: A obtenção de qualidade na execução de uma peça coral é possível desde que se mantenham a sonoridade do conjunto, a pureza da estrutura, a expressividade dos timbres, a dinâmica e o treinamento técnico dos membros do coro. O objetivo deste estudo é determinar o impacto das tecnologias digitais na melhoria da performance coral, considerando os métodos de processamento de som e o trabalho com a peça musical. O treinamento dos cantores corais foi realizado com o uso de tecnologias digitais – Vocalista (para processamento de som) e ChoraLine (para o trabalho com a peça musical). Os resultados da pesquisa demonstraram que os estudantes integrantes do coro atingiram um alto nível de emotividade vocal (4,9 pontos), de coesão das partes vocais (4,8 pontos) e de técnica de interpretação (4,6 pontos); constatou-se que as tecnologias digitais tiveram um impacto positivo no desenvolvimento da percepção musical (4,7 pontos) e da memória musical (5,0 pontos). A relevância prática do artigo reside na possibilidade de ampliar as abordagens de ensino de coros por meio do uso de tecnologias digitais. As perspectivas para pesquisas futuras visam comparar a eficácia das tecnologias digitais e virtuais no processamento de sons e de peças musicais em geral.

Palavras-chave: ChoraLine. conjunto de partes vocais. emocionalidade da performance. Vocalista. sincronia vocal.

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1. Introduction

Choral performance is a collective art form that involves the coordinated blending of different voices to produce a unified sound (Densley et al., 2025). Choral performance is a multi-level system that, through intonation, timbre, and rhythmic characteristics, ensures synchronicity to create a musical image (Cao and Ismail, 2025). The quality of choral singing depends on the singers' auditory control, which affects intonational accuracy. The coordination of choral singing depends on dynamic interaction and the ability to create accents. Minimal deviations in the performance of some choir members affect the "blurring" of the sound and complicate synchronicity (Zhukov and Barrett, 2025).

A comprehensive artistic performance requires a certain singing culture, technical training of singers, developed artistic taste, emotionality, repertoire selected according to certain criteria, and artistic expressive means of conducting technique. The training process should be aimed not only at developing the vocal skills of choral singers, but also at expanding cultural knowledge and understanding the ways of interpretation of the artistic image of a musical piece (Kambs, 2025). It is possible to ensure high-quality training for choral singers by using digital technologies that facilitate a wide range of approaches to developing professional competence.

Despite the increasing integration of digital technologies into music education, their application in choral performance remains methodologically underdeveloped and insufficiently justified. Contemporary research highlights the expansion of digital tools, including AI-based systems, mobile platforms, and interactive environments, which significantly transform vocal pedagogy (Huang and Wang, 2026; Zhang et al., 2025). However, these approaches are oriented toward solo singing, where vocal parameters can be isolated and precisely controlled. Such a focus limits its direct applicability to choral performance, which

is inherently grounded in complex polyphonic interaction, ensemble balance, and collective sound production. Existing technological solutions rarely account for these features, revealing a conceptual mismatch between the design of digital tools and the specific ensemble singing (Turchet and De Cet, 2023).

At the same time, digital technologies demonstrate clear pedagogical potential in choral contexts. They provide expanded access to learning resources, enable flexible rehearsal formats, and support analytical feedback on intonation, rhythm, and sound balance. These capabilities can contribute to the development of individual vocal accuracy within the ensemble. Digital technologies provide a detailed analysis of the performance and mechanisms for improving or editing the musical piece. Specialized applications facilitate the improvement of vocal skills by focusing on voice tuning and compliance with the required rhythm and intonation (Wardani et al., 2023). This allows for a focus on minimizing technical errors to develop dynamics and emotional expressiveness. Focusing on interactive exercises or video lessons facilitates expansion of vocal skills. Digital vocal analysis allows to identify a lack of synchronicity in joint performance, intonation mistakes, and rhythmic inaccuracies. Digital singing recognition motivates choir singers to adjust their vocal skills and interact with other choir members. Therefore, this approach can have a qualitative impact on the processing of an individual sound and musical piece. Processing mechanisms aim to transform a musical piece in accordance with the vocal capabilities of choral singers (Hurley and Atkins, 2023). The process ensures work with sound textures, adjustment of individual sound frequencies, pitch changes, overall expressiveness of the composition, etc.

Nevertheless, their effectiveness remains limited due to several critical constraints. Current systems show insufficient capacity to process polyphonic textures and overlapping vocal frequencies, which are fundamental to choral sound.

As a result, technological feedback often prioritizes individual correction over ensemble cohesion. Furthermore, the lack of robust datasets and computational models for choral sound analysis significantly restricts the accuracy and applicability of such technologies (Narang et al., 2023). This indicates that existing digital approaches may not only be insufficient but potentially problematic when applied uncritically to collective performance.

Therefore, the relevance of this study lies in the need for a critical reassessment of the role of digital technologies in choral practice. While their effectiveness in solo vocal training is well documented, there is an apparent lack of theoretically grounded and empirically validated approaches tailored specifically to choral performance. Previous studies have not sufficiently addressed how digital tools influence key ensemble parameters such as coherence, intonation alignment, and expressive unity. Moreover, the absence of integrated methodological frameworks that combine sound processing technologies with ensemble-based pedagogy reveals a significant research gap. Addressing this gap is essential for avoiding the uncritical transfer of solo-oriented technologies into choral contexts. Accordingly, the present study aims to evaluate the impact of digital technologies on choral performance through sound-processing methods and work on a musical piece.

To achieve this goal, the following research tasks were formulated:

- to develop approaches to teaching choral singing with the use of Vocalista and ChoraLine digital technologies, which facilitate sound processing and work on a choral piece;

- to evaluate the level of choral performance of musical pieces before and after the research according to the criteria determined (performance technique, vocal emotionality, ensemble of vocal parts);

- to evaluate the effectiveness of learning approaches to the improvement of musical ear and the development of musical memory, which are interrelated with the quality of choral performance, by the students' choir members.

- to analyze the performance of arrangements of Ukrainian folk songs by the students' choir (as illustrated by a specific example).

1.1 Literature review

The quality of the ensemble performance of a composition is possible due to consideration of melodic, intonation, and timbre features of the voices and reproduction of a unique sound style. The use of melody variation techniques allows the conductor to expand their creative intent. It is important to ensure a balance between the vocal part and instrumental accompaniment, rationality, and emotionality in performance (Prokopov, 2019; 2022). The complexity of the piece affects the quality of performance. The singing culture, preservation of the artistic integrity, and essence of a musical piece are also important. The created performance version of a piece can be achieved because of the singers' deep comprehension of the musical text, an important level of technical and performance skills, inspiration, and expressiveness (Prokopov, 2023). These parameters collectively define the structural and expressive integrity of choral performance and determine the conditions under which ensemble coherence can be achieved.

Sound-processing mechanisms also directly affect the quality of choral performance, particularly through intonational variability, which influences pitch formation (Huseynova and Seyidov, 2025). Timbre heterogeneity can lead to a "layered" sound and a lack of vocal blending, while dynamic inconsistencies contribute to unevenness and reduced synchronization between parts (Cao and Ismail, 2025). As a result, the absence of clear accents and cohesion becomes apparent, and inadequate

sound processing may lead to deviations from the original interpretation, affecting intonation, timbre, dynamics, and rhythm.

In this context, the growing interest in methodological integration becomes theoretically grounded. The first group of articles for analysis concerned the combination of different methods of choral singing formation with the use of innovative technologies. The use of interactive technologies for vocal education can be combined with work on voice production and expression. A combination of two methods during training allows choral singers not only to focus on vocals but also to understand the meaning of music and embody it in their performance. Such an approach ensures a transition from isolated technical training to a more holistic model of choral pedagogy, in which technological tools support both the analytical and interpretive dimensions of performance. Thus, optimizing the vocal training method involves using VSSA models to focus and refine training, leveraging artistic effects that positively impact the singer's emotions. The artistic effect contributes to the sensual reproduction of music, which is especially important during folk song performances (Huang, 2024).

Innovative vocal technologies foster creative thinking, improve technical skills, and enhance artistry. However, the best results in choral performance can be achieved because of a combination of innovative technologies and a compensatory approach. The compensatory approach aims to create problematic situations during training to promote more focused learning. The combination of approaches in education ensures higher performance by choir members and improves their motivation to develop their vocal and choral technique (Shumska et al., 2024). The emphasis on combining low-level methods to improve choral singing is also found in the study of Batovska et al. (2023). The expansion of traditional performing functions is possible using practical interactive methods (audio analysis, audio selection) and an interdisciplinary, sociocultural

approach. This approach is reflected in a better understanding of intonation principles, an enrichment of technical means, improved sound quality, and greater expressiveness in singing. In the study of Aderogba (2025), it was found that the combination of innovations and a compensatory approach affect not only the quality but also the endurance of singing. This is associated with adjustments in breathing, emotional regulation, and pedagogical systematicity. The combined approach to teaching choral singing affects the consideration of technique and empathy of performance. Awareness of the artistic, professional features of choral performance problems on the coherence of singing (McAllen et al., 2026). Thus, a combination of different educational methods can facilitate better results. However, the regular use of a compensatory approach can create an additional burden on choir members, leading to decreased motivation. In the training process, it is necessary to alternate approaches to achieve better results. The development of the singing voice through the application of digital technologies enables the implementation of more accurate methods for humming and sound transmission. Digital technologies enable a detailed approach to analysis, enhancing the experience of song performance and vocal processing. The approach contributes to vocal aesthetics and to the selection of effective strategies for continuous voice improvement (Hughes and Knowles, 2024).

The peculiarities of combined rehearsals of singers in a choir are analyzed in the next group of scientific papers. Cloud storage services – such as Zoom and Google Drive – can be used to improve a choir's rehearsal process. The storage of video and audio recordings in an accessible format enabled the synchronization of distance training. The process involved not only the reproduction of musical materials but also their edition to achieve vocal individuality. A comparison of students' choir members' results using traditional and technological learning

approaches showed a 5% advantage for the second approach (Zhang, 2023). Cloud storage can be used as an additional tool during the training process. However, the choice of specialized applications enables better results. The training of choristers should first focus on breathing techniques. This will affect flexibility and sound quality, but only if the conductor's gestures are correctly perceived. Preparation of vocal combinations can be regulated using video stimuli. Digital technologies enable the use of congruent and incongruent combinations of gestures, helping choir members understand the conductor's movements and their combination with the voice (Platte et al., 2024).

In the next group of works, attention is paid to the research of the processes of musical piece processing to achieve higher-quality results. During vocal education, it is possible to use new or transformed musical pieces that yield high-quality vocals. Work on musical pieces contributes to choristers' independence and to the regulation of listeners' emotions. The use of various applications facilitates the application of principles to a musical piece and the understanding of more precise mechanisms for its interpretation (Eusterbrock, 2023). The vocal technique is important for the performance of choral compositions, particularly arrangements of folk songs, which are often characterized by a wide range of melodic phrases and profound meaning. For this purpose, singers shall become aware of the fundamentals of the vocal technique during training to improve the sound of their voices. Therefore, it is necessary to develop detailed courses to teach students to sing across different registers, to study the timbre capabilities of the voice, and to master breathing practices. The additional use of innovative technologies will allow for determining the timbre features of the future performer's voice and direct the vector of performance capabilities (Dai and Hu, 2024).

Choral performance should aim to ensure high-quality linguistic and musicological features that are interrelated with the repertoire. Consideration of linguistic and ideological

indicators in education affects emotional performance and enables better transmission of stylistic musical models (Konert-Panek and Gradowski, 2024). These indicators reflect the aspects of work with the repertoire, but in research, the peculiarities of the transformation of musical pieces have not been clearly studied to expand the capabilities of students' choir members.

The Vocaloid virtual application can facilitate improvements in the vocal performance of opera and folk songs. The Vocaloid application facilitates the determination of musical genres for the aesthetic reproduction of images during vocal singing. An important feature of Vocaloid is an opportunity for choral singers to interact with virtual idol characters (Roussel, 2024). Virtual technologies can facilitate teaching to sing. However, their use is expensive, making it difficult to implement in the educational process among many students.

Based on an analysis of published articles, it was possible to identify the use of various methods of teaching choral singing. They are related to the use of digital technologies, a combination of two teaching methods, or consideration of certain elements that need to be addressed for the development of choral skills. At the same time, insufficiently studied issues are ways to adapt selected teaching methods, mechanisms for using digital technologies that require detailed clarification.

2. Methodology

The methodological design is justified by the experimental pedagogical framework aimed at evaluating the impact of digital technologies on choral performance. The study integrates a structured intervention (Vocalista and ChoraLine), longitudinal training (20 weeks), and multi-criteria assessment (performance technique, vocal emotionality, ensemble coherence, musical ear, and memory). The use of combined teacher evaluation

and automated digital feedback enables methodological triangulation, while statistical procedures (Student's t-test, Cronbach's Alpha, Spearman's correlation) ensure quantitative validation of results.

2.1 Research design

The first stage of the research was aimed at implementing a training program for choral singers. Therefore, the authors developed teaching approaches aimed at achieving vocal purity and expressiveness. Thus, considerable attention in the educational process was paid to work with the repertoire and its adaptation to the voices of the choir members. The tools used to implement the training process were digital technologies: Vocalista (for sound processing) and ChoraLine (for working with the repertoire). The choice of these applications for training was made with the educational tasks in mind, which involved not only the development of an ensemble nature of vocal, but also individual work on sound processing and musical composition. Attention was paid to adaption of their interactive capabilities for the learning approach and a certain learning pace. Feedback from the applications and the quality of such feedback were also considered. In total, about fifty digital technologies were analyzed to ensure the training process.

The Vocalista application provided students' choir members with personalized vocal exercises tailored to each choir member's vocal range. Using the application made it possible to control the correctness of each note, performed by the choral singers. Attention was also paid to tracking progress, with consideration of the purity of performance within a particular range. The application contributed to adjusting the dynamics and timbre of the performance and to avoiding additional noise. The Vocalista application was primarily used to work on diction and clarity of intonation as well as emotional expressiveness of the voice production.

The ChoraLine application facilitated rehearsals and work with a specific repertoire. The interaction of the students' choir members with the application primarily involved learning a specific musical piece and achieving a high level of performance. This facilitated improvements in the accuracy and expressiveness of the singers' vocals. Work with vocal parts involved not only vocal correction, but also adaption of the musical piece to the singers' capabilities. This provided a more personalized approach with work on volume and pitch. The application allowed users to listen to and compare different versions of a musical piece, facilitating the search for appropriate ones. A crucial element of the application's functionality was the ability to create your own variations of vocal parts. This approach facilitated the regulation of the ensemble of vocal parts, ensuring a convenient learning pace. The presence of an interactive voice assistant contributed to better information assimilation. For deeper learning, the application enabled analysis of a specific vocal part performed by a professional. The ChoraLine application was used in training to work on understanding the musical piece's content and the ensemble nature of the vocal parts.

The training lasted 20 weeks, from September 2024 to January 2025. The training process included individual and group work with vocalists, involving constant interaction with the Vocalista and ChoraLine digital technologies.

The second stage of the research included an assessment of the choral performance of musical pieces. The evaluation identified three criteria (performance technique, vocal emotionality, and ensemble of vocal parts) as having the greatest impact on the overall quality of the choral sound. The assessment of the performance technique involved a comprehensive approach, including proper breathing techniques. The assessment of intonation during singing was also considered, with a focus on

the preservation of vocal purity in both simple and more complex musical pieces. The performance technique also included an articulation assessment that influenced the overall quality of the choral performance. Vocal emotionality was determined by the musical images conveyed and the emotional mood of the musical piece. The assessment of vocal emotionality also included the dynamics of performance, the appropriateness of changes in vocal power, and the clarity of musical pauses. The ensemble nature of the vocal parts included an assessment of the interaction between the voices and the achievement of a dynamic, timbre balance between them. The level of choral performance of musical pieces was assessed by the teachers, using the Vocalista digital application, because of the exercises. The teachers assessed it through observation, which included an analysis of the dynamics of the quality of the choral singers' performances of musical pieces and their understanding of the materials during rehearsals. The use of the Vocalista digital application provided automatic tracking of the correctness of the performance of musical pieces and voice control based on interactive exercises for students' choir members. The scores from teachers and for the exercises in the Vocalista application were grouped together, which provided an average value for all members of the choir (5 - the highest score). According to the scores received, the student's t-criterion was calculated (O'Hara, 2025). The chosen statistical methods were aimed at verifying the results, given the possibility of comparing the performance of choral singers before and after the research. The calculations assumed adherence to the normal distribution of data, which is based on the expectation of a random variable. The use of digital technologies in education was taken as an impact of a random variable. The number of degrees of freedom was equal to 3, so if $\alpha=0.05$, the student's t-criterion is equal to 3.18. If the calculated value exceeds 3.18, the indicators will not be interrelated.

The third stage of the research aimed to evaluate the effectiveness of digital technology-based learning approaches for improving choral singers' musical ear and developing their musical memory. The assessment included tests for memorizing melodies (musical memory) and recognizing chords, intervals, and their alterations (musical ear). Based on these tests, completed by the students' choir members, not only was the possibility of developing musical ear and memory determined using digital technologies, but also the possibility of assessing the specific level of their development. Musical memory was assessed through the memorization of short musical fragments by ear and their subsequent reproduction, implemented as a quiz. Additionally, it was planned to revise the musical fragments and provide the choral singers with an opportunity to perceive these changes. The assessment was aimed at an ability to memorize melodies and rhythmic patterns. The process of melody reproduction after perception by ear was implemented at several stages – immediately after listening, an hour later, and the next day.

The development of musical ear involved the perception of musical sounds and intervals. It was also intended that the students' choir members repeat the musical rhythm proposed for interpretation. Rhythmic repetition was applied to both simple and more complex fragments. The level of improvement in musical ear and musical memory was determined based on test results and teachers' observations. The observation process focused on comparing the initial and final results of the students' choir members. The level of assessment of the effectiveness of the training process for the development of musical ear and memory among choral singers was conducted after all tests were completed (before the results were received) and due to the direct use of digital applications. Numerical indicators were collected via e-mail that made it possible to track the receipt of values from all students' choir members within 24 hours.

The reliability of the results was assessed using Test-Retest Reliability, which involved receiving repeated results within a week. The reliability was mathematically confirmed with the use of the Cronbach's Alpha coefficient, which was equal to 0.91 (confirming an important level of reliability) (Leiper, 2021). The assessment was scored on a scale of 1 to 5. The results of the effectiveness of the impact of digital technologies on the development of musical ear and memory were also determined with the use of the Student's t-criterion. However, it was considered that the number of degrees of freedom was equal to 2, so if $\alpha=0.05$, the student's t-criterion was equal to 4.30.

The fourth stage of the research included an analysis of the performance of arrangements of Ukrainian folk songs by the students' choir. The folk songs "Kolo mlynu, kolo brodu" and "Vyidu ya na horu" were chosen for performance. The compositions were arranged directly by the choral singers in the choir laboratory within 2 weeks, allowing them to apply the knowledge they had gained. The arrangement of the Ukrainian song "Kolo mlynu, kolo brodu" involved changes, with the application of a more modern approach. This created an opportunity to create musical accents due to changes in the rhythm. The arrangement of the song "Vyidu ya na horu" involved the inclusion of a polyphonic composition. The arrangement is aimed at ensuring ensemble singing and achieving melody. The choice of two songs was related to the possibility of accurately tracking the high artistic level of performance, which involved analyzing the criteria for the quality of musical interpretation and the synchronicity of the choir members' voices. The quality of the musical interpretation was related to assessment of the performance technique, breathing, correct intonation, the dynamics of voice development and preservation of the necessary rhythm. The process included the possibility of reproducing the necessary vocal techniques and musical interpretation methods. The synchronicity of the voices was related to the harmonious combination of the choral parts and

to the ability to ensure a high level of performance in Ukrainian folk songs. The maximum mark that teachers could give for the performance was five points.

A standardized Performance Assessment Rubrics framework (Kaufman et al., 2025) was applied to evaluate the student choir's performance in Ukrainian folk song arrangements. The assessment covered intonation, rhythm, interpretative technique, articulation, and stage presentation, enabling identification of factors with the greatest impact on performance quality. The rubric further facilitated evaluation of intonational stability, ensemble synchronization, interpretative consistency, vocal diction unity, and performance confidence. This ensured a more objective assessment of choral performance quality. As the interpretative technique had been analyzed separately, it was excluded from the rubric-based evaluation. All assessments were conducted using a 5-point scale.

The validity of the results was verified using Spearman's rank correlation coefficient (Rexhepi et al., 2024) to assess monotonic relationships among selected variables. The calculated coefficient ($\rho = 0.88$) indicates an important level of convergent validity. These results confirm both the correctness of the calculations and the reliability of the dataset, supporting the robustness of the analytical approach and its applicability to similar empirical studies while reducing the risk of systematic error.

2.2 Sample

The research involved 50 choir members from Kharkiv I.P. Kotlyarevsky National University of Arts, studying the specialty "Choral Conducting". The sample of respondents included students from the choir of all years of study. When selecting the respondents, the emphasis was placed on the educational institution to enable comprehensive involvement of choir members in the training process. The advantages of choosing

an educational institution also included the availability of the discipline "Arrangement," a choral laboratory where choral singers could develop individual approaches to musical pieces for further interpretation. Restrictions regarding one educational institution were established to ensure equal learning conditions for students' choir members, which involved determining the impact of digital technologies on the improvement of choral vocal skills. The research also involved 10 teachers who supervised the choral singers' training process. All respondents provided voluntary consent to participate in the research and signed the appropriate agreements.

2.3 Statistical processing

Microsoft Excel software was used to process the numerical results that allowed for preliminary processing of the data received. The generation of spreadsheets facilitatedthe grouping of results for more accurate calculations. Additionally, SYSTAT was used to perform statistical calculations. The calculations obtained with the software used served as a basis for creating graphic and tabular material.

2.4 Ethical issues

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval for the study was obtained from the relevant institutional ethics committee of Kharkiv I.P. Kotlyarevsky National University of Arts. All participants received full information about the aim, procedures, potential risks, and benefits of the study prior to participation. Written informed consent was obtained from all participants. Participation was voluntary, and individuals could withdraw at any time without consequences. Confidentiality and participant anonymity were ensured throughout the research process. Personal data were securely stored and used exclusively

for research purposes. No procedures involving deception or any form of physical or psychological harm were applied. The study was conducted in accordance with established standards of research integrity and ethical publication practice.

2.5 Research limitations

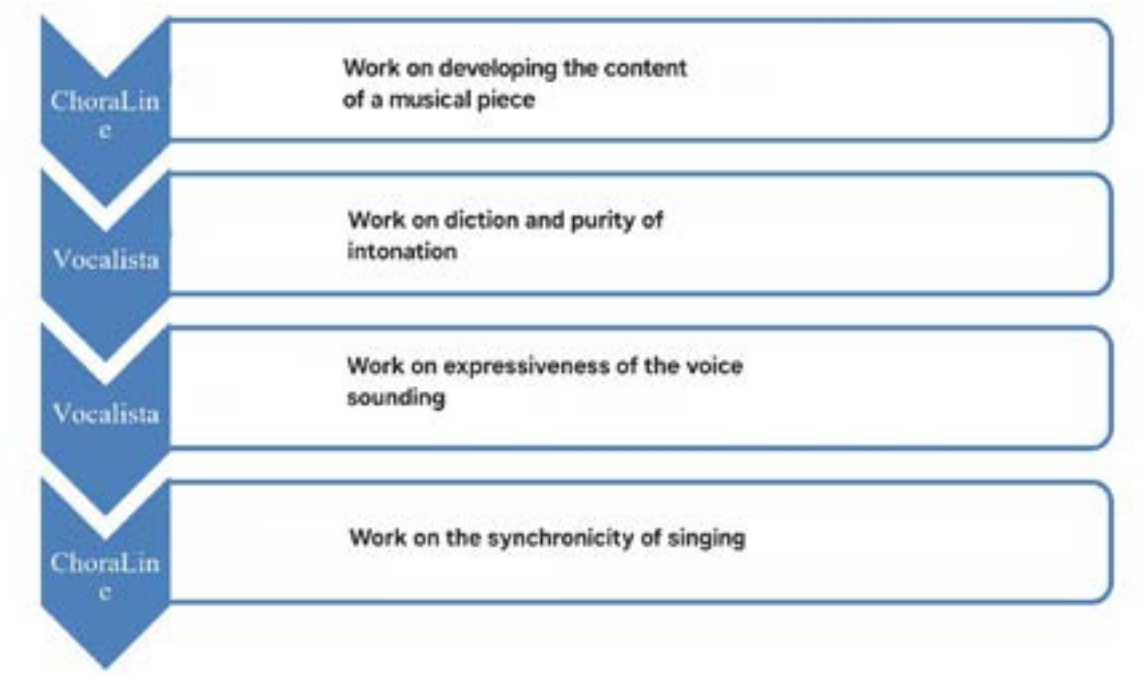
Several limitations are identified. The study is confined to a single institutional context, which restricts external validity. The sample size (n = 50 students; 10 teachers) is adequate for within-subject statistical comparison but limited for population-level generalization. The exclusive use of two digital platforms narrows technological representativeness and limits comparative analysis across alternative systems.

Sample size constraints are acknowledged. Although the current cohort supports statistically significant pre–post comparisons under controlled conditions, larger, more heterogeneous samples would improve statistical power and external validity. However, expansion was limited by the requirement for controlled pedagogical conditions, uniform intervention delivery, and continuous monitoring of digital tool usage. Future research should address multi-site sampling to enhance generalisability and validate scalability.

3. Results

Awareness of ways to adapt a musical piece for choral performance has a positive impact on students' choir members. Therefore, the authors developed approaches to the development of choral skills related to sound processing and choral performance. The learning process was implemented using Vocalista and ChoraLine digital technologies (Figure 1).

Figure 1 - Learning approaches to development of choral skills with a focus on the use of digital technologies for sound processing and choral performance



The work on the musical piece's content understanding was one of the tasks during training of choral performers. The approach ensured not only the analysis of musical scores but also the analysis of concert performances. The work on the musical piece aimed at a comprehensive approach that included an analysis of its history of creation, a fragmentary study, and an analysis of operational and artistically perfect interpretations. The analysis of other choirs' performances enabled a focus on different versions of the musical piece. Thus, the choral singers have developed an understanding of the musical piece's peculiarities and seek the most appropriate strategies for its meaningful and expressive performance. The ChoraLine application facilitated work with musical fragments, allowing the choristers to better understand the imaginative and emotional sphere of a musical piece and convey it to the audience. *The work on diction and intonation* was aimed at achieving a high-quality choral sound. The students' choir members ensured work on individual sounds and syllables, focusing on clarity in pronunciation to generate

a beautiful timbre. The work on diction was performed due to the peculiarities of the figurative content of the text and music. The transition from one range to another, ensuring the equality of the sound, was related to the breathing.

The work on voice expressiveness aimed to change the sound's strength, to reproduce culminating elements, and to create dynamic contrasts. Therefore, work on timbre tint was envisaged, depending on the nature of the musical piece, and development of associations was ensured to reproduce the contrast of sound tint. This was achieved through rhythmic expressiveness, the dynamism of each part, and a deeper understanding of the musical piece's artistic image. Microdynamics techniques were also used. The flexibility of the performance was achieved through improvisational approaches that transformed ordinary musical forms and were implemented using the Vocalista application. *The work on vocal synchronization* aimed to coordinate the voices of all choir members, focusing on tempo and intonation. Synchronized vocals ensured rehearsals were conducted with a clear rhythm. Digital technologies were used to record individual choir members' voices and combine them to assess the level of sound synchronization. This approach was aimed at ensuring the vocal correction in practice. During the training, the voices' synchronicity was achieved through adjustments to each part's role, ensuring a high-quality choir sound.

The effectiveness of the used Vocalista and ChoraLine digital technologies was checked after 20 weeks of training. To present clearer results, the levels of choral performance in the students' choir's musical pieces were compared before and after the research. The criteria for comparison are presented in Table 1.

Table 1 - Level of choral performance of musical pieces by the students' choir during the research period

Performance indicator	Before research			After research			t	p-value
	Received points	M	SD	Received points	M	SD		
Performance technique	3.8	0.527	0.087	4.6	0.875	0.144	-3.192	0.02
Vocal emotionality	4.2	0.531	0.089	4.9	0.883	0.147	3.005	0.04
Ensemble nature of vocal parts	3.5	0.519	0.086	4.8	0.881	0.145	-3.215	0.01

Assessment of the level of choral performance of musical pieces before and after the research demonstrated significant progress in the student choir members' achievements. Comparison of the results *before the beginning of the research* demonstrates lower results, which is due to a lack of an important level of the ensemble nature of vocal parts. Senior choristers achieved a higher level of performance, but first-year choristers did not have a clear idea of how to preserve synchronous vocals. However, the unfamiliarity of the songs for the senior students' choir members also contributed to mistakes in performance technique, vocal emotionality, and overall ensemble cohesion. The results *of the research* demonstrated the achievement of a higher level of musical performance. This was reflected in the synchronicity of the sound of musical phrases, an important level of expressiveness and clarity of vocal.

The vocal emotionality was related to a change in dynamics to ensure a more convincing interpretation of a musical piece. Correct breathing technique and consistent practice ensured improvements in the choristers' performance capabilities. The training process contributed to choral singers' ability to reproduce sound shades, ensuring the reflection of a specific musical image. The achievement of emotional vocal was related to the naturalness and ease of performance, which emphasized the overall aesthetics of a particular musical piece. Due to the choir's vocal emotionality, it achieved a high level of artistry.

The ensemble nature of the vocal parts was also important after the students' choir members used digital technologies in the training process. This contributed to vocal intensity through breathing, articulation, and the rehearsal of musical pieces. The vocal was characterized by the expressiveness of the vocal parts, which ensured a dynamic balance. Development of these skills after training was related to constant control over the performance technique, which contributed to correct inhalation and the ability to use improvisational approaches.

The effectiveness of the learning approaches was also assessed by the choir members themselves. The evaluation process involved consideration of the development of musical ear and musical memory. The emphasis on these indicators was determined by the possibility of ensuring high-quality performance of a vocal piece (Table 2).

Table 2 - Level of choral performance of musical pieces by the students' choir during the research period

Criteria	Received values, points	M	SD	t	p-value
Before research (in choral singers' opinion)					
Ear for music	4.1	0.739	0.123	1.819	0.05
Musical memory	3.9	0.725	0.120		
After research (in choral singers' opinion)					
Ear for music	4.7	0.892	0.148	1.908	0.05
Musical memory	5.0	0.893	0.148		
Level of development of choral singers					
Ear for music	4.9	0.899	0.150	1.923	0.05
Musical memory	4.6	0.894	0.149		

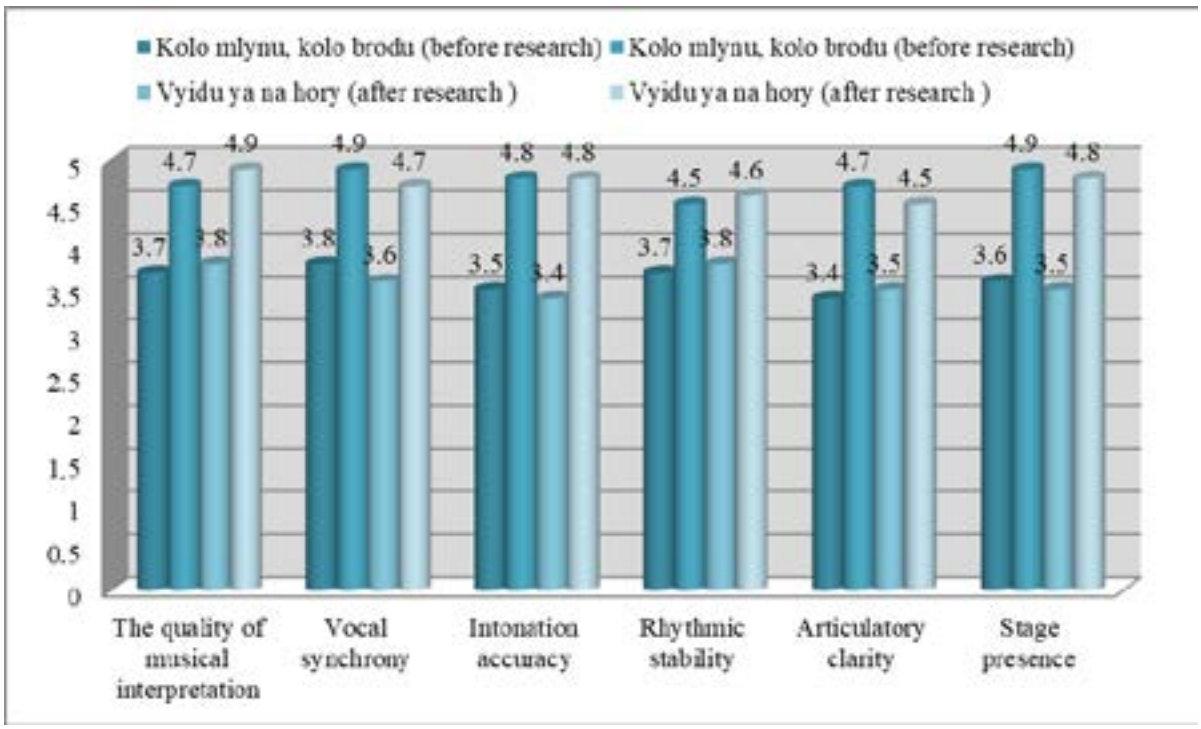
The development of musical ear and memory was related to interactive study that ensured attention and feedback for each student's choir member. According to the choral singers, detailed work on musical pieces and on each sound's processing

ensured an expressive performance. *The development of musical ear* allowed for a more holistic perception of a musical composition and ensured its reproduction through listening. Through active perception of musical pieces, choir members developed skills in melodious performance and emotional perception. Based on their developed musical ear, the choral singers perceived the durations of sounds and pauses to be considered during performance. The development of musical ear influenced intonation accuracy, enabling corrections to improve performance purity. Students were more focused on participating in improvisational vocal work, emphasizing constant voice control. Maintenance of a stable sound ensured high-quality interaction of all vocal parts.

The development of musical memory ensured an ability to recognize different musical pieces during the quiz. Thus, the choir members performed songs more meaningfully and were focused on the use of cause-and-effect relationships in practice. Memory development influenced the understanding and memorization of choral parts with a focus on expressive and emotional performance. It also had an impact on better work with musical texts, ensuring not only the memorization of words but also the transmission of the main sense through emotional reproduction. Choral singers could freely interact with other members of the choir, focusing on flexible, organic performance and on tonal and rhythmic changes. The students' choir members believed that, based on their developed memory, they could be guided in choosing the right ways to present a musical piece. Confidence in their own knowledge helped them reduce stress and maintain psychological stability during public performances. Coordination between the conductor and the choir, based on the development of musical memory, ensured a more synchronized performance.

Additionally, to determine the level of vocal skills of the choral singers, the performance of arrangements of Ukrainian folk songs "Kolo mlynu, kolo brodu" and "Vyidu ya na horu" was analysed. The final analysis of the performance of arrangements of Ukrainian folk songs is shown in Figure 2.

Figure 2 - Level of performance of arrangements of Ukrainian folk songs by the students' choir



The performance of arrangements of the Ukrainian folk songs "Kolo mlynu, kolo brodu" and "Vyidu ya na horu" by the choral singers demonstrated achievement of high-quality musical interpretation and synchronization of voices. The performance of the arrangement of the song "Kolo mlynu, kolo brodu" was characterized by the transmission of lightness and the reflection of a moderate tempo. The use of melody-acceleration approaches ensured the transmission of the song's character. The performance was characterized by a smooth start and build-up of voices, while maintaining clarity of articulation and purity of intonation.

One of the tasks of the performance of the arrangement of the song "Vyidu ya na horu" was to achieve a bright, emotional sound. Preservation of the medium tempo had a positive impact on the performers' deep understanding of the emotional performance. The increase in dynamics ensured the sound of the culmination and the overall emotional intensity. Thus, it can be concluded that the use of digital technologies in teaching choristers has a positive impact. The use of sound correction and processing techniques for choral compositions has led to a better understanding of vocal interpretation methods.

Thus, post-intervention results demonstrated higher student performance, which can be attributed to the implemented instructional approach integrating digital technologies. Improved quality of Ukrainian folk song arrangements was associated with enhanced understanding of musical interpretation, systematic work on diction, and increased intonational accuracy. Work on timbral dynamics improved ensemble synchronization, resulting in greater expressive consistency and greater performance confidence. These outcomes were linked to the systematic processing of acoustic parameters, which enhanced temporal stability and reduced tempo fluctuations across choral parts.

4. Discussion

Recent research demonstrates increasing integration of virtual technologies and AI-based systems into vocal and choral education within constructivist and interactive pedagogical paradigms. Virtual choir environments, AI-assisted vocal training, and video-based collaborative analysis have been shown to improve breath control, intonation accuracy, and learner engagement (Doganyigit and Islim, 2021; Lariccia et al., 2021; Ngobeni, 2024). However, these approaches primarily operate at the level of individual vocal development or simulated ensemble interaction, rather than within a fully structured, repertoire-centered choral training process.

In contrast, the present study is methodologically grounded in a controlled pedagogical intervention design (a 20-week training cycle) that uses two integrated digital tools (Vocalista and ChoraLine), which were systematically embedded into both individual and group rehearsal processes (Section 2.1). Unlike studies focusing on isolated virtual environments, the methodology combined individual vocal calibration (Vocalista) with repertoire-based ensemble construction (ChoraLine), allowing simultaneous development of technical accuracy and collective coherence. This design directly addresses a limitation in previous research, where digital tools are typically evaluated in isolation from real choral rehearsal dynamics.

The findings of this study align partially with prior evidence on AI and interactive feedback systems (Bhatt et al., 2023; Wang et al., 2024), which report improvements in vocal precision and expressive awareness. However, the methodological structure of the present research demonstrates that such improvements become more pronounced when digital feedback is continuously integrated into repertoire adaptation and ensemble synchronization tasks, rather than used as an external corrective mechanism. This is consistent with the intervention design described in Methodology, where ChoraLine was used not only for rehearsal support but also for adapting musical material to vocal capabilities and regulating ensemble balance.

The results further extend previous findings on digital audio production and compositional tools. Studies employing Logic Pro X and similar environments report improvements in pitch accuracy and structural control of musical material (Lei, 2024), while DAW-based approaches emphasize compositional optimization and sound design (Aydın and Sökezoğlu Atılgan, 2024). However, these approaches are fundamentally production-oriented and studio-based and therefore do not account for the dynamic variability of live ensemble singing. In contrast, the present methodology prioritized real-time ensemble interaction, where pitch, timbre, and dynamics were

continuously adjusted through collective performance rather than post-production correction. This distinction is critical, as choral performance quality in this study was evaluated through live criteria (performance technique, vocal emotionality, ensemble coherence), rather than digital sound output alone.

The integration of performance assessment methods further strengthens the validity of the findings. The use of standardized Performance Assessment Rubrics (Kaufman et al., 2025), combined with teacher evaluation and automated feedback from Vocalista (Section 2.1 and 2.1 assessment framework), ensured methodological triangulation. This aligns with the statistical processing approach described in Section 2.3, where Student's t-test, Cronbach's Alpha, and Spearman's correlation were applied to validate both performance changes and measurement reliability. The high internal consistency ($\alpha = 0.91$) and convergent validity ($\rho = 0.88$) confirm the robustness of the measurement framework (Rexhepi et al., 2024).

Importantly, studies on musical ear and memory development (Döğer Gündüz, 2025; Howe et al., 2025) emphasize cognitive gains from digital exposure, typically treating these competencies as separate training outcomes. However, the present study demonstrates that, within a structured choral rehearsal system, musical memory, auditory discrimination, and ensemble performance function as interdependent processes. This is directly supported by the third stage of the methodology (Section 2.1), where melodic memory tasks, interval recognition, and rhythmic reproduction were integrated with real rehearsal cycles and digital feedback loops. The combination of immediate, delayed, and repeated testing further allowed for longitudinal tracking of retention and perceptual stability.

The performance of Ukrainian folk song arrangements ("Kolo mlynu, kolo brodu" and "Vyidu ya na horu") provides additional empirical validation of the methodological model. As described in Section 2.1 (stage four), these works required not

only technical execution but also stylistic adaptation, dynamic restructuring, and ensemble synchronization. The application of digital tools supported controlled modification of rhythm, timbre balance, and polyphonic structure. The observed improvement in ensemble coherence and expressive stability indicates that digital mediation is most effective when linked to interpretative decision-making in repertoire-specific tasks rather than in abstract skill training.

Overall, the literature reveals a fragmented approach to digital choral pedagogy, treating vocal technique, cognitive training, and technological tools as separate domains. The present study addresses this limitation through an integrated methodological framework combining longitudinal training, dual-platform digital intervention, multi-criteria performance assessment, and statistical validation procedures. This structure provides a more ecologically valid representation of choral performance conditions than previous simulation-based or production-oriented studies.

Accordingly, the scientific novelty of this research lies in three interconnected contributions: (1) embedding digital sound-processing technologies (Vocalista, ChoraLine) into a repertoire-centered and ensemble-driven pedagogical model; (2) aligning technological feedback with real-time choral interaction rather than individual correction; and (3) integrating technical, emotional, cognitive, and collective performance indicators within a unified evaluative framework. These findings suggest that the effectiveness of digital technologies in choral education is contingent not on their standalone capabilities, but on their pedagogical integration into structured ensemble practice.

5. Conclusions

The obtained results reflect the achievement of the research aim and the completion of the defined tasks. Thus, the relevance of the selected topic is confirmed through the

demonstrated positive impact of digital technologies on choral performance. The aim was achieved through the integration of two digital tools: the Vocalista application supported sound processing and individual vocal accuracy, while the ChoraLine application facilitated repertoire adaptation to the capabilities of choral singers. The learning approach was primarily focused on understanding musical content, diction, and intonation clarity, vocal expressiveness, and ensemble synchronization. As a result of the implemented intervention, a higher level of choral performance was achieved compared to the pre-study stage, with ensemble coherence (4.8), vocal emotionality (4.9), and performance technique (4.6) indicating overall improvement.

The study also confirmed the positive influence of Vocalista and ChoraLine on the development of musical ear and memory. The obtained results demonstrated elevated levels of musical ear (4.9) and musical memory (4.6), which contributed to improved performance accuracy, interpretative awareness, and psychological stability during singing. In the performance of Ukrainian folk song arrangements, high results were recorded in ensemble synchronization for “Kolo mlynu, kolo brodu” (4.9) and in the quality of musical interpretation for “Vyidu ya na horu” (4.9), confirming the effectiveness of the applied digital intervention.

The practical significance of the study lies in the improvement of methodological approaches to choral training using digital technologies, which may be applied in educational practice by choir conductors and music educators. Research prospects will consider the possibility of determining intonation deviations and rhythmic synchrony in real time during the performance of musical compositions across various genres. This will enable the identification of performance-related issues and the potential transformation of choral singing through advanced digital technologies. Future research will focus on comparative analysis of different interactive systems and their scalability to larger choral ensembles.

References

ADEROGBA, John Ade. Knowledge, Care and Preservation of the Human Voice in Solo and Choral Performance. **Awka Journal of Research in Music and the Arts (AJRMA)**, v. 18, n. 2, 2025. Available in: https://nigerianjournalsonline.org/index.php/AJRMA/article/view/3682 Access in: 15 June 2025.

AYDIN, Seval; ATILGAN, Duygu Sökezoğlu. The Effect of Music Education Through Choir Training and Different Musical Activities on the Musical Development of Secondary School 5th Grade Students. **Online Journal of Music Sciences**, v. 9, n. 2, p. 526–539, 2024. https://doi.org/10.31811/ojomus.1535030

BATOVSKA, Olena; BYELIK-ZOLOTARYOVA, Natalya; IVANOVA, Juliia. Modern Global Trends in the Development of Choral Performance. **Studia Universitatis Babeş-Bolyai, Musica**, v. 68, n. 2, 2023. Available in: https://www.ceeol.com/search/article-detail?id=1212775 Access in: 15 June 2025.

BHATT, Sandeep; SCEARCE, Leda; FRANK-ITO, Dennis; NIXON, Tara; UMSTEAD, Kelly A. A Human-Centered Design Approach to SOVTE Straw Phonation Instruction. **Journal of Voice**, v. 39, n. 4, p. 1139.e1-1139.e9, 2023. https://doi.org/10.1016/j.jvoice.2023.01.023

CAO, Wenjie; ISMAIL, Adzrool Idzwan. Ethnomusicology-Singing Characteristics of Chinese Poetry Choral Works. **Journal of Creative Industry and Sustainable Culture**, v. 4, p. 142-154, 2025. https://doi.org/10.32890/jcisc2025.4.10

DAI, Chen; HU, Axu. A Study on the Rhythmic Characteristics of Mongolian Long Tunes Based on Respiratory Parameter Analysis. In: **2024 IEEE 15th International Conference on Software Engineering and Service Science (ICSESS)**. New York: IEEE, 2024, p. (pp. 163-167. https://doi.org/10.1109/ICSESS62520.2024.10719374

DENSLEY, Belinda; DICKSON-SWIFT, Virginia; MILLS, Jane. Harmonising Theory: Integrating Singing with Grounded Theory Methods. **International Journal of Qualitative Methods**, v. 24, 2025. https://doi.org/10.1177/16094069241312042

DOGANYIGIT, Sati; ISLIM, Omer Faruk. Virtual Reality in Vocal Training: A Case Study. **Music Education Research**, v. 23, n. 3, p. 391–401, 2021. https://doi.org/10.1080/14613808.2021.1879035

DÖĞER GÜNDÜZ, Didem. Musical Hearing Education YouTube Videos: A Netnographic Study of Student Problems and Instructors Responses. **Pegem Journal of Education and Instruction**, v. 15, n. 2, p. 130–138, 2025. https://doi.org/10.47750/pegegog.15.10.13

EUSTERBROCK, Linus. Mobile Safe Spaces and Preset Emotions: Making Music with Apps as a Digital Technology of the Self. **Popular Music and Society**, v. 46, n. 1, pp. 50–69, 2023. https://doi.org/10.1080/03007766.2022.2155029

HOWE, Kathleen S.; ASIM, Sumreen; CHRISTENSEN, Rhonda. Applying a Technology Integration Model to Guide Literacy Lesson Planning: A Focus on Teaching Critical Literacy Skills Using Multicultural Literature and Digital Tools. **Literacy Practice and Research**, v. 49, n. 2, p. 3, 2025.

HUANG, S.; WANG, H. Bibliometric Analysis of Choral Education Research: A Decade of Global Trends and Insights. **SAGE Open**, v. 16, n. 1, 2026. https://doi.org/10.1177/21582440261422348

HUANG, Xiaoling. Optimization of Vocal Singing Training Method Based on Intelligent Big Data Technology. **Applied Mathematics and Nonlinear Sciences**, v. 9, n. 1, p. 8, 2024. https://doi.org/10.2478/amns.2023.1.00179

HUGHES, Diane; KNOWLES, Julian. The Technologically Mediated Voice: Captured and Processed Contemporary Singing. **Journal of Popular Music Education**, v. 8, p. 219-237, 2024. https://doi.org/10.1386/jpme_00143_1

HURLEY, Craig R.; ATKINS, Rebecca L. The Effects of Sequence on Expressivity in Solo Singing of Young Voices. **Bulletin of the Council for Research in Music Education**, v. 236, p. 7–20, 2023. https://doi.org/10.5406/21627223.236.01

HUSEYNOVA, Valida; SEYIDOV, Tofiq. Theatre Elements in Choir a Cappella. **Porta Universorum**, v. 1, n. 9, p. 24-34, 2025. https://doi.org/10.69760/portuni.0109003

KAMBS, Ben. Assessment Practices and Beliefs of Secondary Choir Teachers. **Update: Applications of Research in Music Education**, v. 43, n. 2, p. 65-74, 2025. https://doi.org/10.1177/87551233241236684

KAUFMAN, Brian, KLADDER, Jonathan; PALMER, Elizabeth S. Adjudicating Equity in Music Performance Assessments: A Literature Review. **Update: Applications of Research in Music Education**, v. 43, n. 3, p. 49-59, 2025. https://doi.org/10.1177/87551233241256288

KONERT-PANEK, Monika; GRADOWSKI, Mariusz. Stylistic Contrasts and Social Implications in "You Can't Always Get What You Want." **Popular Music and Society**, v. 48, n. 1, p. 79–101, 2024. https://doi.org/10.1080/03007766.2024.2442208

LAMBERTI, Giuseppe; LOPEZ-SINTAS, Jordi; KATZ-GERRO, Tally. Access to Digital Culture as a Driver of Social and Cultural Openness: European Evidence. **Humanities and Social Sciences Communications**, v. 12, p. 180, 2025. https://doi.org/10.1057/s41599-024-04091-1

LARICCIA, S.; LARICCIA, G.; GABRIELI, M.; DELLA VENTURA, M.; TOFFOLI, G.; MONTANARI, M. MUSEUP: How Virtual Choirs May Help Students Learning to Learn. In: **INTED2021 Proceedings.** Valencia: IATED, 2021, p. 6827-6834. https://doi.org/10.21125/inted.2021.1360

LEI, Xiaowei. Analysing the Effectiveness of Online Digital Audio Software and Offline Audio Studios in Fostering Chinese Folk Music Composition Skills in Music Education. **Journal of Computer Assisted Learning**, v. 40, n. 5, p. 2339–2350, 2024. https://doi.org/10.1111/jcal.13031

LEIPER, Tara. A Study of the Impact on Health and Wellbeing of Amateur Choir Singers as Face-To-Face Group Singing Moved Online. **Voice and Speech Review**, v. 17, n. 1, p. 48–65, 2021. https://doi.org/10.1080/23268263.2021.1994698

MCALLEN, Regina; FORBES, Melissa; HUGHES, Diane. Psychological Well-Being in Elite Performance: Exploring Female Broadway Singers' Experiences Through Self-Determination Theory. **Music & Science**, v. 9, 2026. https://doi.org/10.1177/20592043261417094

NARANG, Jyoti; DE LA VEGA, Viviana; LIZARRAGA, Xavier; MAYOR, Oscar; PARRA, Hector; JANER, Jordi; SERRA, Xavier. ChoralSynth: Synthetic Dataset of Choral Singing. **arXiv preprint**, 2023. https://doi.org/10.48550/arXiv.2311.08350

NGOBENI, Nyiko Condry. Investigating Virtual Teaching Experiences: Perspectives of Undergraduate Student Teachers in Singing and Choral Techniques. **International Journal of Learning, Teaching and Educational Research,** v. 23, n. 2, p. 184–202, 2024.

O'HARA, William. "Let's Think in Layers": On Twenty-First-Century Instruments of Public Music Theory. **Music Theory Spectrum**, v. 47, n. 1, p. 83-90, 2025. https://doi.org/10.1093/mts/mtae029

PLATTE, Sarah Lisette; GOLLHOFER, Albert; GEHRING, Dominic; WILLIMANN, Joseph; SCHULDT-JENSEN, Morten; LAUBER, Benedikt. Breathing Against the Conducting Gesture? The Effect of Congruent and Incongruent Gesture-Task Combinations on Breathing Behaviour and Resulting Loudness of Choral Singers. **Music and Science**, v. 7, 2024. https://doi.org/10.1177/20592043231218558

PROKOPOV, Sergiy M. Compositions of J.S. Bach and G.I. Handel, performed by the students' choir of Kharkiv I.P. Kotlyarevsky National University of Arts. In: **Problems of Interaction of Art, Pedagogy, Theory and Practice of Education: Collection of Scientific Articles (Vol. 52).** Kharkiv: Kharkiv I.P. Kotlyarevsky National University of Arts, 2019, pp. 22-37.

PROKOPOV, Sergiy M. Integrated Approach to Work on a Composition in the Classroom of Choral Conducting. In: **Materials of the VII International Scientific and Practical Conference "Conductorial and Choral Education: Synthesis of Territory and Practice", 2-3 November 2023**. Kharkiv: Planeta-Print LLC, 2023, p. 34-39.

PROKOPOV, Sergiy. **Dirigiren Als Eine Art Musicalischer Darbitung: Entstehugsgeschichte. Musikpädagogik Und Musikwissenschaft In der Ukraine**. Germany: AV Academikerverlag, 2022.

REXHEPI, Flutura Gagica; BREZNICA, Rreze Kryeziu; REXHEPI, Burhan Reshat. Evaluating the Effectiveness of Using Digital Technologies in Music Education. **Journal of Educational Technology Development and Exchange (JETDE)**, v. 17, n. 1, p. 273-289, 2024. https://doi.org/10.18785/jetde.1701.16

ROUSSEL, Lila S. The Animation Medium in the Realm of Vocaloid: A Multidimensional Semiotic Overview on the Functional Circle. **Punctum International Journal of Semiotics,** v. 10, n. 1, p. 177-203, 2024. https://doi.org/10.18680/hss.2024.0010

SHUMSKA, Lyudmyla; CHYNCHEVA, Larysa; DOROKHINA, Liubov; HOMENKO, Alla; YOTKA, Yaroslav. Innovative Vocal Technologies in the Educational Choir of a Higher Education Institution: A Competency-Based Approach. **Multidisciplinary Reviews**, v. 7, p. e2024spe044, 2024. https://doi.org/10.31893/multirev.2024spe044

TURCHET, L.; DE CET, M. A Web-Based Distributed System for Integrating Mobile Music in Choral Performance. **Personal and Ubiquitous Computing**, v. 27, p. 1829–1842, 2023. https://doi.org/10.1007/s00779-023-01709-0

WANG, Jingyi; SHARIFI, Alireza; GADEKALLU, Thippa Reddy; SHANKAR, Achyut. MMD-MII Model: A Multilayered Analysis and Multimodal Integration Interaction Approach Revolutionizing Music Emotion Classification. **International Journal of Computational Intelligence Systems**, v. 17, n. 1, p. 99, 2024. https://doi.org/10.1007/s44196-024-00489-6

WARDANI, Indra K.; OKTADUS, Henry Yuda; SITTIPRAPAPORN, Phakkharawat. Artistic Experiences and Social Interaction in Virtual Choir. In: **2023 Joint International Conference on Digital Arts, Media and Technology with ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunications Engineering (ECTI DAMT and NCON).** New York: IEEE, 2023, p. 419-422. https://doi.org/10.1109/ECTIDAMTNCON57770.2023.10139589

ZHANG, Lele. Compositional Tools Based on Artificial Intelligence for Choral Artistic Education: Enhancing Creative Skills in Choral Arrangements. **Thinking Skills and Creativity**, v. 56, p. 101768, 2025. https://doi.org/10.1016/j.tsc.2025.101768

ZHANG, Weiqiao. Modern Cloud Technology in Choral Vocal Training: The Use of Cloud Storage Services. **Interactive Learning Environments**, v. 32, n. 8, p. 4037–4048, 2023. https://doi.org/10.1080/10494820.2023.2194925

ZHUKOV, Katie; BARRETT, Margaret S. Development of Early Choral Expertise: Insights from Middle School Elite Choristers. **Education Sciences**, v. 15, n. 9, p. 1093, 2025. https://doi.org/10.3390/educsci15091093

Research ethics committee approval

The study was conducted in accordance with the ethical principles approved by the Ethics Committee of Kharkiv I.P. Kotlyarevsky National University of Arts (Protocol No 3462 of 13.06.2025). Informed consent was signed by participants.

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