International Journal on Culture, History, and Religion
https://ijchr.net | eISSN: 3028-1318

Received: May 25, 2025 | Accepted: August 7, 2025 | Published: September 30, 2025
Volume 7 Special Issue 1 | doi: https://doi.org/10.63931/ijchr.v7iSI1.201

Article

Modern Digital Approaches to Training Music Teachers: Evolution from Classical to Interactive

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Abstract

This article explores the integration of digital technologies in the training of music teachers for general secondary education, emphasizing the synthesis of traditional pedagogical methods and modern interactive tools. It investigates how digitalization transforms music and pedagogical education by contributing to the development of essential competencies among future educators. The primary objective is to assess the pedagogical outcomes resulting from the incorporation of digital technologies into the professional preparation of music teachers for work in secondary education institutions. The research employs a structural-functional approach, utilizing pedagogical observation, content analysis of curricula and educational platforms, and comparative analysis of digital tools' functionalities. The study confirms the effectiveness of implementing adaptive digital learning environments tailored to the evolving educational trajectories of music teachers. It proposes a step-by-step model for integrating specialized software into professional training, enhancing auditory, rhythmic, and musical skills. The article also outlines pedagogical strategies and interventions aimed at improving proficiency with artificial intelligence tools in music education, including modeling, neuroanalysis, and visual approximation. Furthermore, it identifies key didactic elements essential to developing arranging competencies through the use of digital synthesizers, multitrack editing, and mixing programs, tools that significantly enhance the quality of hands-on teacher training. Future research should focus on comparative evaluations of digital platforms, the design of optimal blended learning models, and the refinement of instructional methods for effectively incorporating AI tools into music pedagogy.

Keywords: *artificial intelligence, interactive technologies, digital environment, music education, music-theoretical training*

Suggested citation:

Aliksiichuk, O., Borysova, T., Kartashova, Z., Priadko, O., Kuziv, M., and Chaban-Chaika, S. (2025). Modern Digital Approaches to Training Music Teachers: Evolution from Classical to Interactive. *International Journal on Culture, History, and Religion, 7*(SI1), 273-296. https://doi.org/10.63931/ijchr.v7iSI1.201

Introduction

The integration of digital tools into the process of sustainable professional training of music teachers for secondary schools is the basis for the formation of a new generation of teachers who not only have traditional methods of music teaching, but are also able to effectively implement the educational process in the context of the global digital transformation of the modern school, while maintaining a deep connection with cultural heritage and national educational traditions (Walzer, 2024). Within the framework of the outlined research issues, a number of authors, in particular Burke et al. (2023), Yuldashev et al. (2022), argue that the use of distance and digital forms does not contradict general pedagogical principles, but rather serves as a tool to support and expand traditional learning interaction, while maintaining the content and purposefulness of vocational education.

Digital technologies in music pedagogy form a multi-level learning model, integrating both synchronous and asynchronous classes, which can help develop creative skills, provide effective methodological training, and provide clear interactive learning adapted to the modern educational needs of professional training. Bothe (2023) and Samus (2024) indicate that this model can be effectively applied in future music teachers' conducting, choral, vocal and methodological training.

A number of works by Cuervo et al. (2023) and Hörmann et al. (2024) focus on the functional aspects of building a digital learning environment based on student autonomy, development of self-regulation skills, and conscious planning of personal learning trajectory. This concept actualizes the principles of the Dalton Plan and other alternative approaches to the individualized educational process. And these facts confirm the relevance of its use in the context of flexible pedagogical practice, when a future teacher must independently adapt learning tasks to the school context by creating soundtracks, instrumental accompaniments, or integrated projects between the arts.

It is worth noting that, despite the positive discourse around digital educational practices, a number of scholars, including Boton (2024). Xu (2024) emphasizes the psychological challenges of digital learning, particularly the lack of emotional interaction between teacher and student and the disruption of social communication in student groups. In the context of music education, where personal interaction and sensory perception are the foundation of performance and methodological training, these factors can indeed be critical. However, a number of researchers, such as Yang (2024) and Matiash et al. (2025), have found that the use of synchronous interaction tools such as video conferencing, joint virtual rehearsals, digital consoles, and audio editors for collaborative work on scores can partially or completely compensate for

these shortcomings. In the context of conducting and choral training, the use of virtual simulators of choral control and video analysis of conducting gestures posted on educational platforms for self-control and mutual evaluation is considered promising.

Methodological training, in particular in the aspect of integrated art teaching at school, finds a new vector of development in digital technologies, as the creation of didactic scenarios, multimedia lessons, and creative presentations allows the future teacher to act in the polyphony of modern educational requirements confidently. According to Dinham (2024), Makedon et al. (2024), the use of Moodle, Google Classroom, Canvas, Edmodo, and other platforms allows for systematic knowledge control, organization of modular learning, storage of assessment history, and creation of didactic projects for music-theoretical training (harmony, music analysis, polyphony).

Modern scholars also draw attention to the gap between employers' expectations and actual requirements for teachers in general secondary education. As studies by Bui (2025) and Taheri and Pennington (2024) show, despite the constant rhetoric about the digitalization of education, educational institutions do not always formulate professional competencies in the list of requirements for candidates for the position of music teacher. These consequences create an imbalance between the requirements of the new Ukrainian school, which declares an integrated model and an interdisciplinary approach, and the actual practice of the educational process. Despite the growing interest in the study of digital educational practices, critical analysis shows a lack of comparative research on the effectiveness of platforms, taking into account the specifics of training music teachers, not just general education teachers. This creates the need for an in-depth analysis of practices that combine digital pedagogy and music didactics, and the development of optimal blended learning models.

The purpose of the article is to evaluate the complex pedagogical results from the implementation of digital technologies in the professional training of music teachers.

Methodology

The research methodology is based on a comprehensive analysis of the impact of digital technologies on the professional training of future music teachers, which involves an in-depth study of modern pedagogical practices, innovative didactic tools, and a comparative assessment of the functionality of digital educational platforms. The structural-functional analysis is the main methodological approach that allows for a systematic assessment of the integration of traditional components of music pedagogical training: vocal, instrumental, theoretical, conducting, and choral, and

methodological blocks with modern digital forms of education, which are implemented through specialized educational platforms, interactive environments and simulation tools.

The study used methods of pedagogical observation of students' adaptation to digital learning formats, which included an analysis of the level of their involvement in independent work with interactive resources and the effectiveness of communication in synchronous and asynchronous educational modes. The content analysis of curricula and e-courses revealed the specifics of introducing digital tools in various music and pedagogical training aspects. The criteria for the selection of empirical material were formed taking into account the specifics of music education and included an assessment of the level of interactivity of platforms, the availability of pedagogical support tools, opportunities for creating the authors' content, and the degree of individualization of the educational process. A comparative analysis of the functional characteristics of digital solutions was conducted to emphasize their compliance with the music-theoretical, performance and methodological training requirements of future music teachers.

Results

Transition from traditional to digital technologies in the professional training of music teachers for secondary education

Digital educational platforms that are integrated into the teacher education process are characterized by several key features. First of all, their interactivity is manifested in the fact that students are involved in active collaboration with educational material and have the opportunity to interact with teachers in real or delayed time. This approach allows future music teachers to effectively master the practical skills of working with musical material, develop skills in analyzing and interpreting works, and learn the methodology of teaching music based on practice-oriented tasks. Institutions of specialized education that train pedagogical staff in the field of art can initiate the implementation of the authors' courses and training modules based on digital practices that meet the current needs of music education. Modern educational programs and platforms need to be regularly updated and adapted to current standards, and the potential of the digital educational environment needs to be taken into account. At the same time, it should be noted that certain difficulties lie not only in the insufficient material and technical base, but also in the level of music performance, conducting, choral, vocal, and instrumental training of teachers to use digital solutions in pedagogical activities (Chust-Pérez et al., 2024). To overcome them, it is advisable to introduce adaptive educational technologies, in particular the digital format of artistic learning, and collaborative forms of educational interaction:

1. Expanding access to educational content and including the possibility of using global resources, such as master classes from leading musicians, access to educational materials in remote regions, and digital archives of music heritage, which expands the horizons of learning and forms a new level of musical competence.
2. Individualization of the educational process, which involves the creation of flexible learning paths tailored to the individual needs of students, is ensured through the use of digital tools for independent work, instant feedback, and dynamic assessment of musical performances.
3. Development of methods of teaching music that include the acquisition of skills in creating digital content, teaching lessons in a digital format, and integrating artistic and technical components into the educational process.
4. Objectify learning outcomes assessment and accurately measure performance elements (tempo, dynamics, intonation), record student progress in a digital environment that minimizes the risks of bias and increases assessment transparency (Table 1) (Rexhepi et al., 2024).

Table 1. Methodological recommendations for the use of digital technologies in the training of music teachers

Field of study	**Recommendations**	**Description**	**Characteristics**
Musical and theoretical training	Recommended digital tools	1. Interactive platforms for learning music theory (Teoria, Musictheory.net with Ukrainian localization). 2. Mobile applications for the development of musical hearing (EarMaster, Perfect Ear). 3. Programs for analyzing music (Sonic Visualizer, MIDI analyzers).	Provide access to structured theoretical materials, promote the development of aural analysis and understanding of musical structures
	Methodological techniques	1. The "flipped classroom" model. Students learn the theory at home through digital platforms, and in the classroom they perform practical tasks under the guidance of a teacher. 2. Interactive tests with automatic knowledge checking to monitor progress. 3. Visualization of musical concepts through interactive graphics for better learning of complex theoretical concepts.	Promote independent work, increase their motivation and deepen their understanding of music theory
Executive training	Recommended digital tools	1. Video recording and performance analysis systems (Smartmusic).	Help students practice their performance

		2. Applications for slowing down and fragmenting music (Transcribe!, Amazing Slow Downer). 3. Programs for analyzing the quality of the received sound and intonations.	technique, analyze their mistakes and improve their interpretation
	Methodological techniques	1. Create a digital portfolio with regular performance recordings for self-analysis. 2. Compare your own performance with reference recordings to improve your technique. 3. Microlearning by dividing complex works into fragments using digital platforms.	Improve the quality of performance through self-reflection and structured training
Teacher training	Recommended digital tools	1. Platforms for creating interactive lessons (Nearpod, ClassIn). 2. AI tools for the development of multimedia training materials (ChatGPT, Deep Seek). 3. Simulators for modeling lessons with virtual students.	Allows to create modern interactive lessons that are close to real pedagogical situations
	Methodological techniques	1. Micropedagogy: recording and analyzing short fragments of lessons to improve teaching skills. 2. Virtual pedagogical practices with online lessons and their subsequent analysis. 3. Creating digital teaching portfolios with own educational resources.	Form practical skills in planning and conducting lessons, develop reflection and a creative approach to pedagogical activity
Composition and arrangement	Recommended digital tools	1. Programs for music recording (Sibelius, Finale, MuseScore). 2. DAW-systems for creating arrangements (Logic Pro, FL Studio, Ableton Live). 3. Virtual instruments and sound libraries.	Provide opportunities for creating professional musical scores and arrangements, as well as experimenting with sound
	Methodological techniques	1. Project-based learning: creating full-fledged musical works using digital instruments. 2. Collaborative composition through student collaboration on cloud platforms. 3. Experimental creativity using generative algorithms and artificial intelligence.	Stimulate creative development, teamwork and innovative approach to music creation

The active use of interactive platforms, visualized audio-visual resources, and creative digital interaction tools is expected to deepen the content of educational courses, creating an open and flexible learning environment.

Peculiarities of the digital educational environment functioning for music teacher training

The flexibility of the digital educational environment is ensured by the ability to adapt the content of educational courses to the specifics of the curricula of pedagogical universities and the individual educational trajectories of higher education students. In particular, the platforms allow to vary the volume and complexity of the educational material, integrate additional modules related, for example, to the methodology of integrated art education in general secondary education institutions, or specialized topics related to the teaching of choral singing, instrument playing, or solo singing (Avila-Garzon & Bacca-Acosta, 2025). The scalability of digital solutions makes it possible to provide simultaneous training for many students and teachers and maintain a single quality standard of professional training regardless of the location of the participants in the educational process (Table 2).

Table 2. Overview of digital educational platforms for music teacher training

Name of the digital platform	**Brief description of the platform**	**Advantages of the platform**	**Disadvantages of the platform**
Moodle	Moodle is a free and open-source platform for organizing the educational process, which is used in higher education institutions in Ukraine to create an interactive learning environment. It supports a wide range of course development tools, including interactive assignments and tests, and is translated into numerous languages, including Ukrainian	Availability of both desktop and mobile versions (iOS, Android). Extensive customization and integration with additional modules. An active community of users who share their experience of using the platform.	Lack of support via e-mail. Limited gamification opportunities. Complexity and time-consuming setup for beginners.
Blackboard	Blackboard is a learning management system that provides an adaptive learning environment suitable for music teacher education. The platform offers tools for creating interactive and social learning courses that promote student engagement in the learning process	Availability of a mobile application (iOS, Android). Ability to categorize users by various parameters. Integration with video conferencing tools and social networks.	Limited reporting capabilities. Minimum support emification. Lack of data security features.

Coursera	Coursera is a global education platform that partners with leading universities and organizations to offer high-quality online courses for teacher education. It allows students to receive certificates for specialized programs, including music pedagogy, which can be adapted to Ukrainian educational standards.	A wide range of courses and training programs. Opportunity to obtain certificates and degrees from recognized institutions. High-quality tools and interaction with teachers.	Access is limited to those who are not employees of partner organizations. Less flexible tools for creating courses compared to other platforms.
Udemy	Udemy is one of the most popular online course platforms with millions of users and thousands of teachers. It supports the creation of music courses that are accessible to beginning teachers and offers a variety of learning material formats	A large number of training materials (PDF, PowerPoint, videos, text files). Easy to use without the need for deep technical knowledge. Availability of a mobile application (iOS, Android).	Limited interaction between students and teachers. High competition between course authors. Lack of control over branding and course data.
EdX.org and Open-edX	EdX.org and Open-edX are platforms created to provide quality university-level education and used in Ukraine to train music teachers.	Free access and open source. Interactive lessons that promote student engagement. Mobile application for iOS and Android.	Discussion forums look outdated and difficult to navigate. The need for technical knowledge for full use.
Docebo	Docebo is a modern platform that uses artificial intelligence algorithms to personalize learning. It supports the training of music teachers through interactive courses in Ukrainian and offers tools for creating interactive learning materials	Meets the needs of educational institutions. Supports gamification and social learning. Integration with video conferencing tools. Issuance of certificates upon completion of the courses.	Limited options for creating detailed reports. Limited functionality for specific educational tasks.

Particular attention is paid to digital platforms that are focused on supporting the methodological training of future music teachers, including: forums for professional communication, blogs for recording pedagogical reflections, e-mail for counseling, chats for synchronous discussion of pedagogical practice at school, and wikis for the collective development of methodological projects (Makedon et al., 2025). These tools will facilitate not only the exchange of experience between students and teachers, but also the development of skills in the independent design of the learning environment, planning and implementation of an interactive art lesson.

Tools for planning and organizing study time, such as calendars, progress indicators, and synchronization with external resources, allow for high-quality management of the learning activities of students who master the methodological and performance components of the profession of music teacher. At the same time, motivational support tools, such as online profiles, self-assessment modules, and online assignment checking systems, help to engage students in active professional activities and form an attitude of pedagogical reflection and self-analysis.

Digital tools designed to create, publish, and administer educational content provide effective planning of pedagogical activities, drawing up individual curricula, testing the level of knowledge in music-theoretical disciplines, assessing conducting and instrumental skills, as well as monitoring the acquisition of methodological knowledge and skills that are directly applicable in pedagogical practice in general secondary education institutions (Dilekçi & Karatay, 2023).

Despite the obvious advantages of using digital platforms, it is also worth considering the challenges associated with their implementation. In particular, the barriers include the lack of readiness of individual teachers to organize learning in a digital environment, which requires systematic training of teaching staff in digital pedagogy. Another problem is the digital divide, i.e., teacher education students' unequal access to digital resources. In addition, the preparation of full-fledged educational content for digital platforms requires significant time resources from teachers and the possession of skills in structural thinking, editorial work, and multimedia tools (Xu, 2022). In such a scenario, it is desirable to introduce pedagogical models of mentoring and mutual support among teachers, which will allow for the effective implementation of digital transformation tasks in the artistic field of education.

At the same time, digital platforms allow achieving a number of strategic goals of professional training of music teachers, in particular: providing open access to educational material; forming an individualized educational trajectory; creating an interactive environment for the implementation of music-theoretical, performance and methodological tasks; providing constant pedagogical support for students; stimulating the reflective and creative activity of future teachers; developing self-learning and self-organization skills, which is a key.

Specialized software for training music teachers

Digital training of music teachers in the context of using professionally oriented software is carried out in stages, following the technological logic of creating resources that allow not only the development of the ability to analyze musical material, but also

to form practical skills in working with digital music notation tools and audio processing. The initial stage involves determining the content of the educational course, selecting pedagogical materials that correspond to the curricula for music training in the secondary education system, and formulating the goals of digital development focused on the professional development of the future teacher.

The next step is to develop the structure of the digital resource, which includes explanatory materials, methodological instructions, and multimedia components, distributed according to the logic of professional training. The upcoming task here is to select meaningful musical fragments that are of educational and practical value for the development of interpretation skills, rhythmic analysis, intonation accuracy, and timbre differentiation. Particular attention is paid to the use of pedagogically relevant sources: classical and modern educational publications in music-theoretical disciplines. In the technical part of teacher training, the key tool is specialized music notation software, in particular the Sibelius program, which is widely used in professional music pedagogy. With the help of this software, future music teachers will be able to master the professional skills of creating digital scores, editing music notation, exporting material in PDF and MP3 formats, and changing instrumental sound to achieve timbral variability (Pattananon et al., 2024). These actions will allow the development of basic technical skills and a deeper understanding of the sound palette, which will become a valuable and important element of music didactics (Figure 1).

At the next stage of digital learning, teachers master the processes of processing audio content, including changing instruments within a digital editor to create different versions of the same musical material. Pedagogical simulators that integrate interactive tools for developing professionally important musical skills into the learning process, allowing not only to develop aural skills but also to deepen understanding of the theoretical foundations of musical literacy. Dedicated digital resources provide an opportunity to choose a variety of learning modes, including the development of harmonic thinking, interval exercises, determination of note-sound correspondences, as well as tasks focused on recognizing and fixing notes based on auditory analysis (Huang & Xu, 2024).

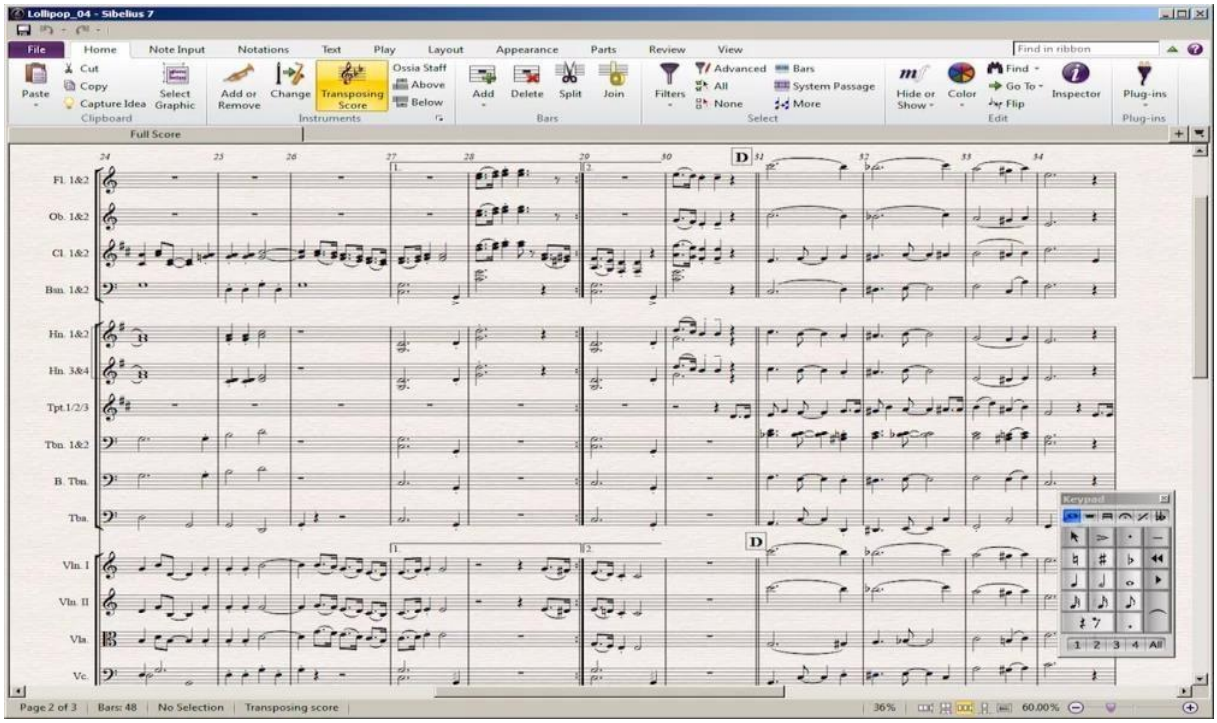

Figure 1. The Sibelius music notation editor

Thanks to these digital tools, teacher education students can purposefully improve both melodic and harmonic hearing, develop a sense of metronomy, master the specifics of harmonic thinking, and consolidate knowledge of musical notation within the violin and bass keys. The process of interacting with the simulator is designed in such a way that visualization of the musical material is combined with tasks to find the appropriate sound equivalents, which activate thinking, visual memory, auditory discrimination, and motor coordination (Figure 2).

The pedagogical value of such digital tools lies in their ability to provide an individualized educational trajectory in which the student independently determines the pace and level of complexity of tasks, gradually forming the systemic skills necessary for quality music teaching in a modern school. In particular, while working with the virtual keyboard, the student learns to navigate the note space, determine the pitch of the notes, and consolidate knowledge through practical interaction, which is an extremely important component of the professional training of a music teacher (Figure 2) (Frytsiuk et al., 2025).

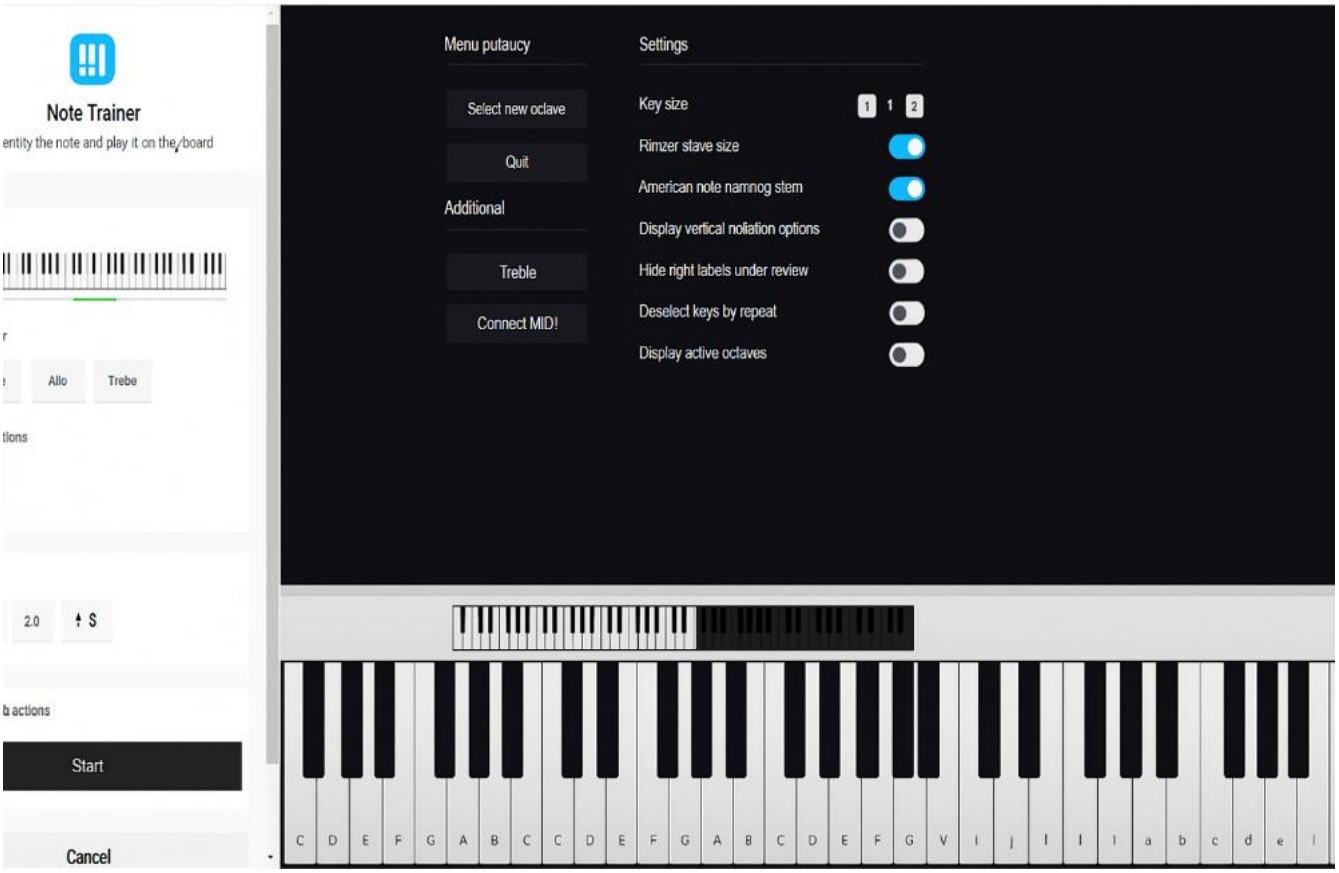

Figure 2. Note simulator (Nearpod software environment)
Source: (Yang, 2024)

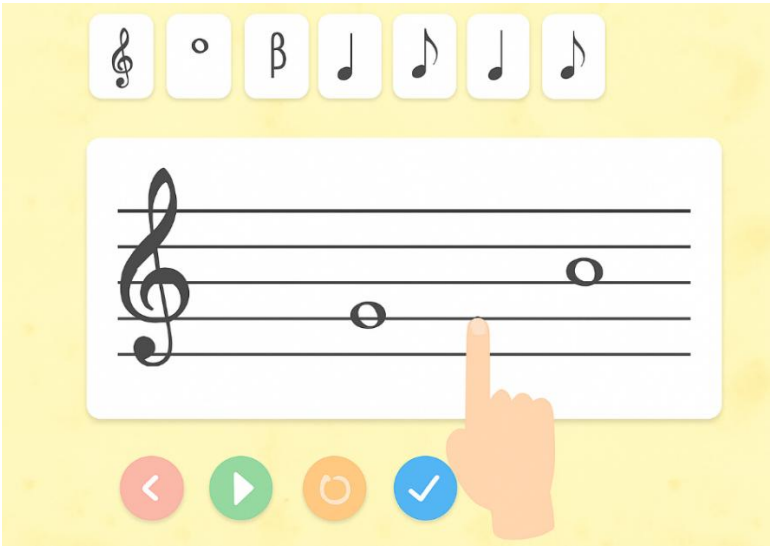

Figure 3. Perfect Ear test simulator for creating a digital score in the process of training music teachers

The development of the learning resource is accompanied by the design of a naming and cataloging system for the created audio and music files that reflect their

structural and didactic function. Each fragment is detailed by the parameters of tone, timbre, and duration, allowing for easy access to materials and contributing to the learning process's efficiency (Figure 3).

In order to provide methodological support for future teachers, explanatory notes are created that contain the goals and objectives of the course, a list of topics, their compliance with current educational standards, as well as methodological recommendations aimed at forming algorithms for pedagogical work with digital music content. These guidelines focus on the preparatory stages of working with an audio file, developing timbre perception skills, determining the rhythmic and metrical structure, and the sequence of conductor gestures in educational modeling. At the final stage of introducing digital tools into teacher training, the created resources are tested in the pedagogical educational environment - in the context of classes, workshops, or methodological training. Based on the results of the testing, the effectiveness of the use of digital tools is analyzed, strengths and weaknesses are identified, and the content, timbre, pacing, and structure of the digital product are improved.

Ensuring the implementation of methods for training future music teachers to use artificial intelligence technologies

Pedagogical support for the process of forming the readiness of music teachers to effectively use digital tools in their professional activities should include a holistic educational and methodological system implemented through multi-level laboratory and practical classes aimed at developing applied skills of pedagogical work with elements of modern digital technologies. Each of these classes is structured into several sequential blocks that allow the gradual mastering of new content and the development of creative, analytical, and reflective thinking in the context of learning (Chaka, 2023).

The first block, which is introductory in nature, provides theoretical information about current approaches to the use of digital technologies, including familiarization with tools for modeling pedagogical processes, libraries, services, and educational platforms that can be adapted to teaching music in general secondary education. The second block, the training block, will involve the completion of structured instructional and methodological tasks accompanied by explanations, graphic illustrations, and examples of the use of digital solutions in music teaching. The tasks cover both the reproductive level, which involves reproducing and consolidating skills, and the productive level, which is focused on creative rethinking of the material, independent search for new solutions, and adaptation to various learning situations (Vindaca et al., 2024).

As part of their independent work, future teachers create pedagogical interaction models using digital platforms. Reproductive tasks involve the application of approaches learned in the course of study to typical situations without the need for additional sources or materials. Instead, productive tasks require active use of the acquired knowledge in new conditions, integration of additional information, creative analysis, and generation of alternative ways to solve a pedagogical problem. In particular, future teachers are encouraged to modify the interface of learning platforms, adapt them to different operating environments, experiment with tools for visualizing music data, and develop alternative means of interacting with students in the digital space (Ma & Wang, 2025).

For example, the training block deals with the creation of models for deep analysis of musical patterns using specialized libraries that allow training algorithms for recognizing musical fragments. As a demonstration task, the formation of a learning structure capable of performing binary classification, for example, determining the dominant part in a rhythmic key or predicting the outcome of a musical game that models creative improvisation, is envisaged (Figure 4).

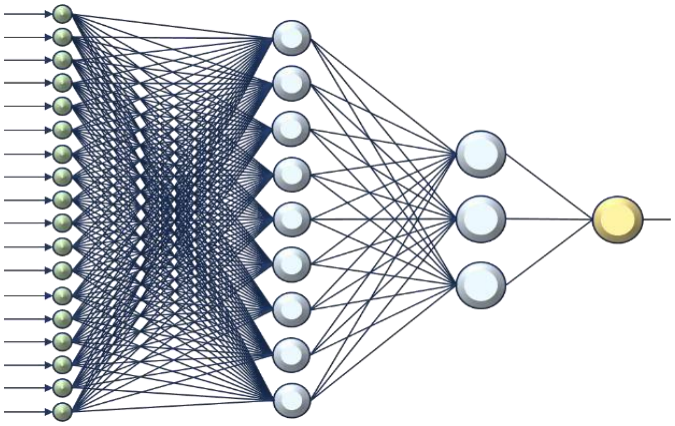

Figure 4. Schematic representation of a neural network model for the development of music analysis skills in the process of pedagogical training

Additionally, the task of approximating the functions related to the dynamics of performance is realized by building digital models of musical functions (Figure 5) using algorithms for pre-processing training parameters.

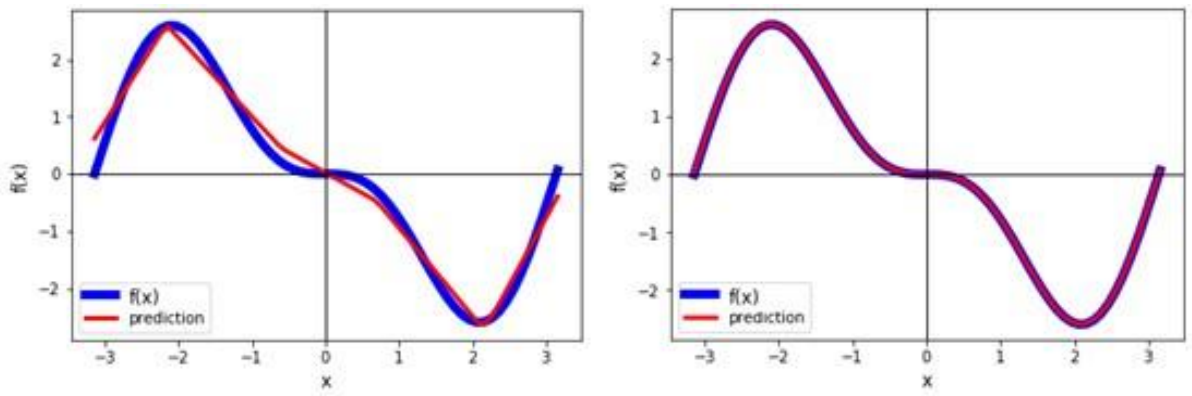

Figure 5. Visualization of the process of interpreting musical parameters by means of neural network approximation with different levels of accuracy

As part of their independent work, future teachers perform tasks involving the creation of models for classifying sound fragments according to various parameters, such as timbre, pitch, duration, rhythm, and approximation of the artistic elements of a musical work using digital interpreters that allow for a series of pedagogical experiments with the model parameters.

A separate area of study is the development of skills in working with visual digital resources used in the context of music education. In particular, it is about teaching the use of optical text recognition technologies on sheet music or materials. For example, authors consider developing a program that allows the transformation of sheet music images using noise filtering and pre-processing of visual content (Figure 6).

In the course of the training, teachers master the tools for adding artificial noise, test the effectiveness of their removal, and compare the quality of the results using different filters. In independent tasks, students must demonstrate the ability to select examples of images with musical texts of varying complexity, analyze the effectiveness of filtering solutions, work with fragments containing artificially added noise elements, and reasonably explain the choice of the optimal approach to processing such materials (Merchán Sánchez-Jara et al., 2024).

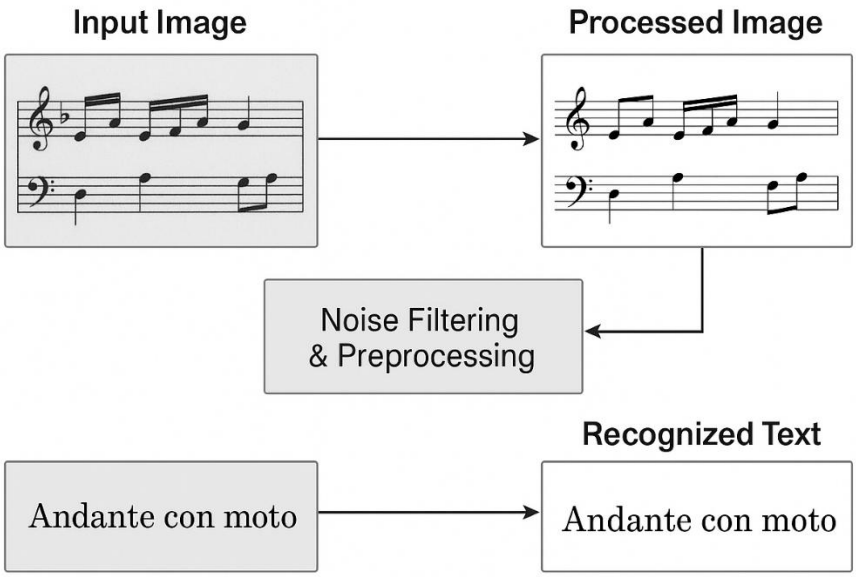

Figure 6. Using artificial intelligence to recreate a note image using noise filtering

As a result, the educational and methodological support for preparing music teachers to use digital technologies should be aimed not only at mastering individual instruments but primarily at forming systematic pedagogical thinking, readiness for experimentation, and flexible use of digital tools to support and develop music education in the general education space.

Formation of arrangement and sound competencies in the training and education of music teachers

When mastering the methodology of creating accompaniment parts, the future teacher gains experience in working with a digital sound environment, which allows them to realize their own arrangements in accordance with the didactic objectives of the music lesson. In the educational process, it is advisable to use specialized musical environments for this purpose, which provide work with audio materials and polyphonic textures, allowing editing, recording, and modeling of the sound space. In this way, a future music teacher learns the basics of building textural sound, selecting instrumental groups, timbre combinations, and textural solutions necessary to create a complete soundtrack.

In practice, this activity involves consistent modeling of sound: from the selection of instruments (flute, clarinet, harp, piano, string quartet, drums) to the creation of melodic lines in accordance with the principles of artistic appropriateness and pedagogical relevance. Teachers master the skills of working with timbre modules that imitate the sound of orchestral groups and the logic of building harmonious

accompaniment in a vocal and instrumental ensemble adapted to the learning environment (Figure 7).

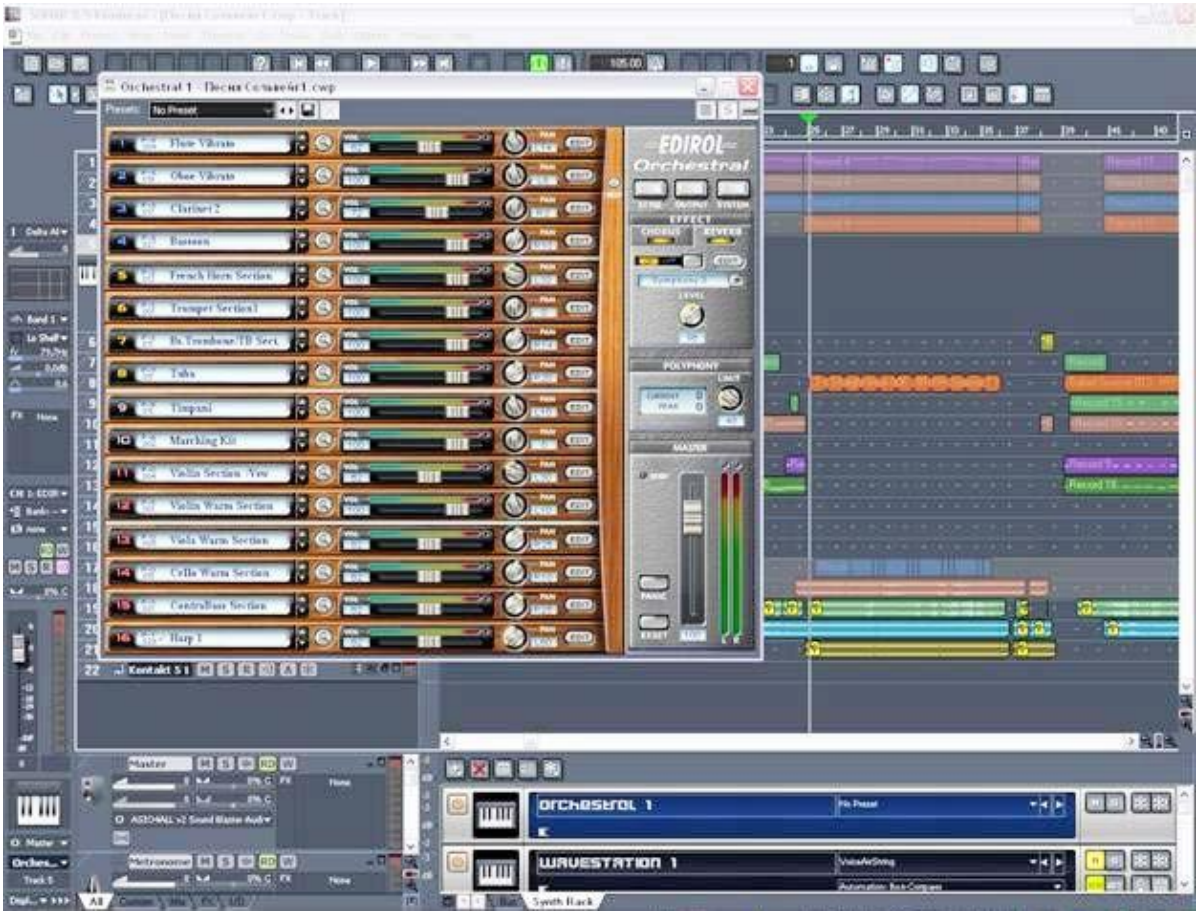

Figure 7. Roland HQ Orchestral Digital Synthesizer's teaching interface for creating a musical sequence

Source: (Rexhepi et al., 2024)

When preparing phonograms for pedagogical purposes, students learn to work with a multichannel environment that allows them to simultaneously form several musical parts, edit rhythmic structures, transpose and change pitches, and adjust tempo and metrical characteristics according to the artistic logic of the work. Such experience is indispensable for future teaching in a school setting, where it is often necessary to adapt the material to the vocal and technical level of a student group or solo performer (Koval et al., 2024).

In addition, future teachers master the techniques of multi-track recording of vocal parts, which is necessary for preparing phonograms for vocal ensembles, choral numbers or solo performances. In this context, it is important to master the practice of multilayer editing, mixing, sound equalization, and the use of effects that allow to

achieve clear sound, balance, and acoustic fullness of the musical material. At the final stage, students master the process of mixing and final processing of audio material, which involves professional dynamics equalization, frequency response adjustment, volume standardization, and preparation of a finished audio recording for use in the educational process (Figure 8).

Figure 8. Learning software environment for the final creation of an audio file (piece of music)
Source: (Rexhepi et al., 2024)

Professional practice also prepares future teachers to create musical content for school events, lessons, vocal and dance performances. In this way, digital technologies in the training of music teachers perform not only an instrumental but also a pedagogical function, forming the readiness to work with students, create high-quality accompaniment, arrangements and soundtracks in accordance with the needs of the educational environment of a general secondary school. Such processes create the integration of technological culture into the teacher's professional thinking, increase their methodological mobility and expand the boundaries of creative self-realization within the educational process.

Discussions

The study highlighted the fact that digital technologies do not replace but complement classical methods of training music teachers, which is fully consistent with the results of research by Burke et al. (2023) and Yuldashev et al. (2022). These scientists argue that digital learning platforms are tools for expanding the educational environment, not for its complete instrumental replacement. The study documented the effective use of digital tools in the formation of competencies such as music-theoretical base, instrumental training, and methodological practice for future music teachers. These positions also resonate with the views of Samus (2024), who emphasizes the advantages of hybrid forms of education in the field of art education. However, as Boton (2024) and Xu (2024) show, there are psychological limitations in digital learning, in particular, the weakening of personal contact between student and teacher, which is particularly important for music education. In this aspect, the scientific results obtained can be viewed as partially controversial because, despite the difficulties identified, authors see the potential to overcome these barriers through the active implementation of interactive technologies. The novelty of our research approach lies in the perception of digitalization not as a separate technical innovation, but as a systemic transformation of the entire structure of teacher education. The authors proposed methodological constructs combining theory, performance, composition, and methodology into a single digital ecosystem. In contrast to Cuervo et al. (2023), who emphasize autonomy in the online environment, the authors emphasize the importance of combining independent work with pedagogical support, mentoring, and live interaction through digital channels of educational communications.

Another distinctive feature of our study is the in-depth comparative analysis of the functionality of such platforms as Moodle, Blackboard, Coursera, EdX, and Docebo in terms of their suitability for the specific tasks of music education. While a number of separate studies by Bui (2025) and Hörmann et al. (2024) focus on general educational aspects, the authors consider their role in shaping the professional skills of future music educators. Authors also address the problem of the mismatch between employers' expectations and the level of digital skills in teaching and professional development for music teachers. As noted by Taheri and Pennington (2024), modern educational standards often do not take into account the specifics of digital competencies. Our study confirms this state of affairs and offers specific recommendations: the development of clear guidelines for the formation of digital skills in each area of training, from music notation to DAW, digital conducting analytics, interactive testing, etc.

An obvious contribution to the scientific discourse was the substantiation of the pedagogical possibilities of applying artificial intelligence in music pedagogy and education. In contrast to the general studies by Chaka (2023) and Vindaca et al. (2024), authors have proposed specific models for using machine learning algorithms to analyze rhythm, interpret dynamic structures of musical phrases, and automatically recognize music texts, which significantly elaborates on previous scientific positions. From a practical point of view, the results obtained can be used to develop new teacher training programs, adjust the curricula of pedagogical universities, and create specialized digital simulators for aural training, rhythmic coordination, and music literacy. The conclusion about transitioning from a reproductive to a productive learning model through digital technologies deserves special support. Future music teachers can create their own musical content: phonograms, scores, and interactive lessons. This confirms and at the same time expands the findings of Koval et al. (2024), which indicate that digital tools contribute to the development of creativity, critical thinking, and pedagogical reflection.

In conclusion, despite the numerous advantages of digital technologies, significant barriers require further research. Among them, authors have identified: the digital divide, the insufficient level of digital literacy of teachers, and the lack of systematized methodological resources for the effective implementation of digital learning in the field of art education.

Conclusions

The study of educational practices in the field of music teachers' training has proved that the use of interactive technologies significantly improves the quality of interaction between participants in the educational process and ensures an appropriate level of quality of learning, providing flexibility in planning and organizing the pedagogical environment. The use of digital tools for objectively assessing musical achievements due to the possibility of accurately recording the results of tasks is proposed. The necessity of adapting digital methods to the specific needs of the musical and pedagogical process, taking into account the instrumental, vocal, choral, and methodological components, is emphasized.

A study of modern educational platforms in the field of professional education has identified their advantages and limitations in the context of music teacher education. A study of the functionality of these systems has shown that elements such as online chats, virtual forums, electronic consultations, calendar plans, and performance analysis tools contribute to the organization of an effective educational process. It is noted that the integration of time and task management tools helps not

only to optimize learning but also to develop independence in learning. At the same time, the effectiveness of digital learning depends not only on technical equipment but also on the quality of pedagogical support, mentoring, and the availability of well-structured learning material.

A study of specialized software for music education has shown its role in the gradual development of technical, theoretical, and performance skills. Programs designed to create music scores, analyze sound material, train auditory memory, and improve intonation demonstrate high pedagogical potential. Their pedagogical value is based on their ability to provide individualized learning, regulate the level of complexity of tasks, and create multimedia conditions for the development of rhythm and hearing. It has been established that in order to maximize the effect of using such software, it is important to provide courses with detailed explanatory materials, clear instructions, and a convenient navigation system.

To form the professional readiness of future music teachers to work with artificial intelligence tools, it is proposed that a comprehensive educational and methodological system be created. The study confirmed the effectiveness of a multi-level approach, which involves the sequential mastery of introductory material, practical modules, and tasks for modeling pedagogical situations in the digital space. The use of machine learning algorithms for analyzing rhythmic structures, classifying musical fragments, and processing music notation proved to be particularly useful, as it actively promotes the development of analytical and creative thinking. The substantiation of the effect of the processes of forming arrangement and sound skills revealed that the main component of the final results of pedagogical training is the active involvement of students in working with digital sound environments aimed at creating full-fledged musical educational materials.

Funding

This research received no external funding.

Conflicts of Interests

The authors declare no conflict of interest.

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