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Musicianship in the digital world: Interdisciplinary approach to bachelor's education

A musicalidade no mundo digital: Abordagem interdisciplinar ao ensino de licenciatura

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Abstract: The purpose of this study was to investigate the effects of computer technology on learning in music education and the integration of digital tools to develop student's creativity, technical skills, and teamwork. The study involved an online survey of art students from Khmelnytskyi Humanitarian-Pedagogical Academy and Kyiv National University of Culture and Arts, which helped to collect quantitative data on their experience with digital audio workstations and music programmes. Quantitative and qualitative

analyses were employed to process the data. Statistical analysis of the surveys revealed general trends, while qualitative interpretation of the observations and projects revealed the specifics of using technology in teaching. 75% of participants reported significant improvements in composition and arrangement skills due to the use of digital audio workstations, and 80% noted positive changes in teamwork thanks to online platforms. The study also found that 55% of participants believed the integration of technology had enabled them to experiment with new musical genres, and 75% reported that learning had become more interactive and engaging due to digital tools. This highlighted the importance of developing interdisciplinary skills that integrate music education with information technology. The study has practical implications for teachers, as it emphasised the significance of adapting teaching strategies to the modern requirements of the music industry and developing new pedagogical approaches. The findings of this study can serve as a basis for improving curricula in music education and training professionals who can effectively use digital technologies in their work.

Keywords: information technology, learning strategy, online platform, interactive lessons, creativity.

Resumo: O objetivo deste estudo foi investigar os efeitos da tecnologia computacional na aprendizagem da educação musical e a integração de ferramentas digitais para desenvolver a criatividade, as competências técnicas e o trabalho em equipa dos alunos. O estudo envolveu um inquérito online a estudantes de arte da Academia Humanitária-Pedagógica Khmelnytskyi e da Universidade Nacional de Cultura e Artes de Kiev, que ajudou a recolher dados quantitativos sobre as suas experiências com estações de trabalho de áudio digital e programas musicais. Foram empregues análises quantitativas e qualitativas para o processamento dos dados: a análise estatística dos inquéritos revelou tendências gerais, e a interpretação qualitativa das observações e dos projetos revelou as especificidades da utilização da tecnologia no ensino. 75% dos

participantes relataram grandes melhorias nas competências de composição e arranjo devido à utilização de estações de trabalho de áudio digital, e 80% notaram mudanças positivas no trabalho em equipa graças às plataformas online. O estudo descobriu ainda que 55% dos participantes sentiram que a integração da tecnologia lhes deu a oportunidade de experimentar novos géneros musicais, e 75% disseram que a aprendizagem se tornou mais interativa e envolvente graças às ferramentas digitais. Isto realçou a importância de desenvolver competências interdisciplinares que combinem a educação musical com a informática. O estudo tem implicações práticas para os professores, uma vez que enfatizou a importância de adaptar as estratégias de ensino às exigências modernas da indústria musical e de desenvolver novas abordagens pedagógicas.

Palavras-chave: informática, estratégia de aprendizagem, plataforma online, aulas interativas, criatividade.

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1. Introduction

The relevance of this study was influenced by the rapid development of digital technologies, which have significantly impacted all aspects of music education and the professional training of music specialists. In the modern world, musicianship is not limited to conventional performance skills or music theory but requires the ability to adapt to the latest technological conditions. This includes knowledge of software for creating and editing music, skills in working with electronic instruments, as well as the ability to analyse and interpret musical data. The study focused on the need to integrate computer technology into the educational process of music education institutions, thereby preparing future professionals for the challenges posed by the music industry.

Kukulska-Hulme et al. (2024) analysed innovative approaches to pedagogy, including the use of mobile and digital technologies to support the latest forms of teaching and learning. Particular attention was paid to personalised learning, which enables students to take a more active role in the process and access learning resources at any time and from anywhere. The researchers also examined alternative assessment approaches, including self-assessment and peer assessment. Gosavi and Deore (2023) investigated innovative technologies in education, including distance learning and adaptive educational systems. In their study, the researchers conducted a detailed analysis of the effectiveness of the latest teaching methods, integrating distance learning technologies and intelligent engineering systems. The use of such technologies can substantially improve the accessibility and quality of the educational process, as they enable teachers to adapt courses to meet the individual needs and learning styles of students (MARTYNIUK, 2022).

Bates (2019) emphasised the significance of adapting curricula to new conditions to ensure quality and affordable education. The researchers noted the need to revise conventional approaches to learning, highlighting that accounting for technological changes

and learning needs is crucial to creating effective learning environments. Bates emphasised the integration of pedagogical theories with the latest technologies, which not only improves the quality of learning but also gives more opportunities to students with unique needs. Liu (2022) presented a model of interactive music learning that used the Radial Basis Function (RBF) algorithm to adapt learning material to individual student needs. Liu's research demonstrated how algorithmic approaches could be used to create personalised learning experiences that increase the efficiency of knowledge acquisition. The model made provision for the dynamic adaptation of course content in real-time, enabling students to receive individualised recommendations based on their progress and performance, which considerably increased the level of engagement and motivation to learn.

Other researchers also developed innovative approaches to teaching music theory and pedagogy. Fang and Luen (2024) found that the introduction of innovative teaching methods, including interactive strategies, gamification, project-based learning, technology, and collaborative learning, significantly increased student motivation in music education. The researchers noted that interactive strategies that engage students in active learning contributed to the development of critical thinking and creative skills. Váradi et al. (2020) analysed the effects of the COVID-19 pandemic on teaching methods, focusing on the challenges and opportunities that have arisen from the transition to distance learning. They pointed out the difficulties faced by both teachers and students, including limited access to technology, a lack of proper skills in using online platforms, and generally low motivation to learn in an unfamiliar environment. Numerous studies by leading researchers emphasised the significance of an interdisciplinary approach that combines classical artistic disciplines with modern digital tools. Khamdamova (2022) examined the characteristics of learning activities in educational institutions, with a focus on various teaching methods. The researcher proposed an analysis of the effectiveness of these methods in the musical context.

Khamdamova suggested analysing the effectiveness of these methods by assessing their effects on the quality of learning and student motivation.

Lorenzo de Reizabal (2022) proposed the model of musical mediation for social engagement in learning based on the use of music as a tool for creating social relationships between students and promoting their active engagement in the learning process. The researcher emphasised that music can act as a mediator between diverse social groups, facilitating communication and promoting mutual understanding. The study also emphasised that the integration of music into the social context contributes to the development of emotional intelligence, increases motivation to learn, and creates a favorable atmosphere for collective cooperation. Thus, music mediation becomes a powerful tool for building social cohesion and inclusiveness in the educational environment. Sengupta and Blessinger (2022) reviewed innovative approaches to pedagogy for higher education, focusing on the need for transformational changes in educational methods. They examined modern pedagogical strategies that promote active student engagement, the use of technology to create an interactive learning environment, and the development of critical thinking. The analysis of the conducted study highlighted the understudied issue of teaching music majors using digital instruments.

The purpose of the present study was to analyze modern approaches to the training of a Bachelor of Music in the context of digitalization. The objectives of the study were to investigate the integration of digital instruments in the teaching of music disciplines, specifically for creating, performing, and analysing music to determine their effects on the learning process; to investigate the role of an interdisciplinary approach that combines conventional music education with digital technologies to improve the quality of professional training of future music professionals. Furthermore, a significant task was to survey art students of the Khmelnytskyi Humanitarian-Pedagogical Academy and Kyiv National University of Culture and Arts to examine their experience and attitudes towards the use of digital tools in the learning process.

2. Literature review

Zamorano-Valenzuela and Serrano (2022) investigated innovative approaches to music teacher education in Spain, with a focus on secondary education. The study examined existing teacher training methods, their shortcomings, and opportunities for innovation. The researchers provided examples of successful practices that demonstrate how innovative approaches can improve the quality of learning and increase students' interest in music. The study also contained recommendations for the introduction of interactive teaching methods that encourage students to take an active part in the learning process, including the use of modern technologies and approaches to group collaboration. Overall, the study highlighted the significance of innovations in music teacher training and their effects on the development of quality music education in Spain.

Maharaj and Gill (2023) studied the influence of technology on music education in Trinidad and Tobago. The researchers found that integrating modern technology into the learning process not only increases student motivation but also expands access to resources. However, the researchers also pointed out some challenges faced by teachers, such as a lack of training in the use of the latest technologies. Petrie (2021) investigated the impact of integrating music and programming on the development of critical thinking and creative skills. The researcher gave examples of the use of Sonic Pi, a music programming platform that enabled students to create music by writing code. De Reizábal and Gómez (2022) analysed the role of introducing modern technologies into teaching practices, which can significantly improve the quality of education in the arts, including music. Rexhepi et al. (2024) analysed the methods of integrating digital technologies into the music teaching process. The researcher noted that the use of technology can positively impact student engagement and learning, and the study reviewed various examples of successful practices.

Lyu and Sokolova (2022) focused on the positive effects of digital technologies on the learning of primary school students. The researchers found that interactive approaches, such as the use of curricula and applications, increase students' interest and improve their performance in music. Gouzoasis and Bakan (2011) explored how digital transformation is changing the processes of music learning and creation. The researchers offered recommendations for educators on how to adapt educational programs to new realities, ensuring that learning remains relevant and practical.

Christophersen (2021) highlighted the need to introduce innovative methods that factor in the changes in the cultural and technological environment. The researcher acknowledged that conventional teaching methods no longer adequately addressed modern challenges and needed to be substantially updated. According to Christophersen, it was the integration of the latest approaches and tools that could help improve the quality of music education and better prepare future teachers. Biesta (2017) questioned the effectiveness of conventional approaches to teacher education, especially in the context of rapid change. The researcher emphasized that pedagogical activity should be based on wisdom, flexibility, and the ability to adapt to new realities, which requires a rethinking of the goals and objectives of education. Biesta also emphasised the role of reorienting pedagogical practice to meet the current challenges and needs of society. Ma (2022) examined innovative models of integrating information technology into music education. The researcher focused on how these models can positively influence student engagement and learning, offering practical recommendations for teachers. Asare et al. (2023) studied the preparation of music educators for teaching using information and communication technologies. The researchers discussed the significance of technology in improving the learning process, particularly in the context of distance learning.

Yanan (2024) analyzed the role of digital audio workstations (DAWs) in the development of students' creative thinking and confidence. It was noted that the practical application of these

technologies in the educational process is necessary for training modern musicians. Li (2023) emphasised the need to reform music education at universities. The researcher stresses the importance of integrating modern technologies into the curriculum to ensure high-quality training. Liu-Rosenbaum and Creech (2021) examined the effects of technology on collaborative learning in music education. The researchers emphasized that technology can significantly facilitate the interaction between students and teachers, creating more opportunities for collaboration. The researchers noted that the integration of modern digital tools facilitated more active student engagement in the learning process, as well as enhanced communication and cooperation in music projects. They noted that technology enabled the creation of conditions for more effective development of both individual and collective musical skills.

Regelski and Gates (2009) discussed the adaptation of music education to modern challenges. The study focused on innovative teaching methods that can change the learning process and make it more relevant. Dyndahl and Nielsen (2021) considered the challenges of music education in the context of cultural diversity and social polarisation. The researchers emphasised the role of inclusivity in education, which allows accommodating the needs of all students, regardless of their cultural and social background. They also noted that conventional teaching methods have not always been effective in the context of diverse learners. The study emphasised the need to adapt curricula to meet the demands of modern learners. Finally, the researchers emphasised the value of introducing a variety of methodologies that would support inclusivity in music education. Maharaj and Gill (2023) considered the effects of modern technology on music education. According to the researchers, technology has not only improved teaching methods but also contributed to increasing student engagement and developing their creative skills.

3. Materials and Methods

An online survey was conducted among 100 art students from Khmelnytskyi Humanitarian-Pedagogical Academy and Kyiv National University of Culture and Arts to collect data on their experiences with learning and using modern technologies in music education. Participants were given access to the survey via the online platform Google Forms, which facilitated the collection of their opinions and feedback in a convenient format. As a result, the data obtained enabled an analysis of the effectiveness of introducing innovative teaching methods and helped identify the needs of students in using technology in the learning process. The survey included structured questions about their experience of using DAWs, music software, and online platforms for creating and performing music.

Within the framework of the survey, a questionnaire was developed (Appendix A), which enabled students to share their experience of using DAWs. The survey covered 100 bachelor's students who were in their 3rd year of study. The participant selection for the study employed a purposive sampling method, focusing on students who were most likely to provide pertinent and knowledgeable responses regarding the integration of digital technology in music instruction. The participants were selected due to their consistent use of digital audio workstations and music software, thereby representing the broader demographic of students undergoing digitization in music education. Participants were solicited for the study via institutional email lists and course advertisements, guaranteeing voluntary participation and informed consent. The collected data was systematised, analysed, and statistically processed, which helped to identify general trends in the responses. Observations were conducted where students worked with digital tools, recording the specific features of their interaction, as well as the effectiveness of using technology in learning. It helped to identify how students integrate computer technology into their practice, as well as what teaching methods

promote their activity and interest. The observation included recording students' behavior during work, their interaction with teachers and fellow students, as well as the processes involved in completing tasks. This method provided insight into students' real-life experiences with technology and their attitudes toward learning.

This study employed theme analysis, a versatile and often utilised approach, to qualitatively interpret observations and student projects by discovering, evaluating, and reporting patterns within the qualitative data. Thematic analysis was selected for its ability to identify both overt and covert content in students' engagement with digital technology, creative processes, and educational experiences. Thematic analysis was performed in five stages. Initially, researchers examined observational notes and student projects to familiarise themselves with the data. Secondly, open coding was employed to discern reoccurring themes associated with digital tool utilisation, cooperation, and innovation. Third, associated codes were aggregated into overarching themes such as "creative autonomy" and "collaborative learning." Themes were improved by cross-referencing with the complete data set and engaging in peer conversations. Reliability was ultimately established by triangulation using survey data, inter-coder agreement, and the documenting of coding decisions.

Within the framework of this study, a variety of projects created by students in the context of music education, specifically in the areas of composition, arrangement, and performance, were carefully studied. Attention was focused on the digital tools and technologies used, such as music production and audio editing software Ableton Live, GarageBand, and FL Studio, as well as online collaboration platforms: Yousician, Melodics, Pure Data (Pd). The study analysed finished musical works created on platforms such as Soundtrap and BandLab, Logic Pro to assess the technical quality of performance, creativity, and use of diverse musical styles. This analysis provided insight into how students use technology to implement their creative ideas and what technical

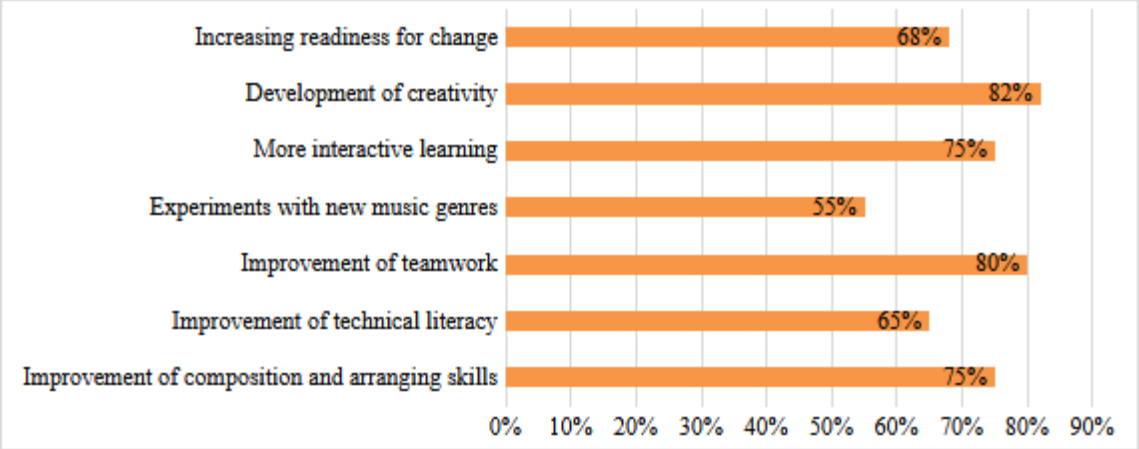
skills they develop in the process. The work with programming languages such as Max/MSP and Sonic Pi was also analysed. Students used Magenta Studio to generate music and analyse audio tracks automatically. Quantitative data from the survey was statistically analysed to identify general trends. Qualitative data from observations and project analysis were interpreted to gain a deeper understanding of the role of technology in learning. The findings helped to formulate recommendations for improving the curriculum.

4. Results

According to the survey, 75% of students reported that using a DAW considerably improved their composition and arranging skills. 65% of the participants reported that their technical literacy had improved due to the use of music software, and 80% reported that teamwork had improved due to the use of online platforms.

As the statistics in Figure 1 indicate, the use of digital tools substantially affected the development of students' skills. The study found that 55% of participants believed that integrating technology enabled them to experiment with the latest music genres. In comparison, 75% reported that learning became more interactive and engaging due to the use of digital tools. Notably, 82% of students confirmed that learning with technology has helped to develop their creativity, while 68% noted they were more prepared to work in a rapidly changing technological environment.

Figure 1 - Statistics on the influence of digital tools on students' skills



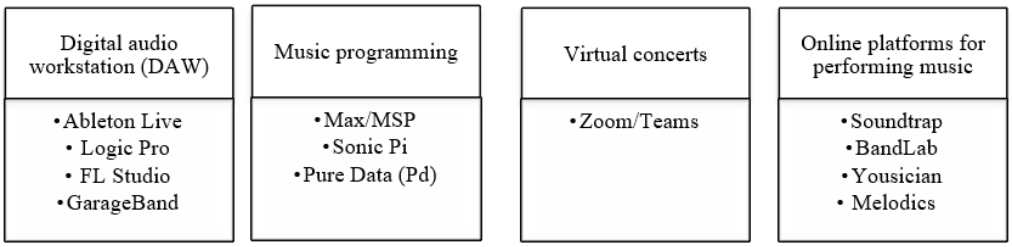
Source: compiled by the authors.

Another significant aspect was the expansion of music programming skills. Students who worked with platforms such as Ableton Live, Logic Pro, and FL Studio gained a deeper understanding of the music creation process through programming, which enhanced their ability to experiment with sound and improved their knowledge of musical composition and arrangement. Furthermore, the use of online platforms for performing and sharing music projects has increased the level of interactivity between students and teachers. The use of Internet platforms for executing and disseminating music projects has not only improved interaction but has also profoundly transformed conventional power relations in music education. Digital mediation decentralizes information dissemination by empowering students to take greater control over their learning processes by collaborating, creating, and sharing content independently (Iklassova et al., 2024). This transition reduces the conventional hierarchical framework in which the educator serves as the principal source of knowledge and authority. The instructor increasingly adopts the position of a facilitator or mentor, assisting pupils in utilising digital technologies, collecting materials, and fostering independent creative discovery. Platforms like Soundtrap and BandLab promote peer-to-peer learning and instantaneous feedback, enabling students to evaluate and provide feedback on one another's work autonomously, without teacher

oversight (Spytska, 2024a). This collaborative, co-creative setting promotes active learning and fosters a more equitable educational space in which students contribute to the information ecosystem, challenging traditional, teacher-centered paradigms.

Tools such as Soundtrap or BandLab enabled students to collaboratively create and edit music in real-time, which helped develop teamwork skills. The integration of digital tools into the learning process also contributed to a comprehensive approach to music education, combining theoretical and practical aspects with technical skills related to recording and sound processing (Novosiadla, 2023). This enabled students to gain a deeper understanding of the various aspects of music production. Figure 2 illustrates a variety of digital tools and platforms that support the development of musical skills and creativity.

Figure 2 - Tools and platforms for digital music production



Source: compiled by the authors.

Furthermore, the introduction of digital technologies in music education prepared students to work in the modern music industry, where the use of such tools is standard. They have become more adaptable and ready to work in a rapidly changing technological environment. Thus, the integration of computer technology into music education is an effective tool for developing new skills that are essential in the modern industry. It also promotes interdisciplinary integration by combining music education with digital technologies, thereby opening up more opportunities for students. The introduction of such methods enhances creativity, technical literacy, and collaboration, thereby preparing future professionals for the realities of the modern professional world.

The use of computer technology in music education has immense potential to enhance the learning process and promote interdisciplinary integration (Akhsutova et al., 2024). This is how digital audio workstations, music software, and online performance platforms can contribute to this process. DAWs such as Ableton Live, Logic Pro, or FL Studio provided students with endless opportunities for creative development and technical improvement. These programs enabled them to record, edit, and mix music with complete control over all aspects of the sound palette. For instance, students managed to record multiple instruments, such as guitar, keyboards, and vocals, simultaneously using separate audio tracks with multi-track recording.

Thanks to editing tools such as cropping, pitch correction, or noise removal, students improved their recordings and achieved a professional sound. Furthermore, DAWs enabled the use of a wide range of sound effects, which opened opportunities for creating unique sound textures. For instance, using an equaliser and compressor, the student leveled the sound of the vocals, and adding reverb or delay made them more voluminous and expressive. These tools enabled the students to experiment with sound and create different sound effects and approaches to arrangement. Thus, a student could easily make an electronic composition using synthesisers or add effects to create an ambient atmosphere. Thanks to the DAW, students also learned the basics of arrangement and composition. They arranged the parts of the track in the proper order, used repetition, and added transitions between verses and choruses. For instance, a student created a musical composition where the first verse was performed only with guitar accompaniment, and the chorus added drums and synthesisers to enhance the emotional impact.

One of the crucial aspects of working with DAW was the development of self-esteem skills. The students could listen to their recordings repeatedly, analyse their performance, and find mistakes. For example, after the first recording, the students noticed that the guitar was slightly ahead of the vocals or that the

transition between the two parts sounded abrupt. This not only helped correct technical errors but also developed critical thinking. This approach fostered responsibility for their learning process and autonomy as students identified what needed to be improved. Another advantage of the DAW was the ability to experiment with multiple musical genres. Students created compositions in the style of classical music, electronica, or even combined several genres. For instance, in FL Studio, a student made a hip-hop track using a drum machine to create a rhythm, added a bass line and synthesisers, and then experimented with sound textures to add depth and drive to the composition.

Finally, working with the DAW developed the technical skills required for modern music production. The students learned how to balance the volume of instruments on a mixer (mixing console), adjust the frequency spectrum, work with panning, and other technical aspects. For example, in Logic Pro, the student adjusted the compression level on the vocals to make them sound balanced concerning the instruments and used panning to place the guitars on different sides, creating a spatial effect. Music programming opened new horizons for students in making music (Aviv et al., 2024). For example, working with programming languages such as Max/MSP and Sonic Pi enabled students to learn the principles of sound synthesis and process automation in music production. This contributed to a deeper understanding of the physical foundations of sound and its digital processing, as well as developing logical thinking, which is essential for programming. Such knowledge and skills proved to be useful not only in the music field but also in other IT-related fields. For example, students have used their knowledge to create interactive multimedia projects that combine music, video, visual effects, and programming. This fostered interdisciplinary integration, combining music learning with other technical disciplines.

Examples of the use of music programming, such as Max/MSP and Sonic Pi, demonstrated how this approach can contribute to both the creative and technical development of students.

Students used Max/MSP to create interactive music systems (Andrievskyi et al., 2024). For instance, by using motion sensors connected to a computer, they made a system that generated sounds based on a person's movement. Such a project proved helpful in performing arts, where music and movement interacted in real-time. This system enabled students to program complex musical processes and explore the interaction between physical and digital environments. The Sonic Pi allows students to create music tracks using software code. For instance, they programmed drums, synthesisers, and basses, synchronising them to make an electronic track. A feature of Sonic Pi is the ability to execute code in real-time, which enables students to improvise, change the rhythm, or melody during performance. This approach was widely used in the genre of "live coding," where musicians created music on stage, demonstrating the programming process.

Max/MSP helped students to create their synthesisers or sound effects. For instance, they programmed sound synthesis through frequency modulation (FM synthesis) or synthesised sound waves of various shapes to produce unique timbres. One of the most popular projects was to create an instrument that changed the sound depending on time or using randomisation algorithms. This helped students learn about the physics of sound and gain control over sound parameters such as amplitude, frequency, and phase. In Sonic Pi, students programmed automation in compositions, such as gradual changes in tempo or dynamics throughout a track. They created musical phrases that automatically repeated themselves or programmed an algorithm to generate random melodies based on specified parameters. This particularly interested students in developing experimental compositions or generative music, where they could program musical changes that occurred without their direct intervention.

Music programming opened the possibility of creating projects that combine music, video, and visual effects (Tkachenko et al., 2024). For instance, students created a multimedia project where the sound was synchronised with the video, and the change of

colours on the screen affected the sound effects. Using Max/MSP, students created interactive visualisations that responded to sound or movement, making such projects ideal for performances or installations. Online platforms, such as Soundtrap or BandLab, provided students with the opportunity to work on collaborative music projects in real-time, even when they were in distinct geographical locations. This made the learning process more interactive and contributed to the development of teamwork skills. Students shared their ideas, edited their peers' work, and received instant feedback from teachers and peers. Furthermore, such platforms created opportunities for distance learning and performance, which became especially relevant in the context of global challenges such as the pandemic. Students performed their works on virtual stages, organised online concerts, and took part in international projects, which contributed to a global approach to music education.

Online platforms, such as Soundtrap and BandLab, enable students to work together on music projects regardless of their geographical location. For instance, they created tracks by adding various instruments, vocals, or effects, while other participants could edit or add new elements in real-time. In Soundtrap, they worked simultaneously on the same track, viewing their colleagues' changes instantly. This proved especially useful for remote projects, where participants could be in different cities or countries but still work together. BandLab also offered analogous opportunities by providing integrated tools for editing and mixing music. For instance, one student could produce a track, adding drums and bass lines, while another focused on vocals or melodic parts. The collaborative editing feature enabled tracking of each contribution and provided easy access to feedback from teachers or other students.

Furthermore, both platforms opened opportunities for distance learning. Students attended virtual classrooms, recorded their projects, submitted them for evaluation, and took part in international competitions or online concerts. For example,

students organised a virtual concert where each participant performed their part from their seat, while the platform combined these recordings in real-time to create a complete performance. The integration of computer technology into the music education process substantially expanded students' opportunities to learn music and develop skills in related fields such as information technology, programming, and multimedia (Ramankulov et al., 2015). This interdisciplinary approach not only encourages flexibility in learning but also creates professionals who are ready for modern challenges. For instance, students combined music programming with video art to create interactive multimedia projects. Using programs such as Max/MSP, they managed to develop systems that combine sound and video, responding to music in real-time. This opens the possibility of creating installations where audio and visual elements interact to offer a unique experience for the audience.

Students also developed music applications for smartphones. Using programming languages such as Swift for iOS or Java for Android, they created simple applications for recording, editing, or learning music. This not only helped them understand how mobile technology works but also enabled them to implement their ideas for music education. Using online platforms like Soundtrap or BandLab enables students to collaborate on joint projects even when they are in different cities or countries. For example, they could simultaneously create a track using real-time editing features. One student would add vocals, another would add instruments, and yet another would add sound effects. This not only improved their teamwork skills but also developed their distance-learning skills. Exploring the principles of automation in music using software such as Sonic Pi also became a prominent part of the learning process. For instance, students programmed algorithms to generate random melodies or automatically change the tempo and dynamics of a track. This stimulated their creativity and enabled them to experiment with new forms of musical expression.

Furthermore, the use of virtual reality (VR) technology has become a new innovative area in music education. Students could create virtual music installations where viewers interacted with music in a 3D environment. For example, VR-based projects enabled visitors to 'enter' a musical world where they controlled sounds and visual elements, creating a unique experience. As Table 1 shows, computer technologies are actively used in the music education process, which emphasises their role in improving the effectiveness of education.

Table 1 - Examples of the use of computer technology in the music educational process

Example	Technologies	Description
Music programming and video art	Max/MSP,	Creation of multimedia installations where music interacts with visual elements.
Creation of music applications for smartphones	Swift, Java (iOS, Android)	Development of applications that allow users to play virtual instruments or generate music.
Virtual environments for interactive music	Yousician, Melodics	Creation of interactive music worlds or platforms for music performances in VR.
Sound analysis and musical instruments based on artificial intelligence (AI)	Magenta Studio	Use of machine learning to automatically generate music or analyse audio tracks.

Source: compiled by the author.

Digital audio workstations have played a significant role in modern music education (Avalion et al., 2024). For instance, Ableton Live was used to create electronic music, live performances, and

audio production. Students managed to create compositions using MIDI controllers and synthesisers, record vocals or instruments, and mix tracks in real-time. One example of such training was a student project where they had to create a soundtrack for a short film, using Ableton Live to record and edit sound effects, synthesise electronic instruments, and integrate sound design into multimedia content.

Logic Pro, a powerful music recording and processing software, is particularly popular with composers and music producers. Lessons in which education students recorded and edited live instrumental performances enabled them to combine them with electronic elements. Using Logic Pro for audio mixing and mastering helped them create orchestral music using libraries of virtual instruments and adding electronic effects. FL Studio was commonly used to make beats and electronic music, and was particularly popular among young musicians and producers. Students were challenged to create a complete hip-hop or EDM track using FL Studio to program drums, synthesise bass lines, and organise sound loops.

Music programming has also become an essential element of the learning process. Max/MSP, a graphical environment for music and multimedia programming, enabled the creation of customised sound instruments or effects through coding. Students developed tools for generative music, where algorithms generated sound sequences independently. For example, writing code to change the parameters of synthesizers in real-time, depending on movements or light signals, demonstrated a practical approach to learning. Sonic Pi, a popular software platform for creating music through coding, enabled the students to learn music programming using simple commands in Ruby. Lessons, where students programmed electronic music to create rhythms, melodies, and harmonies, provided an interactive way to learn the basics of programming and music composition. Pure Data (Pd), an open-source programming environment, was used to create interactive music and multimedia applications.

An example was a student project that developed an interactive installation responding to sound or movement in real time, creating unique musical pieces using sensors. Online platforms for performing music also played a significant role in the learning experience. Soundtrap, for example, was an online collaboration platform that allowed multiple students to work simultaneously on a music project from any location. In a group project, students created and edited a song, with each student responsible for a specific element: one wrote the music, another added vocals, and yet another handled mixing and mastering. BandLab, analogous to Soundtrap, focused on collaboration and real-time music creation. Students from multiple countries collaborated to create a pop or rock album, using BandLab to create and edit tracks, allowing them to record instruments, share ideas, and receive instant feedback.

Performing pieces in virtual concerts, such as those on Zoom or Teams, has also become part of modern music education. Universities and music academies have used these platforms to organise online performances, concerts, and discussions of music. Students organised virtual concerts using Zoom or Microsoft Teams to perform live or stream their recordings to an audience, enabling them to practice public performance without even having access to real stages. Thanks to these tools, students acquired new skills that combined music education with digital technologies, developing both their creative and technical potential. These skills helped them prepare for the modern music industry, where digital instruments and online collaboration have become integral to the music creation process.

Vocal and conducting continue to be the core components of music education, but their teaching has adapted to a new reality. For example, conducting has been supplemented with knowledge of software for creating arrangements, enabling students to understand better the role of the conductor in the digital age. Teaching theoretical subjects, such as musical harmony and analysis, was complemented by practical computer classes, enabling students to absorb theoretical knowledge in practice better. The

findings confirmed that the interdisciplinary approach contributed to improving the quality of bachelor's training in music. Students who managed to combine knowledge from different disciplines became more competitive in the labour market (Prontenko et al., 2019).

Virtual and augmented reality technologies were actively integrated into music education, allowing students to create new forms of interaction with music (Rexhepi et al., 2024). For example, with the help of VR, students could "play" virtual instruments that did not require physical presence but fully reproduced authentic sound and reaction. Students used VR software to create three-dimensional musical environments where they controlled virtual synthesisers or stringed instruments, experimenting with different sound effects and space conditions. This facilitated interdisciplinary collaboration with engineering or design faculties. The use of augmented reality enabled students to better understand music theory by visualising musical elements in real space.

Musical notes or chord progressions appeared as three-dimensional objects through augmented reality (AR) applications, helping students learn music interactively by displaying music sheets on top of an instrument or demonstrating chord structures in real-time. The gamification of the learning process through music applications has also become a prominent aspect of education. Yousician, for instance, is a mobile application that uses gamification to teach musical instruments such as guitar, piano, bass, and ukulele. Students learned chords, melodies, and performance techniques through interactive lessons and tasks that resembled a video game. Melodics, an application for learning to play drums, MIDI controllers, and piano, also used gamification to stimulate learning. Users performed exercises to music, earning points and reaching new levels. Students used Melodics to practice playing on MIDI controllers or drum machines while learning rhythm and playing techniques through interactive lessons that tracked their progress.

The use of digital technology in music education has several pedagogical benefits, although it also introduces substantial ethical issues that require thorough scrutiny. Three primary concerns are notably significant: data privacy, accessibility, and inherent biases in AI-driven technologies. Data privacy is a critical ethical concern due to our dependence on cloud-based platforms, collaborative software, and learning management systems. These systems frequently gather, retain, and analyse students' personal data, including user engagements, performance indicators, and creative products. Insufficient regulation or ambiguous data ownership regulations may subject students to the dangers of monitoring, commercial exploitation, or unauthorised data dissemination (Amangeldiyeva et al., 2020). Educators and institutions must verify that used platforms adhere to applicable data protection rules, such as the General Data Protection Regulation (GDPR), and implement transparent privacy standards, especially when students are mandated to submit personal or creative information.

Secondly, accessibility and digital equality provide a substantial ethical dilemma, especially in situations where access to dependable internet connections, high-performance hardware, or licensed software is inequitably allocated. Students from economically disadvantaged homes or rural regions may have obstacles in accessing technology-driven courses, consequently intensifying existing educational disparities. In these instances, the ethical obligation is to implement inclusive design principles, provide low-bandwidth or offline options, and provide institutional assistance (e.g., device lending, campus access) to guarantee that the digital divide disadvantages no student.

The growing use of AI-driven technologies in music education—such as automated composition generators, performance assessors, and adaptive learning systems—elicits worries about algorithmic transparency and bias (Kuchansky et al., 2021). These algorithms are often trained on data that can reflect cultural, stylistic, or demographic biases, leading to uneven decisions or the reinforcement of existing musical norms. AI technologies may

preferentially emphasise Western tonal systems or specific genres while neglecting non-Western or experimental methodologies. Moreover, opaque algorithmic procedures may impede students' comprehension of their work assessment, diminishing their agency and critical participation. The ethical use of AI in education requires transparency, cultural inclusivity, and frequent audits to guarantee fairness and pedagogical integrity (Fedoryshyn et al., 2024).

Thus, the study confirmed that interdisciplinary integration has become an essential element in the training of bachelors in music. The combination of different disciplines allowed students to gain a deeper understanding of their specialisation and provided a holistic approach to learning. This included the synthesis of theoretical knowledge, practical skills, and modern technologies, which together formed a trained specialist in music. Specifically, the integration of computer technology with music courses has become a vital component of the educational process.

5. Discussion

The study found that digital audio workstations can not only improve students' technical skills but also contribute to the development of critical thinking, creativity, and active involvement in the learning process. These conclusions align with the study by Rexhepi et al. (2024), which conducted a thorough assessment of digital technologies in music education and found that their application significantly enhances student involvement and promotes more efficient learning processes. Their research revealed that the combination of digital audio workstations and collaborative platforms may improve motivation and lead to more consistent academic success in music-related endeavors. Wen (2024) examined the impact of interactive online classes on students' creative thinking in music education. The findings demonstrated a significant enhancement in students' capacity to produce innovative musical concepts facilitated by the dynamic and personalised learning settings provided by online technology. These findings corroborate the current study, emphasising the

ability of digital tools to enhance both technical competency and advanced cognitive and creative skills in music students.

George (2023) revealed the significance of using Bloom's taxonomy to evaluate the effectiveness of an interdisciplinary approach to teaching music theory. In this context, the study focused on theoretical aspects, specifically on how various levels of learning objectives can affect the improvement of students' musical literacy. George employed survey methods and curriculum analysis but focused mainly on the theoretical components without paying sufficient attention to the practical aspects of learning. The present study emphasised the practical use of digital tools such as DAWs to teach music theory. This approach not only complemented but also extended the findings of S.F. George, as the researcher indicated that the integration of practical tasks into the learning process substantially increased the level of student interest. The study results showed that students who actively used DAWs not only improved their musical skills but also developed critical thinking while working on projects. This was a significant aspect because, unlike S.F. George, the study emphasised how the practical application of technology encouraged students to be creative in their learning. It was noted that when students can work with real musical instruments and technologies, they become more active participants in the learning process, which contributes to a deeper understanding of theoretical aspects.

Shi and Ning (2022) focused on the possibilities of introducing artificial intelligence in music teaching, emphasising the personalisation of learning and the automation of routine tasks. The researchers noted that interactive learning environments created using virtual reality (VR) and augmented reality (AR) can significantly increase student motivation. The study also found that the introduction of digital technologies, specifically DAW, allowed students to adapt their projects to meet individual needs and preferences. This increased their involvement in the learning process, unlike the approaches described by Shi and Ning, who did not consider this practical component. However, the study also

highlighted the importance of discussing ethical issues related to the use of innovative technologies in education, as emphasized by Shi and Ning. Notably, while technology can provide students with new learning opportunities, its use also carries risks, such as interference with data privacy or impact on social interaction between students. Thus, it is necessary not only to introduce the latest technologies into teaching but also to educate students about the possible consequences of their use.

Weisheng and Hui (2022) focused on the use of digital images to improve music perception and visualisation. The researchers emphasised that the integration of visual elements into the learning process makes it more interactive and engaging for students. The study confirmed these findings, suggesting that the use of digital tools to visualise the musical process contributed to a better perception of the learning material. Students who had the opportunity to work with visual elements showed greater interest and creativity in completing projects (Spytska, 2024b). However, the present study noted that there was not enough focus on visual elements, as was done by Weisheng and Hui. This created opportunities for further research into the effects of visualisation on music perception and student engagement in the learning process. It would be significant to examine in detail what concrete visual tools students use in their projects and how these tools can help them to understand musical concepts more deeply. For example, studying the graphics that accompany music or the visualisation of rhythm and melody could provide additional information about the impact of such elements on the learning process.

Fang and Luen (2024) focused on innovative approaches to music teaching, emphasising the value of increasing student motivation through interactive platforms and adapting learning materials to their individual needs. The researchers noted that the latest teaching methods, including the use of digital technologies and interactive platforms, significantly increase students' interest in the learning process. This contributes to a more active and engaged learning environment where students feel responsible

for their learning. The study confirmed these findings, highlighting that the active use of technology in teaching, particularly digital audio workstations, contributed to increased student interest in the learning material. The findings showed that students who worked with DAWs were more interested in music theories and practices, as these tools enabled them to apply their knowledge in practical activities directly.

The study provided much more practical information on how concrete tools can be used to implement innovative teaching methods. For instance, the study analysed how students interacted with technology during their projects. It turned out that using a DAW not only increased motivation but also developed practical skills essential for future careers in the music industry. Students successfully created their music projects, experimenting with diverse styles and sounds, which enabled them to receive direct feedback on their work and refine their skills. Studying the concrete platforms used by students could provide valuable insights into their impact on the learning process. The significance of adapting curricula to modern requirements has become apparent in the context of technological progress. The conducted study revealed that tools such as DAW not only meet the interests of students but also increase their ability to learn independently and think creatively.

Innovative approaches based on the use of interactive platforms open new horizons for teachers and students, promoting not only interest in the educational material but also a deeper understanding of musical concepts and practical skills necessary for success in the music industry. This allows for more flexible and adaptable curricula that accommodate the individual needs of students and the demands of the modern labour market. Research in music education reveals the increasing importance of integrating modern technologies into the learning process, including digital audio workstations and artificial intelligence.

6. Conclusions

The findings showed that students reported marked improvements in their composition and arranging skills through the use of digital audio workstations (DAWs), as well as positive changes in teamwork facilitated by online platforms. The study also found that the integration of technology provided an opportunity to experiment with new musical genres, making learning more interactive and engaging through digital tools. This research project highlighted the value of developing interdisciplinary skills that combine music education with information technology. The integration of digital instruments into the learning process enabled students to experiment with new genres, increasing their creativity and readiness to adapt to rapid changes in the technological environment. Specifically, the interdisciplinary approach to teaching bachelor in music performance in the digital world proved to be an effective method for integrating conventional artistic disciplines with modern computer technologies.

Furthermore, the findings of this study underscore the importance of continuous professional development for teachers seeking to integrate innovative technologies into their curricula effectively. This includes the need for regular training, the sharing of experiences, and the sharing of resources to improve the quality of learning. Overall, the study highlighted that the integration of computer technology into music education is key to the development of new pedagogical strategies that meet the needs of modern students and teachers. Modern music education should focus on innovation and adaptation to rapidly changing conditions, thereby contributing to the successful training of future musicians and music professionals.

The limitation of this study was the small sample of participants, which did not allow for generalizing the findings to a larger population. There were no repeated measurements and assessments of participants' progress, which is significant for understanding the stability of the findings and their influence on further learning activities of students. These factors highlighted the

need for larger, longer-term studies in the future that factor into the diversity of learning contexts and the possibility of analysing the long-term results of introducing innovative approaches to music education.

Further research on this subject is necessary to enhance curricula and teaching methods, thereby contributing to the more effective training of professionals prepared for the challenges of the music industry. This can be achieved by analysing the needs of the industry, involving representatives of the music sector in the curriculum development process, which will help to adapt education to modern requirements. An interdisciplinary approach that combines music, technology, business, and communication will create a comprehensive training format that meets the realities of the modern music industry. Such research can substantially improve the quality of training specialists who can implement their ideas in a dynamic environment.

References

AKHSUTOVA, Assiyat; KASYMALIEV, Muratbek; TOIKENOV, Gumyrbek; AVDARSOL, Sailaugul; ORAZBEKOV, Zhasulan. Methodical System of Teaching Students Computer Science: Competence-Based Approach. **Scientific Herald of Uzhhorod University. Series Physics**, v. 55, pp. 961-971, 2024. https://doi.org/10.54919/physics/55.2024.96dp1

AMANGELDIYEVA, Gulmira; TOKTAGAZIN, Muratbek; OMAROV, Bauyrzhan; TAPANOVA, Saule; NURTAZINA, Roza. Storytelling in Media Communication: Media and Art Models. **International Journal of Criminology and Sociology**, v. 9, pp. 3166-3174, 2020. https://doi.org/10.6000/1929-4409.2020.09.383

ANDRIIEVSKYI, Ivan; SPIVAK, Sofiia; GOGOTA, Olga; YERMOLENKO, Ruslan. Application of the Regression Neural Network for the Analysis of the Results of Ultrasonic Testing. **Machinery and Energetics**, v. 15, n. 1, pp. 43-55, 2024. https://doi.org/10.31548/machinery/1.2024.43

ASARE, Samuel; TWUM, Ebenezer; AMOAH, Jessica. Teaching for the Digital Stage: Preparing Future Music Educators for the ICT-driven Classroom at Colleges of Education. **International Journal for Multidisciplinary Research**, v. 5, n. 5, p. 7291. https://doi.org/10.36948/ijfmr.2023.v05i05.7291

AVIV, Itzhak; LEIBA, Moshe; RIKA, Havana; SHANI, Yogev. The Impact of ChatGPT on Students' Learning Programming Languages. In: ZAPHIRIS, P.; IOANNOU, A. (Eds.). **Learning and Collaboration Technologies. HCII 2024. Lecture Notes in Computer Science**. Springer: Cham, 2024. vol 14724. https://doi.org/10.1007/978-3-031-61691-4_14

AVTALION, Ziv; AVIV, Itzhak; HADAR, Irit; LURIA, Gil; BAR-GIL, Oshri. Digital Infrastructure as a New Organizational Digital Climate Dimension. **Applied Sciences (Switzerland)**, v. 14, n. 19, p. 8592, 2024. https://doi.org/10.3390/app14198592

BATES, A.W. (Tony). **Teaching in a Digital Age: Guidelines for Designing Teaching and Learning**. Vancouver: Tony Bates Associates Ltd., 2019. https://pressbooks.bccampus.ca/teachinginadigitalagev2/

BIESTA, Gert. The Future of Teacher Education: Evidence, Competence or Wisdom? In: PETERS, M. A.; COWIE, B.; MENTER, I. (Eds.). **A Companion to Research in Teacher Education**. Singapore: Springer, 2017. p. 435-453. https://doi.org/10.1007/978-981-10-4075-7_29

CHRISTOPHERSEN, Catharina. Educating Music Teachers for the Future: The Crafts of Change. In: HOLDHUS, K.; MURPHY, R.; ESPELAND, M. I. (Eds.). **Music Education as Craft: Reframing Theories and Practices**. Cham: Springer, 2021. p. 63-74. https://doi.org/10.1007/978-3-030-67704-6_6

DE REIZÁBAL, Margarita; GÓMEZ, Manuel. Learning Analytics and Higher Music Education: Perspectives and Challenges. **ARTSEDUCA Electronic Journal of Education in the Arts**, v. 34, p. 219-228, 2022. https://doi.org/10.6035/artseduca.6831

DYNDAHL, Petter, NIELSEN, Siw. Crafting Music Education for All? The Composite Knowledge Base of Music Education in Times of Cultural Diversity and Social Polarisation. In: HOLDHUS, K.; MURPHY, R.; ESPELAND, M. I. (Eds.). **Music Education as Craft: Reframing Theories and Practices**. Cham: Springer, 2021. pp. 39-50. https://doi.org/10.1007/978-3-030-67704-6_4

FANG, Liu; LUEN, Loy. Innovative Teaching Approaches and Student Motivation in Music Education at Shangrao University, China. **International Journal of Academic Research in Progressive Education and Development**, v. 13, n. 1, p. 2067-2074, 2024. http://doi.org/10.6007/IJARPED/v13-i1/20793

FEDORYSHYN, Halyna; LUKIIANCHUK, Alla; ZELENIN, Vsevolod; LUNCHENKO, Nadiia; IVASHCHENKO, Alyona. The Role of Psychology in the Formation of Emotional Intelligence in Ukrainian Education. **Amazonia Investiga**, v. 13, n. 76, pp. 297-307, 2024. https://doi.org/10.34069/AI/2024.76.04.24

GEORGE, Stephanie. **An Interdisciplinary Approach to Music Theory Pedagogy: How Bloom's Taxonomy Promotes Music Literacy in the First Year Music Theory Sequensce for Undwegraduates.** Temple: Temple University Graduate Board, 2023. http://doi.org/10.34944/dspace/8889

GOSAVI, Chhaya; DEORE, Mahendra. Higher Education's Innovative Pedagogical Approaches and Teaching Practices. In: **Proceedings of the E-Learning and Smart Engineering Systems (ELSES 2023): Atlantis Highlights in Social Sciences, Education and Humanities**. Amsterdam: Atlantis Press, 2023. p. 251-266. https://doi.org/10.2991/978-94-6463-360-3_26

GOUZOASIS, Peter; BAKAN, Danny. The Future of Music Making and Music Education in a Transformative Digital World. **UNESCO Observatory, Faculty of Architecture, Building and Planning, The University of Melbourne Refereed**, v. 2, n. 2, p. 12, 2011. https://

www.unescoejournal.com/wp-content/uploads/2020/03/2-2-12-GOUZOUASIS.pdf

IKLASSOVA, Kainizhamal; AITYMOVA, Aliya; KOPNOVA, Oxana; SHAPOREVA, Anna; ABILDINOVA, Gulmira; NURBEKOVA, Zhanat; ALMAGAMBETOVA, Leila; GOROKHOV, Alexey; AITYMOV, Zhanat. Ontology Modeling for Automation of Questionnaire Data Processing. **Eastern-European Journal of Enterprise Technologies**, v. 5, n. 2-131, pp. 36-52, 2024. https://doi.org/10.15587/1729-4061.2024.314129

KHAMDAMOVA, Diloramkhan. Characteristics of Teaching Performance in Educational Institutions. **Society and Innovations**, v. 3, n. 4, p. 274-282, 2022. https://doi.org/10.47689/2181-1415-vol3-iss4/S-pp274-282

KUCHANSKY, Alexander; BILOSHCHYTSKYI, Anatiliy; BRONIN, Sergiy; BILOSHCHYTSKA, Svitlana; ANDRASHKO, Yuriy. Use of the Fractal Analysis of Non-stationary Time Series in Mobile Foreign Exchange Trading for M-Learning. **Advances in Intelligent Systems and Computing**, v. 1192, pp. 950-961, 2021. https://doi.org/10.1007/978-3-030-49932-7_88

KUKULSKA-HULME, Adnes; WISE, Alyssa; COUGHLAN, Tim; BISWAS, Gautam; BOSSU, Carina; BURRISS, Sarah; CHARITONOS, Koula; CROSSLEY, Scott; ENYEDY, Noel; FERGUSON, Rebecca; FITZGERALD, Elizabeth; GAVED, Mark; HERODOTOU, Christothea; HUNDLEY, Melanie; MCTAMANEY, Catherine; MOLVIG, Ole; PENDERGRASS, Emily; RAMEY, Lynn; SARGENT, Julia; SCANLON, Eileen; SMITH, Blaine; WHITELOCK, Denise. **Innovating Pedagogy 2024: Exploring New Forms of Teaching, Learning and Assessment, to Guide Educators and Policy Makers.** Milton Keynes: Institute of Educational Technology, The Open University, 2024. http://doi.org/10.13140/RG.2.2.15627.30246

LI, Jiahua. Reform and Innovation of College Music Teaching under Background of Multimedia and Network Technology. **International Journal of Educational Innovation and Science**, v. 4, n. 1, p. 41-53, 2023. https://doi.org/10.38007/IJEIS.2023.040104

LIU, Fengqin. Interactive Music Learning Model Based on RBF Algorithm. **Computational Intelligence and Neuroscience**, v. 2022, n. 1, a.n. 5759986, 2022. https://doi.org/10.1155/2022/5759986

LIU-ROSENBAUM, Aaron; CREECH, Andrea. The Role of Technology in Mediating Collaborative Learning in Music. In: CREECH, A.; HODGES, D. A.; HALLAM S. (Eds.). **Routledge International Handbook of Music Psychology in Education and the Community**. London: Routledge, 2021. p. 433-448. https://doi.org/10.4324/9780429295362-37

LORENZO DE REIZABAL, Margarita. Music Education Models in the 21st Century: The Music Mediation Model for Social Engagement. **Education Journal**, v. 46, n. 2, a.n. 49922, 2022. https://doi.org/10.15517/revedu.v46i2.49922

LYU, Ling; SOKOLOVA, Alla. The Effect of Using Digital Technology in the Music Education of Elementary School Students. **Education and Information Technologies**, v. 28, n. 4, p. 4003-4016, 2022. https://doi.org/10.1007/s10639-022-11334-8

MA, Erhong. Research on the Teaching Innovation Model of the Integration of Information Technology and Music Education. **MATEC Web of Conferences**, v. 365, a.n. 01054, 2022. https://doi.org/10.1051/matecconf/202236501054

MAHARAJ, Adita; GILL, Akini. Technology in Music Education. **Canadian Journal of Learning and Technology**, v. 49, n. 2, p. 1-15, 2023. https://doi.org/10.21432/cjlt28153

MARTYNIUK, Tetiana. Implementation of Artistic and Pedagogical Interpretation Technologies in the Content of Professional Training of Future Music Teachers in the Study of Artistic Innovations in Educational Institutions. **Professional Education: Methodology, Theory and Technologies**, v. 8, n. 1, p. 164-187, 2022. https://doi.org/10.31470/2415-3729-2022-15-164-187

NOVOSIADLA, Iryna. Psychophysiological Factors of Effective Development of Piano Technique of Future Music Teachers. **Scientific Bulletin of Mukachevo State University. Series "Pedagogy and Psychology"**, v. 9, n. 1, p. 47-58, 2023. https://doi.org/10.52534/msu-pp1.2023.47

PETRIE, Christopher. Interdisciplinary Computational Thinking with Music and Programming: A Case Study on Algorithmic Music Composition with Sonic Pi. **Computer Science Education**, v. 32, n. 2, p. 260-282, 2021. https://doi.org/10.1080/08993408.2021.1935603

PRONTENKO, Kostiantyn; BLOSHCHYNSKYI, Ihor; GRIBAN, Grygoriy; ZHUKOVSKYI, Yevgenii; YAVORSKA, Tetiana; TKACHENKO, Pavlo; DZENZELIUK, Dmytro; DOVGAN, Nadya; BEZPALIY, Sergiy; ANDREYCHUK, Volodymyr. Formation of Readiness of Future Physical Culture Teachers for Professional Activity. **Universal Journal of Educational Research**, v. 7, n. 9, pp. 1860-1868, 2019. https://doi.org/10.13189/ujer.2019.070903

RAMANKULOV, Sherzod; SULTANBEK, Malik; BERKIMBAEV, Kamalbek; MEIRBEKOVA, Gulmira; USSENOV, Sagidulla; ZHASUZAKOVA, Meiramkul; SHEKTIBAYEV, Nurdaulet. Didactic Conditions of Implementation of ICT in the Formation of Creativity of Future Teachers of Physics. **Asian Social Science**, v. 11, n. 28, pp. 51-57, 2015. https://doi.org/10.5539/ass.v11n28p51

REGELSKI, Thomas; GATES, Terry. **Music Education for Changing Times: Guiding Visions for Practice**. Dordrecht: Springer, 2009. https://doi.org/10.1007/978-90-481-2700-9

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

SENGUPTA, Enakshi; BLESSINGER, Patrick. Introduction to Innovative Approaches in Pedagogy for Higher Education Classrooms. In:

SENGUPTA, E.; BLESSINGER, P. (Eds.). **Innovative Approaches in Pedagogy for Higher Education Classrooms: Innovations in Higher Education Teaching and Learning**. Leeds: Emerald Publishing Limited, 2022. p. 3-9. http://doi.org/10.1108/S2055-364120220000042001

SHI, Junyan; NING, Qinliang. Research on the Innovation of Music Teaching in Universities Based on Artificial Intelligence Technology. **Security and Communication Networks**, v. 2022, n. 1, a.n. 3140370, 2022. https://doi.org/10.1155/2022/3140370

SPYTSKA, Liana. Practice-Based Methods of Bringing to Legal Liability for Anonymous Defamation on the Internet and in the Media. **Social and Legal Studios**, v. 7, n. 1, pp. 202-209, 2024a. https://doi.org/10.32518/sals1.2024.202

SPYTSKA, Liana. Symptoms and Main Differences between a Psychopath and a Sociopath. **Journal of Nervous and Mental Disease**, v. 212, n. 1, pp. 52-56, 2024b. https://doi.org/10.1097/NMD.0000000000001728

TKACHENKO, Oleksandr; CHERNYKH, Maksim; KUZNETCOV, Ivan; KARPOVICH, Vitali; JATKIEWICZ, Przemysław. An Impact of Web Animation on User Perception and Engagement. **Journal of the Balkan Tribological Association**, v. 30, n. 5, pp. 875-897, 2024.

VÁRADI, Judit; RADÓCZ, Miklos; MIKE, Ádam; ÓVÁRY, Zoltan; JÓZSA, Gabriella. Lessons from the COVID Pandemic in Music Education the Advantages and Disadvantages of Online Music Education. **Heliyon**, v. 10, n. 15, a.n. e35357, 2020. https://doi.org/10.1016/j.heliyon.2024.e35357

WEISHENG, Luo; HUI, Hong. Approaches and Methods of Music Education Innovation Based on Digital Image Technology. **Mobile Information Systems**, v. 2022, n. 1, a.n. 5612545, 2022. https://doi.org/10.1155/2022/5612545

WEN, Mo. Interactive Online Classes in Music Education: The Impact of Online Technologies on the Level of Creative Thinking of Students.

Current Psychology, v. 43, p. 13619-13629, 2024. https://doi.org/10.1007/s12144-023-05411-5

YANAN, Gai. Use of Digital Audio Workstations in Music Education to Develop Creative Thinking and Increase Self-Efficacy. **Current Psychology**, v. 43, n. 29, p. 24320-24331, 2024. https://doi.org/10.1007/s12144-024-06093-3

ZAMORANO-VALENZUELA, Felipe; SERRANO, Rosa. Approaching Innovation in Music Teacher Education for Secondary Education: The Case of Spain. **Arts Education Policy Review**, v. 125, n. 4, pp. 213-223, 2022. https://doi.org/10.1080/10632913.2022.2076269

Authorship contribution

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Oleksandra Barytska, Iryna Gavran and Hutsal Rosina. The first draft of the manuscript was written by Natalia Turovska and edited by Olena Bukhniieva. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Research ethics committee approval

This study aligned with the ethical principles of research, including anonymity, confidentiality, and beneficence. Ethical approval of the study was obtained from the Ethical Committee of the Khmelnytskyi Humanitarian-Pedagogical Academy with No. 251.

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APPENDIX

Appendix A

QUESTIONNAIRE

1. Which of the following digital audio workstations (DAWs) have you used? (You can choose several options.)
o Ableton Live;
o FL Studio;
o Logic Pro;
o Pro Tools;
o Cubase;
o GarageBand;
o Reaper;
o Other (please specify): _____.

2. How often do you use a DAW to create music?
o daily;
o once a week;
o once a month;
o less frequently;
o never.

3. What DAW features do you use most often? (You can choose several options.)
o sound recording;
o music editing;
o sequencing;
o mixing;
o use of plugins;
o other (please specify): _____.

4. Do you use online platforms for collective music creation or performance?
o yes;
o no.

5. What online platforms do you use? (You can choose several options.)
o Soundtrap;
o BandLab;
o Audiotool;
o Soundation;
o other (please specify): _____.

6. Assess your level of experience in music programming:
o beginner;
o intermediate;
o advanced;
o expert.

7. Have you taken any music programming courses?
o yes;
o no.

8. How do you assess the role of digital technologies in modern music education?
o very important;
o important;
o neutral;
o unimportant;
o completely unimportant.

9. Share your experience of using the DAW. What features did you like the most?_____
_____
_____

10. What challenges did you face when using music programming?

_____
_____
_____

11. Describe how you use online platforms to create or perform music.

_____
_____
_____

12. What advice would you give to other students who are just starting to use DAWs and music programming?

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13. Do you think that an interdisciplinary approach to music education (e.g., combining music with other arts or technologies) is important? Why?

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14. What genres of music do you create or perform most often?

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15. What technologies do you think will be most relevant to the future of music education?

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