International **R**eview of **R**esearch in **O**pen and **D**istributed **L**earning
Volume 26, Number 1

March – 2025

Peculiarities of the Development of Students' Musical Skills Under the Influence of Modern Software

Hui Yang
Conservatory of Music, Xinyang College, XinYang, China

Abstract

This study explored the impact of digital technologies on the development of musical skills among music students. A learning experiment was conducted with 66 students between the ages of 18 and 21 from China, France, Italy, and Spain. The study used the methods of a survey and online discussions. Participants verified that the present advancement of digital technologies allows artists to participate in a professional musical environment without formal schooling. Students in the experimental group had a more positive attitude toward learning and its significance for their personal and professional development. Most survey items were rated between 3 and 4 on a 4-point scale, indicating students' overall satisfaction with the training. The results of the online discussion also indicated a high level of support for the use of digital technologies in music education, as well as highlighting the innovative nature of the training course and the advantages of traditional music education. Three quarters of participants supported the use of digital technologies in education. Students in the experimental group were able to acquire more advanced professional musical skills, which facilitated the creation of melodies (including the composition of musical fragments on specified themes, musical arrangements of varying complexity, and the development of principles for processing musical works) compared to students in the control group (focused on the development of musical ear and sense of rhythm), who were initially trained under the traditional system. The study's findings support the effectiveness of an integrated strategy for nurturing musical creativity that involves collaboration between students, teachers, and cutting-edge technology.

Keywords: creative musical talents, digital music creativity, music creation technology, music education, music software

The Impact of Academic Music Education and Relevant Software on the Development of Musical Skills in the Contemporary World

Music is a universal medium that people use in their daily lives for both aesthetic pleasure and functional and social purposes (Valdivia et al., 2021). As a medium for evoking and expressing emotions, enhancing social experience, and establishing and strengthening cultural identity, music is an invaluable contributor to human development. In addition, music facilitates the exchange of personal attitudes, values, and beliefs as a means of self-reflection and activation (Bendel et al., 2022). Therefore, the reproduction of melodies requires a deliberate approach that facilitates the development of various methods of interpretation, ultimately resulting in distinctive sound qualities. The selection of interactive technologies represents a modern approach to the perception of educational materials, which is closely related to the choice of appropriate interactive potential.

The music industry and consumer habits have shifted dramatically over the last two decades. The realization of new technical capabilities has been a major force behind the gradual unfolding of these changes in a multi-stage transformation process (Dolata, 2021). The advent of the digital age has allowed for novel understandings of many aspects of today's professional music industry. It has shaken up the ways music and art are made, and professional performing practices have moved out of concert halls, theatres, and galleries into more diverse, interactive, digital, and democratic settings (Westerlund & Gaunt, 2021). Advanced digital technologies are widely adopted in the music education sector, modernizing the teaching process and the entire worldwide music industry (Wu & Tao, 2022). Digitalization in music education has increased access to high-quality educational options for a broader spectrum of people. Nevertheless, the digital revolution has not diminished the emphasis on individuality and hands-on experience that have always been hallmarks of music education (Pereverzeva et al., 2021).

Music education is a complex, skill-based learning process emphasizing improvisational performance and musical creativity (Liu et al., 2023). Recently, the focus of music education has changed from passing on traditional musical knowledge and experience from teacher to student to focusing on students' overall development and personal growth. Factors such as the development of personal and critical aesthetic taste, the enhancement of creative abilities, the acquisition of transferrable skills, and the empowerment of personal well-being have particular significance in the context of modern music education (Concina, 2023).

The expansion of new information technologies has brought about a revolution in music pedagogy. This has happened due to teachers having access to a setting where they can foster and advance online learning practices through increased connectivity, individualization, and collaboration. To enhance students' musical learning experiences, today's educators use a variety of technologies. A perfect fusion of music theory and practice is made possible by digital technologies, which offer numerous technical benefits and real-world applications (Liu et al., 2021). Modern technologies can enhance communication, effectiveness, and healthy practice in music learning through sophisticated and interactive behavioral analysis and feedback systems (Waddell & Williamon, 2019). Interactivity, integrity, didactic potential, a comfortable learning environment, and creativity are the benefits of using digital technologies for music-instrumental learning (Suvorov et al., 2022).

The music industry serves as an example of the inherent uniqueness and vulnerability of creative expression in light of the vast potential offered by today's multimedia technologies. These technologies,

which include electronic musical instruments, specialized software, and sound equipment, are uniform and built to the musical instrument digital interface (MIDI) standard, which unites hardware, software, and hardware solutions to operate on a single digital communication protocol. Combining MIDI encoding and a sequencer is an alternative to digital music composition that can help musicians expand their creative toolkits (Malaschenko et al., 2020). Digital sound analysis and digital music control are the two main ways computer technology is used in music production (Wang & Zhou, 2022). Creative music students can switch from studio gear, including a multitrack recorder and an analog synthesizer, to a stand-alone computer environment that can offer a more accessible and liberating set of compositional tools thanks to computer-based music synthesis and sequencer software (Stevens, 2018). The three key elements of music education—sound analysis, creation, and processing—as well as the subsequent organization of that sound into musical material—are all made possible by digital technologies (Fornari, 2020).

Some authors claim that the global applicability of innovative technologies opens up new and, in fact, unlimited opportunities for self-realization. The use of innovations stimulates the rapid development of intelligence, raising learning to a new level. Additionally, compatibility with traditional music technologies allows for the continuity of musical eras and styles, as well as their interpenetration and synthesis, strengthening interest in musical culture in general (Gorbunova & Hiner, 2018). Gorbunova et al. (2018) addressed problems related to the process of teaching the art of performing on electronic musical instruments, emphasizing that the possibility of innovative training is possible in the presence of highly qualified teaching staff. Therefore, as in other industries, the development of students' knowledge and experience through the use of information technologies in music education should be a key principle of the modern educational system (Maba, 2020).

Creativity is a fundamental process involving imagination, exploration, discovery, experimentation, and curiosity. Digital art involves more than simply mastering new software. Educators use open technology to bridge the gap between art and a variety of other disciplines, including engineering, mathematics, computer science, statistics, physics, and telecommunications. Understanding how computers function is a prerequisite for learning digital art. Open technologies in the arts can therefore be a fantastic phenomenon for interdisciplinary dialogue (Junior & Schiavoni, 2019).

New digital media environments and applications enable students to demonstrate their talents, knowledge, and skills through creativity. Additionally, they can share their compositions via specific applications so that potential viewers can see them and give them a proper evaluation (Suvorov et al., 2022). Students can effectively express themselves through music using digital music technologies without even considering the fundamentals of music. Composing music with digital instruments can facilitate musical creativity and comprehension of musical phenomena and structures (Baek & Taylor, 2020). Visual programming languages appear to break new ground in music production (Bresson, 2022).

Modern music education is closely linked to the use of interactive systems for creating musical compositions. The use of the Lumanote application facilitates the training of piano students and enhances their motivation to create new melodies. This has led to higher performance outcomes for students using the Lumanote application compared to those who followed traditional learning methods. This can be attributed to the ability of interactive systems to overcome learning obstacles and focus on the development of specific musical functions (Zhao et al., 2022).

Augmented reality technologies have a significant impact on the implementation of educational practice, which can be achieved through applications such as Flowkey, Simply Piano, Skoove: Learn to Play Piano, and AR Pianist. Through the use of these applications, beginner students have been able to attain high levels of musical literacy, note reading, and working with musical material (Cui, 2022).

Creative thinking develops under the influence of multidisciplinary learning, allowing for the integration of multiple academic subjects and enabling a focus on various details. The MusiMath application facilitates the combination of music and mathematics, thereby enhancing the understanding of the principles of melody creation. Combined learning has positively influenced the expression of creativity across different academic domains, contributing to the development of creative thinking (Azaryahu et al., 2023).

The purpose of this research was to analyze the advantages of digital music applications (MadTracker, Virtual DJ, MU.Lab, and DarkWave Studio) for the development of musical skills among students. The hypothesis stated that the use of digital instruments contributes to the enhancement of the musical creative process and the development of musical skills. The following objectives were set:

1. Develop an experimental training course titled Music-Making: Innovative Technologies and Innovative Skills, with the goal of teaching music creation skills using computer software such as MadTracker, Virtual DJ, MU.Lab, and DarkWave Studio.

2. Administer a survey at the end of the training to determine students' attitudes towards the learning experience, its value in terms of personal and professional development, and its adequacy for carrying out the desired musical activity;

3. Hold an online discussion with experiment participants to ascertain students' attitudes towards traditional music education in light of modern technological opportunities.

Methods and Materials

Research Design

The performing arts, whether music, sculpture, painting, dance, or drama, can help people fulfill their innate desire for self-actualization. Self-expression through art is a key component of society's intellectual, emotional, and social development. Creativity is the basis of all art. Visual art expresses originality and creativity and combines the artist's innate drive, talent, and skill (Suguna, 2018). Using technological tools in the visual arts can help increase and deepen audiences' emotional connections to music (Oliveira et al., 2024).

Our study, conducted from September 2022 to December 2022, involved 66 students from China, France, Italy, and Spain. It examined students' attitudes towards traditional music education in the context of modern digital opportunities. We recruited participants through an awareness campaign on Facebook, WhatsApp, and WeChat that focused on an audience of music-related groups and sought to enlist people willing to participate in the 3-month training course. The open workshop presentation of the course Music-Making: Innovative Technologies and Innovative Skills drew 221 participants. We set the criteria for the two groups of participants in the experiment.

The control group, Beginner, included 32 students (Table 1). Students in the control group studied for 1 month using the traditional teaching method without the Innovation Program and then for another 2 months using the Innovation Program. They met the following requirements: interested in music art; aware of their musical talent; no musical education or skills; creative and interested in creativity; having basic computer skills and digital literacy; having the technological capability to work with music computer software and applications; being 18–21 years old; and, studying at a higher education institution (HEI). During the research process, these students relied on their knowledge, musical literacy, and instruments (most frequently the piano) to create musical compositions.

The experimental group, Intermediate, included 34 students (Table 2). They met the following requirements: interested in music art; aware of their musical talent; studying at a music education institution; having creativity and interest in creativity; having basic computer skills and digital literacy; having the technological capability to work with music computer software and applications; and being 18–21 years old. During the learning process, the students in the experimental group used digital technologies to facilitate their creation of musical compositions.

The Skillshare educational platform was used to deliver the 3-month educational programme. The moderators encouraged the students in the experimental group to use MadTracker, Virtual DJ, MU.Lab, and DarkWave Studio, four contemporary digital music creation tools, to create their musical pieces. The Innovation Program was the same for both groups. However, the control group received a condensed version of the training: the students did not study in as much detail as the experimental group. The control group was trained without the use of digital technologies, which necessitated a focus on theoretical and practical sessions instead of the incorporation of additional tools or mechanisms.

Table 1

Characteristics of the Beginner Group Participants

Country	*n*	Higher education institution
China	10	Beijing Normal University University (1 person) Beijing University of Posts and Telecommunications (3 people) Beijing University of Technology (2 people) Peking University (1 person) Tsinghua University (2 people) University of Science and Technology Beijing (1 person)
France	4	University of Bordeaux (1 person) University of Toulon (1 person) University of Tours (2 people)
Italy	8	University of Bologna (2 people) Humanitas University (4 people) University of Brescia (2 people)
Spain	10	Universidad Autónoma de Madrid (2 people) Universidad de Navarra (3 people)

		Universitat Politècnica de Catalunya (2 people)
		IE University (2 people)
		Universidad de Alcalá (1 person)
Total	32	

Table 2

Characteristics of the Intermediate Group Participants

Country	*n*	Higher Education Institution
China	12	Central Conservatory of Music (3 people)
		Fujian Normal University (2 people)
		China Conservatory of Music (1 person)
		Guangxi Arts Institute (4 people)
		Shenyang Conservatory of Music (1 person)
		Shanghai Conservatory of Music (1 person)
France	6	IMEP Paris College of Music (2 people)
		Institute for Research and Co-ordination in Acoustics/Music (2 people)
		Bordeaux Conservatory Jacques Thibaud (2 people)
Italy	7	Jul academy (3 people)
		SAE Institute Italy (3 people)
		International Academy of Modern Music Italy (1 person)
Spain	9	European University of Valencia (1 person)
		University of Granada (2 people)
		Complutense University of Madrid (2 people)
		Autonomous University of Barcelona (4 people)
Total	34	

A survey was held at the end of the training to determine students' attitudes towards the learning experience, its value in terms of personal and professional development, and its adequacy for carrying out the desired musical activity. The survey used 4-point Likert scale, with responses ranging from 1 = *completely disagree* to 4 = *completely agree*. The experts who conducted the survey were music teachers and experts in the field of music education. A total of 17 individuals were surveyed, all of whom were involved in teaching musical composition, both with and without the use of digital technologies. These individuals had experience in preparing students for music competitions, which involved applying various approaches to the creation of musical works. The questionnaire was evaluated by analyzing students' responses to questions regarding their attitude towards the learning experience and

its value in terms of personal and professional growth, as well as its relevance to their desired musical activity. As the experts were professional educators, they were capable of evaluating the accuracy of the responses provided. However, this required students to give detailed answers to all questions, which would allow for the determination of their level of interest in learning and the assessment of their understanding of the mechanisms involved in creating musical compositions. During the evaluation, an analysis was conducted to distinguish between positive and negative responses. The responses to the questionnaire were analyzed using IBM SPSS Statistics (Version 25). The highest score, *very good*, was assigned a value of 1 (5/5 = 1), and *good* was given a value of 0.8 (4/5 = 0.8), with other scores assigned accordingly. Google Forms was used to administer the questionnaire. The use of Google Forms enabled immediate access to responses for all educators, thereby facilitating timely evaluation. The questionnaire had 10 questions:

1. Did the potential of the tested technologies help you implement your musical ideas?
2. Were you able to use the tested techniques to turn creative ideas into finished musical compositions?
3. Was your experience with technological music-making/using traditional approaches solutions simple, intuitive, and comfortable?
4. Did you require additional guidance from instructors in the process of creating musical technologies?
5. Did you require additional guidance from music instructors during the creative work phase?
6. Which of the tested music technologies'/traditional approaches benefits most impressed you during your music learning process?
7. Did you have the necessary skills to use music software/work with traditional learning mechanisms, given your knowledge of music composition and sound design?
8. Did you feel that you lacked basic musical knowledge and skills while creating music?
9. Do you believe that you need additional musical training to implement your creative ideas?
10. In your opinion, has participation in the training program affected your creative ability?

After the survey, we held a videoconference discussion with the students which we titled, Facilitating Academic Music Education for the Creative Self-Realisation of a Musician, and in which each participant had the opportunity to voice their opinion on whether taking part in formal educational programs is a good idea in order to realize their potential as talented musicians. The criteria for evaluating the effectiveness of the program were the following: overall satisfaction with the learning process; expectations for achieving musical goals and developing skills; and impressions of using digital technology/the traditional teaching approach in music training.

Students underwent a final examination over the course of one week. During the exam, students were required to create musical fragments and complete compositions based on specified criteria, while also considering their capabilities. To compose their works, students from both groups used interactive

technologies that were employed by the experimental group during their training. This approach allowed for the assessment of the skills acquired by the students throughout the learning process. The skills initially selected were defined at the beginning of the study to enable melody creation. These skills were empirically derived through observation of senior students and the level of their performance on assignments related to musical composition. The skills acquired by the students were assessed by educators who participated in the earlier phase of the research. Accurate results were achieved through the application of a student's *t*-test (Barabash et al., 2021).

Limitation

The study's primary limitation was its small sample size and geographic scope (66 respondents from four countries). Additionally, we chose participants based on criteria. One reason was that the chosen age range (18–21 years old) made it difficult to understand how the target audience felt about digital music production. Finally, the number of digital tools included in the training course was another limitation, despite the Internet's vast supply of such tools.

Ethical Issues

The experiment was free to participants, and open-source developers provided the digital tools they used. We explained the study's purpose and objectives to the participants. They gave informed consent to participate in the experiment, which allowed us to ensure we were respecting the Declaration of Helsinki research protocols.

Results and Discussion

A survey was held at the end of the training to determine the students' attitudes towards the learning experience, its value in terms of personal and professional development, and its adequacy for carrying out the desired musical activity. The hypothesis suggests that the use of digital instruments contributes to the improvement of the musical creative process and the development of musical skills. The results showed (Table 3) that students in the experimental group had a more positive attitude toward learning and its significance for their personal and professional development.

Table 3

Students' Positive Attitudes Toward the Experimental Training, by Group

Group	*n*	*M*
Beginner	32	3.5
Intermediate	34	3.8

Note. The mean value is the average of the following scores: 1 = *completely disagree*, 2 = *slightly disagree*, 3 = *agree*, and 4 = *completely agree*.

Student participants conveyed mainly a positive attitude to the learning experience. Most responses had values ranging from 3 to 4 on a 4-point scale, indicating students' overall satisfaction with the training. The students believed that digital technologies allowed them to implement their musical ideas, create musical compositions, and develop the skills necessary to work with music software. Nevertheless, some students lacked the skills and level of music education to fully implement their creative ideas. Students

in the beginner group also noted improvements in learning, which is connected with a more detailed elaboration of musical skills as a result of using the mechanisms of traditional training. However, they noted that the process of creating compositions using digital applications is more effective, as traditional learning mechanisms require a thorough development of each musical approach. Nevertheless, these improvements were less noticeable, which may have been due to the duration of the experimental intervention.

After the questionnaires were completed, we engaged the students in a video discussion on the topic Features of Talented Musicians' Development in the New Digital Age: The Mediating Function. Each participant was free to express their thoughts on the best methods and strategies for developing their musical talent. We summarised the participants' points of view and reached conclusions at the end of the video conference. The online discussion also confirmed the high level of support for the use of digital technologies in music education and highlighted the innovation of the training course and the advantages of traditional music education. The study yielded comprehensive results among students in both groups. See Table 4.

Table 4

Participants' Views on Traditional Music Education, Digital Technology, and the Experimental Course

Topic	*n*	Level of support (%)
Advantages of traditional music education	48	65
The use of digital technology in education	52	75
Innovation of the training course	58	80

Note. The level of support is the percentage of participants who agreed with a given statement about the topics listed in the table.

Participants confirmed that the current advancement of digital technology enables musicians to participate in a professional musical environment without formal education. Musical social networks and communities enable even newcomers to showcase their talents to a large audience. However, participants generally concluded that cultivating musical talent is a long process that requires both the student's effort and the skillful guidance of knowledgeable teachers. Intermediate group participants shared eight arguments in favour of traditional music education with a teacher:

1. The teacher provides the student with effective and proven practices and person-centered learning strategies.

2. The teacher maintains the student's intense motivation to learn. The basic motivators are students' personal and creative growth, success in lesson planning, and performance opportunities.

3. The teacher encourages students to become more culturally aware, broaden their horizons, and cultivate their musical imagination.

4. The teacher sets precise learning goals, emphasizes technological learning points, and offers timely feedback and encouragement.

5. The teacher fosters a student's dedication to the art of music and encourages long-term efforts by students to study music.

6. The teacher gives detailed instructions and feedback. The most effective method of teaching music is verbal because it incorporates teacher feedback.

7. The teacher-to-student dialogue facilitates the most effective methods of music education: transfer, collaboration, and induction.

8. The teacher encourages the student's musical abilities to advance.

The Beginner group participants confirmed that the learning experience they gained during the Music-Making: Innovative Technologies and Innovative Skills course significantly impacted their aspirations. It was also determined that their lack of musical skills, knowledge, and abilities limited their ability to put their creative ideas into action. Participants in the Beginner group agreed that digital music creation tools are excellent tools for novice musicians who want to experiment with music creation but lack the opportunity or desire to participate in formal training.

The Intermediate group participants discussed the appropriateness of using digital instruments in formal educational settings. They agreed that combining musical knowledge, skills, and abilities with the capabilities of digital instruments raises musical performance quality to a new level and opens a new future in musical art. The students concluded that modern professional musicians need to develop musical and digital literacy skills. Music educators should consider this as they modernize their curricula to reflect the trends of contemporary digital reality.

In the final stage of the research, an assessment of the acquired musical skills was conducted among students in both the control and experimental groups. Emphasis was placed on skills that facilitate the creation of musical compositions. Results are shown in Table 5.

Table 5

Musical Skills Acquired by Students During Training

Skill	Beginner group			Intermediate group			*t*	*p*
	%	*M*	*SD*	%	*M*	*SD*		
Development of musical ear	30	0.511	0.129	18	0.472	0.118	-1.993	.02
Development of sense of rhythm	23	0.471	0.124	17	0.468	0.116	-1.984	.03
Ability to create musical fragments based on a given theme	5	0.427	0.059	24	0.542	0.137	1.975	.05
Creation of musical arrangements	7	0.432	0.061	21	0.505	0.129	1.953	.04

Development of principles for processing musical works	17	0.454	0.103	20	0.493	0.126	1.938	.04
Skills not developed	18	0.463	0.115					

Based on the results, it was established that the students in the Beginner control group were able to develop basic skills in melody creation. However, these skills were insufficient for executing complex approaches in musical composition. To create musical compositions, control group students required additional analysis of similar compositions to facilitate the creation of their own works. During the creation of musical arrangements, control group students lacked the skills to eliminate extraneous noise, even when using digital technologies.

In contrast, the experimental group demonstrated more advanced results due to their use of interactive mechanisms during training, which led to a more nuanced perception of musical parameters. Enhanced musical ear contributed to a fuller perception of melodies, including the ability to recognize musical intervals and melodic embellishments. The development of a sense of rhythm allowed students to create musical compositions that effectively used strong and weak beats, thereby enhancing the expressiveness of the sound. This ability facilitated the creation of musical fragments and high-quality arrangements without additional preparation, resulting in improved sound quality, with a more balanced tone and reduced extraneous noise.

After analyzing recent scholarly publications, we informed the attendees of the following arguments in support of traditional teacher-led education:

1. According to Chinese researchers, teaching music not only serves as a means of imparting artistic knowledge but also helps students regulate their emotions, which positively affects their psychological health and academic and psychological performance (Sun, 2022).

2. According to Finnish researchers, music instruction enhances general cognitive abilities required for learning activities and positively affects students' nervous systems, auditory system reactivity, and neurocognitive development (Tervaniemi et al., 2018).

3. According to Colombian academics, learning music and an instrument improves a student's rhythmic accuracy, which influences their physical and motor development by enhancing their balance, laterality, and motor skills (Guzmán, 2021).

4. Malaysian scholars maintain that the abilities developed in the study of music can be applied to other fields, both social and cognitive. The learning theory can explain the ability of music education to positively influence students' academic performance. An education in music typically covers a wide range of topics and activities, such as how to play an instrument, sing in a choir, compose music, and read musical notes. These activities foster knowledge, skills, and attitudes that are transferable to other academic domains. The student creates a unique mental model of learning that can be applied to other subjects, such as science, mathematics, and languages by gaining knowledge and skills through independent study and group music practice (Haddad & Heong, 2020).

The recommendations of American, English, and Bolivian scholars to enhance the quality of music education are consistent with students' opinions on the significance of the technological modernization of curricula in music education institutions. Music education focuses on the interaction of people, music, and social contexts. The individual should be the primary focus of educational innovations because everyone has a distinct socio-musical ability resulting from their most intimate aesthetic experiences (Angel-Alvarado, 2020). For students to develop and maintain their musical identities, music education must be accessible and offer opportunities, skills, and support (Pitts, 2017). Modern music education necessitates the use of innovative teaching strategies that make students active participants in the teaching and learning process (Mamani Mamani & Quispe Chambi, 2021).

The participants concluded that musical talents should be developed in an environment that allows students to communicate and interact creatively. The open-source nature of some technology programmes, in the opinion of the Spanish researchers, improves collaborative musical practice by expanding the possibilities for people to produce musical works together. Encouraging collaborative music-making with participants outside the group/class allows the educator to design innovative learning tasks that engage students in more diligent learning (Cuervo et al., 2022). Costa Rican researchers believe that participating in collective musical activities makes a person feel safe, secure, important, needed, and accepted as a group member. Beyond its therapeutic purposes, music has the power to evoke a carefree and joyful mood solely to promote individual and social well-being (Lorenzo de Reizabal, 2022). According to Spanish academics, one benefit of using music technology in educational settings is that it encourages collaborative music-making even with individuals not in the group or class. This enables the development of novel tasks based on singing, choreography, staging, and musical interpretation (Cuervo et al., 2022).

Overall, the participants agreed that an integrated approach to developing creative musical talents is required, one that recognizes the interaction of the student, the teacher, and modern technology.

The way musicians now develop their musical practice has been revolutionized by music software. A study involving music students at the Universidad Nacional del Altiplano Puno found that using digital technology significantly impacted the teaching and learning process. Composing, arranging, and orchestrating music have all progressed as a result. Music computer software makes it easier to create audiovisual compositions. Most importantly, it allows for quick and easy management of notation and symbols (Valdivia et al., 2021). Peruvian researchers believe using artificial intelligence technologies to create music can accelerate the creative process. Systems with artificial intelligence are now among the technologies that are affordable to the general public. These platforms do not require prior technical expertise (such as programming knowledge) or formal musical training. Thus, to engage in creative activities, a user only needs a working knowledge of computers and some basic musical skills (Valdivia, 2022). Canadian researchers say digital technology in music education can help students unlock their creative potential. They contend that digital technology eliminates barriers that arise from a lack of musical knowledge or practices and impedes creativity. Consequently, students who cannot read or write music notation or play instruments can still create music using digital audio stations. Robichaud (2023) suggested using a digital-based explanatory model to understand better the creative process in music when using digital tools.

The ability to implement individual creative practice is the primary benefit of using digital technologies in music education (Mota, 2019). Making music is a creative act that relies on the creator's own ideas. Multimedia and processing technologies within computer technology are only used as aids to music

creation, speeding up and streamlining the creative process. Using computer technology in music production can enhance a musical work's quality and give its creators new creative opportunities (Wang & Zhou, 2022).

Conclusion

This study confirmed the hypothesis about the positive impact of digital technology on the development of the musical creative process and musical skills of students. Participants in the experimental group showed a more positive attitude toward learning and its significance for personal and professional development because interactive technologies were used in training. Students in the control group exhibited lower levels of engagement in learning, as traditional approaches contributed to a more complex learning process. The research results indicated that the use of different instructional approaches affected the acquisition of varying levels of musical skills, which in turn influenced the professional creation of musical compositions.

The practical and scientific significance of the study lies in its ability to expand the understanding of digital technology and its impact on the process of musical learning and creativity. The information obtained from investigating traditional and innovative teaching methods can be useful for music teachers and educational institutions seeking to optimize their curricula and provide students with maximum opportunities to develop their musical potential. Thus, the results of this study can help modernize educational programs in music institutions and design new methods and tools for teaching music using digital technologies. In addition, they can serve as a basis for creating additional teaching materials and resources for self-study. Further research may focus on the impact of various types of digital technologies on specific musical skills, as well as on optimal strategies for using these technologies to enhance music learning and creativity. In addition, it is necessary to assess the effect of digital technologies on musical creativity in different age groups and cultural contexts.

References

Angel-Alvarado, R. (2020). The crisis in music education resulting from the demise of educational institutions. *Revista Educación*, *44*(1), 598–611. https://doi.org/10.15517/revedu.v44i1.39188

Azaryahu, L., Broza, O., Cohen, S., Hershkovitz, S., & Adi-Japha, E. (2023). Development of creative thinking patterns via math and music. *Thinking Skills and Creativity*, *47*, Article 101196. https://doi.org/10.1016/j.tsc.2022.101196

Baek, Y., & Taylor, K. (2020). Not just composing, but programming music in group robotics. *Music Education Research*, *22*(3), 315–330. https://doi.org/10.1080/14613808.2020.1767558

Barabash, O., Weigang, G., Dychko, A., Zhelnovach, G., & Belokon, K. (2021). Modeling a set of management approaches for the effective operation of the environmental management system at the business entities. *Ecological Engineering & Environmental Technology*, *22*(6), 1–10. https://doi.org/10.12912/27197050/141895

Bendel, L., Funk, F., Hug, F., Peters, L., Roth, F., & Zöllner, O. (2022). *Wenn Spotify den Ton angibt: Audiostreaming-Dienste und die Frage nach der persönlichen Autonomie [When Spotify sets the tone: audio streaming services and the question of personal autonomy]*. Hochschule der Medien. https://nbn-resolving.org/urn:nbn:de:bsz:900-opus4-67412

Bresson, J. (2017). *Composition assistée par ordinateur: Techniques et outils de programmation visuelle pour la creation musicale* [Post-doctoral dissertation, Université Pierre et Marie Curie, Sorbonne Universités]. HAL Open Science. https://hal.science/tel-01525998v2

Concina, E. (2023). Effective music teachers and effective music teaching today: A systematic review. *Education Sciences*, *13*(2), Article 107. https://doi.org/10.3390/educsci13020107

Cuervo, L., Bonastre, C., & García, D. (2022). Tecnología digital en la educación musical infantil [Digital technology in music education for children]. *Praxis & Saber*, *13*(32), Article e13201. https://doi.org/10.19053/22160159.v13.n32.2022.13201

Cui, K. (2022). Artificial intelligence and creativity: Piano teaching with augmented reality applications. *Interactive Learning Environments*, *31*(10), 7017–7028. https://doi.org/10.1080/10494820.2022.2059520

Dolata, U. (2021). *The digital transformation of the music industry: The second decade: From download to streaming* (SOI Discussion Paper 2020-04). University of Stuttgart. https://www.sowi.uni-stuttgart.de/dokumente/forschung/soi/soi_2020_4_Dolata.digital.transformation.music.industry.pdf

Fornari, J. (2020). *Softwares e Hardwares musicais livres para o ensino musical [Free musical software and hardware for music education]*. ResearchGate. https://doi.org/10.13140/RG.2.2.32112.89604

Gorbunova, I. B., Davletova, K. B., & Tovpich, I. O. (2018). Electronic musical instruments in the general music education system. In R. Ahmadi, K. Maeda, & M. Plaisent (Eds.), *15th*

International Conference on Education, Economics, Humanities and Interdisciplinary Studies (EEHIS-18). International conference proceedings (pp. 102–106). EEHIS. https://www.uruae.org/siteadmin/upload/4439AE06184023.pdf

Gorbunova, I. B., & Hiner, E. (2018). Music education today: Music computer technology system for learning music Soft Way to Mozart. *World of Science, Culture, Education*, *5*(72), 336–341.

Guzmán, J. (2021). La educación musical y sus relaciones con la ciencia, tecnología, sociedad e innovación [Music education and its relationships with science, technology, society and innovation]. *Mendive. Revista de Educación*, *19*(2), 659–672. https://mendive.upr.edu.cu/index.php/MendiveUPR/article/view/2350

Haddad, M. Z., & Heong, Y. M. (2020). Music and education efficiency: A systematic review. *Journal of Talent Development and Excellence*, *12*(1), 4665–4680.

Junior, I. S., & Schiavoni, F. L. (2019). Sustainable interfaces for music expression. In F. L. Schiavoni (Chair), *Anais do XVII Simpósio Brasileiro de Computação Musical* (pp. 63–68). SBCM. https://doi.org/10.5753/sbcm.2019.10424

Liu, C., Hwang, G.-J., Tu, Y.-F., Yin, Y., & Wang, Y. (2023). Research advancement and foci of mobile technology-supported music education: A systematic review and social network analysis on 2008–2019 academic publications. *Interactive Learning Environments*, *31*(7), 4535–4554. https://doi.org/10.1080/10494820.2021.1974890

Liu, C., Wei, L., & Chen, L. (2021). Research on the application of computer technology in music creation. *Journal of Physics: Conference Series*, *1883*(1), Article 012031. https://doi.org/10.1088/1742-6596/1883/1/012031

Lorenzo de Reizabal, M. (2022). Music education models in the 21st century: The music mediation model for social engagement. *Revista Educación*, *46*(2), 666–686. https://doi.org/10.15517/revedu.v46i2.49922

Maba, A. (2020). Computer-aided music education and musical creativity. *International Journal of Human Sciences*, *17*(3), 822–830. https://doi.org/10.14687/jhs.v17i3.5908

Malaschenko, V. O., Antonova, M. A., Knyazeva, G. L., Belokon, I. A., & Pechersky, B. A. (2020). Theoretical and practical aspects of integrating the computer and music technologies into the instrumental performance training of the pedagogical university students. In V. V. Ryabov (Ed.), *International Scientific and Practical Conference "Theory and practice of project management in education: Horizons and risks"* (Article 01014). EDP Sciences. https://doi.org/10.1051/shsconf/20207901014

Mamani Mamani, E., & Quispe Chambi, R. (2021). Application of ITC in music reading. *Horizontes: Revista de Investigación en Ciencias de la Educación*, *5*(19), 892–900. https://doi.org/10.33996/revistahorizontes.v5i19.245

Mota, C. B. (2019). O Uso de Softwares na Educação Musical [The Use of Software in Music Education]. *Revista Educação em Foco*, *11*, 23–32. https://portal.unisepe.com.br/unifia/wp-

content/uploads/sites/10001/2019/05/002_O-USO-DE-SOFTWARES-NA-EDUCA%C3%87%C3%83O-MUSICAL.pdf

Oliveira, A., McPherson, G. E., Ribeiro, L. M., & Oliveira-Silva, P. (2024). Can motivation and intentions of parental support predict musical achievement before the commencement of musical studies at the elementary school level? *International Journal of Music Education*, *42*(1), 17–31. https://doi.org/10.1177/02557614231151446

Pereverzeva, M. V., Davydova, A. A., Zhilina, A. V., Meleshkina, E. A., & Baidalinov, S. N. (2021). Digitalization in the field of music education: Assessment of prospects. In N. A. Orekhovskaya (Ed.), *International Scientific and Practical Conference "Solovyov historical and philosophical readings. Russian and foreign experience in the system of humanities education: History, modernity, prospects" 2020* (Article 02018). EDP Sciences. https://doi.org/10.1051/shsconf/202110302018

Pitts, S. E. (2017). What is music education for? Understanding and fostering routes into lifelong musical engagement. *Music Education Research*, *19*(2). 160–168. https://doi.org/10.1080/14613808.2016.1166196

Robichaud, X. (2023). Créativité musicale à l'ére numérique: Une étude d'explorations sonores conduites par les élèves du primaire à l'aide d'une station audionumérique [Musical creativity in the digital age: A study of the sound explorations of primary students using a digital audio workstation]. *Revue hybride de l'éducation*, *6*(1), 92–116. https://doi.org/10.1522/rhe.v6i1.1259

Stevens, R. S. (2018). The evolution of technology-based approaches to music teaching and learning in Australia: A personal journey. *Australian Journal of Music Education, 52*(1), 59–69. https://files.eric.ed.gov/fulltext/EJ1269612.pdf

Suguna, D. (2018). Role and importance of music in educational institution. *International Journal of Creative Research Thoughts*, *6*(2), 422–426.

Sun, J. (2022). Exploring the impact of music education on the psychological and academic outcomes of students: Mediating role of self-efficacy and self-esteem. *Frontiers in Psychology*, *13*, Article 841204. https://doi.org/10.3389/fpsyg.2022.841204

Suvorov, V., Skakalska, Z., Pyavka, M., & Dushniy, A. (2022). Theoretical and methodological aspects of the use of digital educational technologies in the process of musical-instrumental training of applicants for the higher education of the future. *Futurity Education*, *2*(4), 91–100. https://doi.org/10.57125/FED.2022.25.12.08

Tervaniemi, M., Tao, S., & Huotilainen, M. (2018). Promises of music in education? *Frontiers in Education, 3,* Article 74. https://doi.org/10.3389/feduc.2018.00074

Valdivia, P. R. A. (2022). El futuro de la industria musical en la era de la inteligencia artificial [The future of the music industry in the era of artificial intelligence]. *Artnodes, 30*, 1–9. https://www.researchgate.net/publication/362289078_El_futuro_de_la_industria_musical_en_la_era_de_la_inteligencia_artificial

Valdivia Terrazas, R. F., Ponce, W. C. C., & Reyes, B. V. (2021). Musical software in the teaching-learning of music students of the National University of the Altiplano Puno. *Comuni@ccion: Revista de Investigación en Comunicación y Desarrollo*, *12*(1), 25–36. https://doi.org/10.33595/2226-1478.12.1.471

Waddell, G., & Williamon, A. (2019). Technology use and attitudes in music learning. *Frontiers in ICT, 6*, Article 11. https://doi.org/10.3389/fict.2019.00011

Wang, Y., & Zhou, P. (2022). Research on the application of computer technology in music creation. In Z. Pei (Ed.), *International Conference on Mechanisms and Robotics—ICMAR 2022* (pp. 754–759). SPIE. https://doi.org/10.1117/12.2653046

Westerlund, H., & Gaunt, H. (2021). *Expanding professionalism in music and higher music education: A changing game.* Taylor & Francis.

Wu, Y.-h., & Tao, T.-t. (2022). Improving music education using virtual reality techniques. *Música Hodie*, *22*, Article e73536. https://revistas.ufg.br/musica/article/view/73536

Zhao, H., Narikbayeva, L., & Wu, Y. (2022). Interactive systems for music composition: A new paradigm in music education. *Interactive Learning Environments*, *32*(4), 1194–1203. https://doi.org/10.1080/10494820.2022.2115081