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Innovative Pedagogies in Musical Education: Integrating Technology for Enhanced Learning Outcomes

Pedagogias inovadoras na educação musical: integrar a tecnologia para melhores resultados de aprendizagem

Kaili Chen
Musical and Dance College, Huaqiao University, Xiamen, China
kailichen@onmail.com

Abstract: This article aims to examine the effectiveness of innovative pedagogy in music education through the integration of digital technologies in piano instruction. The training was conducted with students who were taught using interactive technologies (Group 1) and did not use interactive technologies (Group 2). The innovative training incorporated digital applications such as Pianote, Smart Pianist, Firehawk, and Music Piano Master. The educational process aimed to develop students' motor skills in piano playing, explore stages of working on musical pieces, enhance melody intonation skills, and increase the complexity of musical compositions. The Gold-MSI v.1.0 test was employed to evaluate student performance, reflecting the level of musical information acquisition by the students. Group 1 students performed higher according to the Gold-MSI v.1.0 test criteria. The calculation of Cronbach's alpha coefficient indicated that Group 1 students achieved high levels of musical skills (0.792), musical engagement (0.903), professional competence (0.867), emotional responsiveness to music (0.881), and overall musical development (0.849). Researchers found that 89% of Group 1 students confirmed the high quality of such training, emphasizing creativity and a systematic approach. In contrast, 53% of Group 2

students rated the training as neutral, which was associated with a lack of motivation. The practical significance of this work lies in the potential adaptation of the applied approaches to piano instruction for a larger number of students through various digital applications.

Keywords: digital applications; motor skills; personalized approach; piano playing; stylistic features.

Resumo: O objetivo deste artigo é examinar a eficácia da pedagogia inovadora na educação musical através da integração das tecnologias digitais no ensino do piano. A formação foi realizada com alunos que foram ensinados utilizando um método inovador (Grupo 1) e um sistema tradicional (Grupo 2). A formação inovadora incorporou aplicações digitais como Pianote, Smart Pianist, Firehawk e Music Piano Master. O processo educativo teve como objetivo desenvolver as capacidades motoras dos alunos na execução de piano, explorar etapas de trabalho em peças musicais, melhorar as capacidades de entoação da melodia e aumentar a complexidade das composições musicais. Para avaliar o desempenho dos alunos, foi utilizado o teste Gold-MSI v. 1.0, que reflete o nível de aquisição de informação musical por parte dos alunos. Os alunos do Grupo 1 demonstraram melhor desempenho de acordo com os critérios do teste Gold-MSI v.1.0. O cálculo do coeficiente alfa de Cronbach indicou que os alunos do Grupo 1 atingiram níveis elevados de competências musicais (0,792), envolvimento musical (0,903), competência profissional (0,867), capacidade de resposta emocional à música (0,881) e desenvolvimento musical geral (0,849). Verificou-se que 89% dos alunos do Grupo 1 confirmaram a elevada qualidade desta formação, dando ênfase à criatividade e a uma abordagem sistemática. Em contraste, 53% dos alunos do Grupo 2 classificaram o treino como neutro, o que se associou à

falta de motivação. O significado prático deste trabalho reside na potencial adaptação das abordagens aplicadas ao ensino do piano a um maior número de alunos através da utilização de várias aplicações digitais..

Palavras-chave: aplicações digitais; habilidades motoras; abordagem personalizada; tocar piano; características estilísticas.

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1. Introduction

Using innovative technologies in Chinese music education facilitates re-evaluating traditional teaching systems. Implementing modern technologies aims to enhance professional competence by diversifying educational approaches and engaging with musical forms and sounds (Cui, 2023). The advantage of innovative technologies lies in their focus on developing practical skills, enabling a detailed study of musical information. This new format of educational methodologies affects the structure of students' thinking, encouraging creative development. It also provides opportunities for self-directed learning, ensuring a consistent focus on studying educational materials. Integrating various educational resources allows for comprehensive learning, which entails the interconnection of theory and practice (Qiu and Wei, 2022). Additionally, through different exercises, students can generate diverse musical ideas, considering critical and aesthetic criteria, which is essential for Chinese music.

By completing individual practical tasks using interactive technologies, students can alter their musical style based on the improvement of their musical skills (Yao and Li, 2023). This occurs through understanding the students' initial musical abilities, enabling the selection of more personalized exercises. These exercises may be related to developing technical skills through modeling artistic exercises, intonation, or improvisation (Liu et al., 2023). A personalized approach significantly impacts students' interest in acquiring new knowledge. The time required for students to develop musical skills using interactive technologies may vary, depending on their innate musical abilities and the teacher's approach (Olvera-Fernández et al., 2023). Education should combine auditory, visual, and performance-based methods to facilitate rhythmic development during vocal or instrumental performance of melodies. The objective of such education is to foster creative thinking and emotionality. Deep reinforcement of theoretical knowledge influences students' cognitive activity, enhancing the quality of musical interpretation (Yoo, 2022).

During musical instrumental training, attention should be given to the development of playing skills and to attentiveness and creativity. Piano playing allows for the conveyance of the uniqueness of Chinese music while preserving its spirituality and artistic imagery (Hu, 2023). A pertinent example is the piano composition "Clouds Chasing the Moon" by composer Chen Gang. The work's spiritual dimension is realized by deploying the pentatonic scale and modal structures characteristic of Chinese music. Moreover, imitating traditional Chinese instruments—most notably the pipa—imbues the piece with heightened expressive coloration via judicious trills and arpeggiated figures. A poetic soundscape is further cultivated by employing "blurred" harmonic progressions. Technically, the attainment of both spirituality and artistic expressiveness relies on integrating melismatic passages, rhythmic freedom, the emulation of instrumental melodic lines, and the nuanced application of the half-pedal. In this way, pianistic performance not only preserves the national character of the source material but also functions as a medium for cultural self-expression (Guobin et al., 2025). This is achieved through nuanced performance techniques, ensuring a multifaceted sound. By developing students' skills in the associative perception of melodies, the quality of piano playing and harmony of performance is enhanced. This approach subsequently enables the conveyance of the music's spiritual essence to the listener.

In piano training, attention should be paid to folk philosophy, which influences the expressiveness of interpretation and helps preserve the spiritual foundation of Chinese culture (Barberá-Pastor et al., 2024). Therefore, selecting digital technologies should involve choosing the most effective interactive technologies focusing on repertoire work. Proper repertoire selection expands musicians' capabilities, gradually aiming to enhance piano skills through diverse rhythms and melodies. The choice of educational technologies should facilitate the development of emotional performance, which can be realized through timbral embellishments (Susino et al., 2024). Techniques for enhancing sounds should be developed to provide additional brightness.

Digital technologies offer numerous advantages for the production of musical sounds and forms, the development of characteristic interpretation, and the combination of traditional and contemporary motifs.

1.1 Literature review

Innovative technologies contribute to the development of a conscious perception of educational materials by allowing the regulation of individual musical skills. In musical training, digital technologies facilitate body coordination and influence diaphragmatic breathing training (the application of diaphragmatic activation to cultivate slow, deep inhalations) and movement coordination. These technologies enable a natural musical interpretation of both traditional and contemporary pieces. These skills can be developed by tracking students' movements using sensors and capturing the sounds they produce. This allows students to adjust the quality of their instrumental performance (Wang, 2024b).

Virtual learning (training that involves virtual reality technology) incorporates mechanisms of constructive learning theory based on the complex dynamics of student-teacher interactions, various technologies, and motivational factors. Digital technologies influence time management and the innovative perception of educational materials. Interactive learning fosters intonation skills, enhancing expressive musical interpretation (Ngobeni, 2024). According to Cao's (2024) research, the effectiveness of applications such as Superstar Learning and Dingding was established. Implementing remote music education through digital technologies positively impacted students' motivation and academic performance. Both the control and experimental groups showed nearly identical results; however, the experimental group developed skills in reading musical notation more freely. Additionally, using digital technologies allowed for the development piano skills in a shorter time frame (Cao, 2024).

The utilization of modern technologies in remote piano instruction is associated with the possibility of acquiring new knowledge within a shorter period. The application Flowkey integrates technological and psychological aspects of learning, promoting improvisation and self-control. Using Flowkey enabled 83% of the 120 students to achieve high results, with developed skills in melody recognition, rhythm, and tempo improvement (Zhang and Gao, 2024). Innovative educational strategies enhance the development of creative abilities and student motivation. Such methods include modern technologies aimed at mobility and flexibility, such as the applications Pocket Pitch and SoundCloud, which improve the educational approach.

This type of education also facilitates personal development, the level of which was determined using questionnaires on the formal-dynamic properties of personality, psychological methods regarding professional motivation, and the study of creative imagination. The results indicated high levels of development among students linked to their proficient handling of musical knowledge (Wang, 2024a). Innovations in educational programs impact the development of students' professional skills. For instance, using applications like Yousician, Flowkey, and Music Theory with Piano Instruments led to average results during the learning process, but the highest results in academic concerts were observed. Conversely, violin students achieved high results during the learning process but average results in academic concerts (Li and Sun, 2023).

The development of mixed-reality technologies based on color transmission can be utilized for piano instruction. The Synthesia application allows for the reproduction of melodies by illuminating specific keys, which impacts the direct view of the piano, enabling students to focus on the quality of their play. This application fosters the creative abilities of pianists by executing melodies with complex rhythms (Banquiero et al., 2024). Piano instruction should incorporate a combination of cognitive and motor exercises. Education can be implemented

through a combination of digital and traditional models, ensuring individualized approaches to acquiring musical knowledge. These mixed educational approaches provide extensive knowledge, including music theory, composition basics, music history, and more. Creative abilities can be further developed through exercises in performance, melody selection, and arrangement creation (Worschech et al., 2024).

Organists who are additionally trained in piano playing may improperly adapt their keyboard technique. This is due to organists' use of additional muscle tension for greater dynamic control, which affects the overall sound quality. Audio-cognitive intervention, built on digital capabilities, allows for correcting playing techniques and improving motor control. Audio-cognitive intervention involves using recordings of instrumental performances and their subsequent analysis. Playing musical excerpts softly and loudly on both the piano and organ demonstrated high student performance, reflected in the quality of their play (Kan et al., 2024).

Multimedia technologies, in general, enhance the breadth of sound range, auditory development, and the beauty of instrumental performance during piano training. These technologies enable the correct interpretation of melodies, aiding in preparation for performance. Automatic music annotation impacts the segmentation of audio signals and the potential for expressive melody performance in the future (Liu, 2023).

The pedagogical framework for piano instruction should be grounded in principles of universalism and tailored to the individual needs of each student, a goal that may be realized through the integration of digital technologies (Ma, 2025). During the instructional process, emphasis was placed on repertoire analysis and the enhancement of musical expressivity via varied interpretative strategies, employment of timbral contrasts, and exploration of polyphonic textures. Consequently, students exhibited marked improvements in dynamic control and creative interpretation (Ma, 2025). The MusicFlow application has proven effective for piano pedagogy, enabling learners to develop proper hand positioning and accelerate their overall progress. Moreover,

MusicFlow's compositional-generation features facilitated a more nuanced transmission of both technical and aesthetic performance practices (Song and Wang, 2025).

Digital technologies exert a positive influence on the development of pianistic skills. For instance, the XAPT platform supports a blended-learning model that combines remote and in-person instruction, through which students enhance their sight-reading abilities and rhythmic precision by leveraging the platform's adaptive pedagogical design (Wang and Zhu, 2025). Artificial intelligence contributes to the analysis of student performances and provides targeted feedback on pianistic quality, thereby improving learners' self-efficacy and fostering the consolidation of musical competencies (Wang, 2025). Finally, the AI-driven Flowkey application has been shown to advance technical proficiency and increase student motivation. Its collaborative features promote an emotionally supportive learning environment, and its adaptive algorithms ensure a flexible, personalized instructional approach (Zhang and Li, 2025).

A literature review revealed numerous studies on the positive effects of digital technologies on remote music education. The description of digital technologies in offline education is also common, but the learning mechanisms require further study to improve piano skills.

1.2 Problem statement

Effective music education can be facilitated by using digital technologies, which encompass a set of logically devised instructional mechanisms. The selection of interactive technologies for instruction should be aligned with the specific knowledge set of students at a given moment. This approach will ensure the competent training of musicians, contributing to enhancing both practical and theoretical knowledge. Digital technologies can also be employed for piano instruction, allowing for the portrayal of the nuances of Chinese music. This study aims to investigate the

effectiveness of innovative music education by integrating digital technologies to enhance learning outcomes.

To ensure a quality exploration of the research aim, the authors formulated the following objectives:

- To develop teaching approaches aimed at enhancing piano playing proficiency based on the utilization of applications such as Pianote, Smart Pianist, Firehawk, and Music Piano Master.
- To assess the effectiveness of piano instruction using the Gold-MSI v.1.0 test for students who used interactive technologies (Group 1) and those who did not (Group 2).
- To examine the quality of instruction among students based on a conducted survey.

2. Methodology

2.1 Research design

The first stage involved the development of music education approaches. The authors concluded the necessity of devising their approaches to music education. This decision stemmed from the analysis of existing methodologies, which revealed gaps in the organization of the learning process, both theoretically and practically, necessitating adjustments to instructional approaches (Acquilino and Scavone, 2022; Susino et al., 2024; Yao and Li, 2023; Zhu, 2022). Parameters conducive to developing musical skills were identified from previous research and approaches that do not contribute to quality music education. The authors chose Piano instruction for music education, as the piano is a widely used musical instrument in China, expressing the uniqueness of traditional culture. Based on this, the authors formulated the following educational approaches: development of piano playing motor skills, exploration of stages in musical compositions, enhancement of melodic intonation skills, and complexity augmentation in working on musical compositions for improved sound quality (Figure 1). The instructional topics included:

- Development of hand positioning for proper piano movement formation;
- Study of the characteristics of working on musical compositions of different genres;
- Exploration of the nature of musical sound, focusing on the rhythmic structures of their performance;
- Specifics of imitative polyphony (performance of the main melody in different variations) to ensure brightness in piano playing;
- The role of musical nuances in the variety of instrumental melody execution;
- Influence of intonation on the quality of piano performance;
- Symbolism and artistic embellishments in piano performance;
- Development of practical skills in interpreting complex piano compositions;
- Techniques for creating piano improvisations.

During the preparatory stage, 25 applications were selected based on a set of characteristics corresponding to the potential for developing piano playing skills under the specified topics. Subsequently, a random selection of 4 applications (Pianote, Smart Pianist, Firehawk, and Music Piano Master) was made to complement the curriculum of Group 1. The pedagogical objective of the Pianote application is to establish correct hand positioning, which constitutes the foundational technique of piano performance. Its instructional design follows a stepwise progression of learning activities, enabling a personalized approach to each student's development. Functionally, the application comprises modules on basic technique (hand positioning), dynamic control and expressivity, and improvisation exercises. Pianote provides a library of piano repertoire, specialized technical drills, and ear-training exercises. Its principal advantage over traditional methods lies in its interactivity, which facilitates real-time collaboration between

students and instructors to refine individual performance skills. Additionally, the application grants 24/7 access to instructional materials and allows learners to progress at their own pace, in contrast to the fixed schedules of conventional studio instruction.

The primary aim of the Smart Pianist application is repertoire advancement, thereby enhancing the learner's musical engagement. It supports the study of new works, enables individualized instrument voicing for each student, and synchronizes accompaniment with piano scores. Core functionalities include chord recognition via the Chord Tracker feature, automatic score generation through Audio-to-Score conversion, adaptive timbral and effects presets for expressive performance, and access to a diverse repertoire catalog. Compared to traditional pedagogy, Smart Pianist's strengths lie in its capacity for personalized settings tailored to specific compositions and the integration of interactive prompts that facilitate real-time correction of pianistic technique.

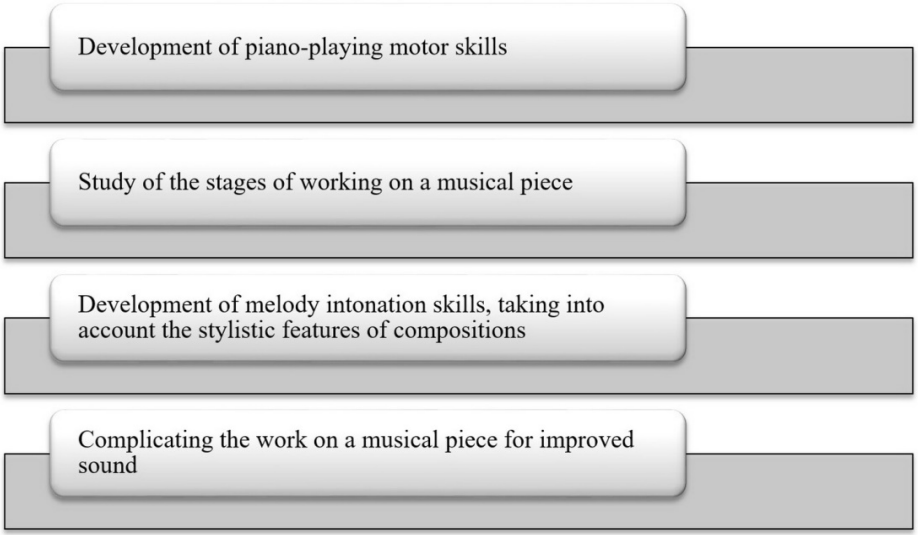
The Firehawk application is chiefly dedicated to the cultivation of musical intonation. It permits the configuration of bespoke exercises targeting specific intonational challenges. Its functional components leverage modeling algorithms to enhance sonic effects, enable fine-tuning of audio signals, provide a cloud-based repository of repertoire, and support the sharing of interpretive melodies. Firehawk's advantages over conventional instruction include its extensive, varied repertoire and on-demand intonation guidance, which adapts to each student's needs.

Music Piano Master is designed primarily to foster improvisational competence. It enables users to generate original compositions and develop creative skills by manipulating selected melodic fragments. The application's core functionality encompasses the adaptation of existing works and the realization of original musical ideas, as well as interoperability with other music-making applications to identify optimal strategies for sonic realization. Relative to traditional instruction, Music Piano Master offers automated tools for melodic variation, thereby reducing the

time required for score preparation and facilitating the selection of effective compositional strategies that support technically accurate and expressive performance.

Students in Group 2 did not use interactive technologies for instruction, employing the same topics for developing piano skills. Thus, the students in Group 2 demonstrated a clear preference for a traditional pedagogical model, which inherently precluded the use of modern interactive tools to augment their practical pianistic skills. Their learning trajectory was largely predicated on direct engagement with the instructor, whereby repertoire was assimilated through the teacher's interpretative framework. Knowledge acquisition relied heavily on systematic repetition, enabling students to internalize specific stylistic conventions and nuances of musical intonation. This method shaped their perceptual and analytical understanding of the music, subsequently informing their performance choices. Instruction was organized around the cultivation of technical proficiency and aesthetic interpretation; however, this instructor-centered approach constrained pedagogical flexibility and limited the potential for tailoring instruction to each student's needs. However, digital technologies were not utilized in the instruction of Group 2 students.

Figure 1 – Components of instruction for improving piano playing skills



The second stage involved skill testing. The effectiveness of student learning was determined using the standardized Gold-MSI v.1.0 test (Li et al., 2024). The selection of the Gold-MSI v.1.0 test was based on an analysis of a set of indicators contributing to the determination of musical competence. The test allows for a multidimensional approach to learning, aiming to assess student engagement and the level of development of musical parameters associated with professional competence, emotional responsiveness, and overall musical development. Additionally, the test characterizes the level of development of musical skills. The original Gold-MSI v.1.0 test can include up to 153 items, but more commonly used is its adaptation, which provides for parameters outlined in our article. The "musical skills" scale is based on the assessment of acquired musical abilities contributing to piano playing learning. Musical skills were further categorized into more pronounced types among the students. The "Musical Engagement" scale reflected the level of student motivation in the learning process. "Professional Competence" was associated with determining the level of piano playing skills development and the ability to perform more complex melodies. The "Emotional Responsiveness to Music" scale implied the students' ability to convey musical experiences and moods of the composition. The overall level of musical development was associated with determining students' broadening of horizons. Each scale of the Gold-MSI v.1.0 test was evaluated to track the improvement in the quality of piano performance. Calculations were determined using the Cronbach's alpha coefficient (Zhu, 2022). The coefficient affects the ability to assess the consistency of each scale. During the calculation of the Cronbach's alpha coefficient, the indicators' mean (M) and standard deviation (SD) were determined.

Additionally, the study aimed to identify the maximum and minimum results obtained by students according to the Gold-MSI v.1.0 test criteria. The assessment of student performance was conducted by 12 instructors with 7 years of experience in teaching piano playing. The testing was carried out after students completed their training.

The third stage involved using a survey method to assess student satisfaction with the new teaching approach based on their experience. Students were required to evaluate the quality of instruction based on the musical skills acquired as a result of specific teaching approaches. Students' evaluations could be categorized as high, neutral, or low based on the piano skills acquired. The survey was conducted remotely via Skype. Statistical calculations were obtained using the Cronbach's alpha coefficient (α).

2.2 Sample

The study involved 196 students who had already undergone one year of piano instruction. Engaging students with pre-existing piano skills aimed to determine the level of their enhancement. Group 1 comprised 96 students who were subsequently instructed to use interactive technologies, while Group 2 consisted of 96 students who did not use interactive technologies in training. The distribution of students into groups was equitable, involving 52 students initially possessing high-level musical skills, 30 students with intermediate-level skills, and 14 students with low-level skills in each group. Students were recruited from the Musical and Dance College, Huaqiao University, with prior arrangements made by the article's authors.

2.3 Statistical processing

The processing of results (both quantitative and qualitative) was conducted using Microsoft Excel. The software facilitated the automation of result grouping and data collection from respondents and enabled the creation of sequential calculations.

2.4 Ethical issues

Ethical considerations entail creating equitable conditions for students in both groups, which includes providing necessary learning tools. Additionally, among the criteria for equity was the distribution of students into groups based on varying levels of initial musical data.

2.5 Research limitations

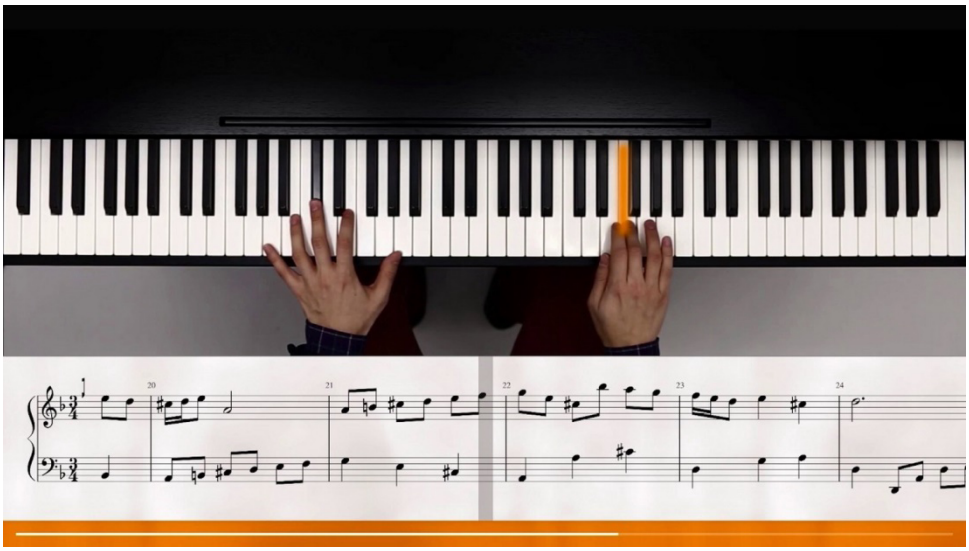
The study's limitations are associated with determining the effectiveness of innovative education in enhancing musical skills through piano instruction. However, the article lacks a comparison of the efficacy of innovative education with other musical instruments, such as violin instruction. Nonetheless, the authors presented results regarding the efficacy of innovative approaches for the experimental group compared to the control group.

3. Results

The authors presented mechanisms of innovative piano instruction to improve outcomes (enhancing piano playing motor skills, studying the stages of working on musical pieces, developing melody intonation skills, considering stylistic features of compositions, and elaborating on the execution of musical pieces for enhanced sound quality). Instruction was based on selecting a set of digital technologies directed towards developing various piano playing skills.

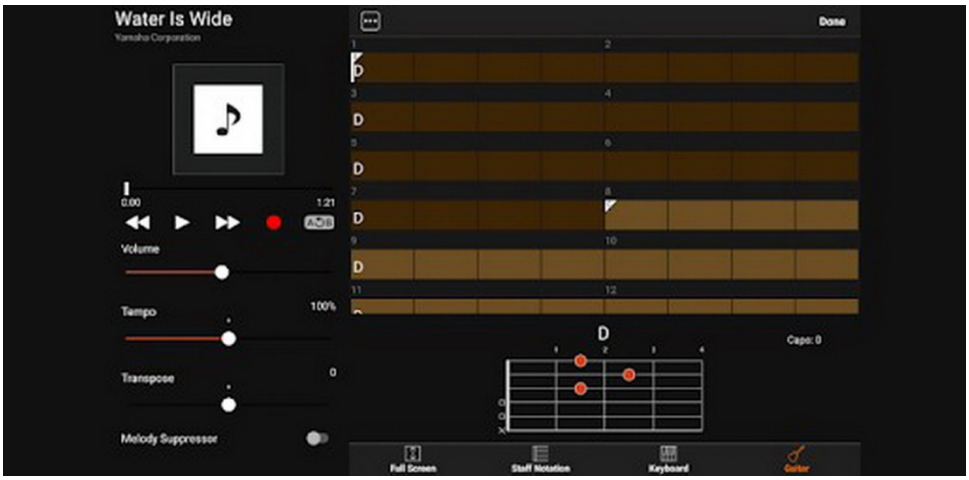
Initially, the authors proposed developing motor skills for piano playing. Piano-playing motor skills entail the establishment of proper coordination of movements to ensure natural muscle operation, focusing on concentration and professional orientation. Interactive video lessons facilitated the refinement of various piano playing skills. Motor skill development was associated with correcting technical movements, implemented through the Pianote application (Figure 2). The Pianote application allows for collaborative learning, influencing immediate feedback reception. Performing suggested interactive tasks (implying the use of modern digital technologies) influences the establishment of proper finger and hand movements. Through the perception of piano melody fragments, students develop fine motor skills, thinking, attentiveness, memory, and imagination. Instruction is based on adjusting each sound, promoting the establishment of piano movements.

Figure 2 – Principle of piano instruction using the Pianote application



Studying the stages involved in working on a musical composition is associated with ensuring a precise analysis of the piano piece. Approaches are directed toward examining the musical structure, rhythm, complex or simple fragments, and chord sequences. The process aims to provide pitch orientation. The Smart Pianist application facilitated the automation of the learning process, thereby influencing the development of playing quality (Figure 3). Preliminary performance analysis contributes to determining approaches to interpretation, allowing for the repetition of individual melody fragments for their high-quality execution. Thoughtful selection also impacts artistic perception, ensuring metrical-rhythmic accuracy in playing (ensuring the exact tempo and rhythm under the indicated notes). Thus, during the performance of melodies, there is variation in musical nuances, leading to a stronger rendition. The logical construction of melodies fosters the development of creative thinking.

Figure 3 – Adjusting work with a musical composition based on the Smart Pianist application

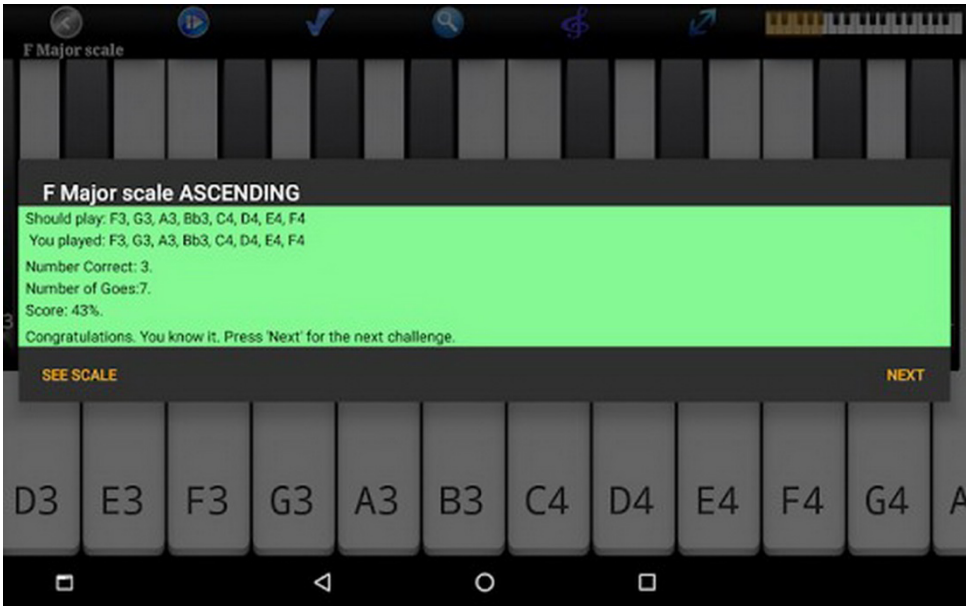


The development of melodic intonation skills, considering the stylistic features of compositions, occurred through working with various repertoires. This stage of education was associated with the formation of the musical ear and understanding the principles of intonation of individual musical phrases. To facilitate learning, students were encouraged to focus on repertoires of different genres aimed at performing intonation exercises. Within this approach to teaching, students could gradually develop skills in individual piano playing. Working on intonation influences the conveyance of the composition's mood, emphasizing particular sounds. Intonation skills were cultivated using the digital application Firehawk (Figure 4). The Firehawk application allows for recording musical compositions, separating them into piano chords for subsequent quality performance.

Figure 4 – Using the Firehawk application for melodic intonation

The elaboration of musical compositions for enhanced sound quality is linked to developing improvisational skills. The refinement of sound quality involves the selection of expressive means, alteration of dynamics, or tempo. This approach was geared towards fostering creative skills for an expressive sonic balance. Exploring creative abilities contributes to the enriched melodic sound, facilitating the conveyance of necessary moods and emotions. This phase of instruction is aimed at active student engagement, enabling them to delve deeper into specific playing techniques and thus nurturing their potential. The Music Piano Master application facilitates engagement with musical compositions through the utilization of a professional key set and interactive tools (see Figure 5).

Figure 5 – Refinement of students' creative skills using the music piano master application during piano training



After completing the students' training, the authors examined the results. The outcomes were presented for both the experimental and control groups. Their acquisition became possible through the Gold-MSI v.1.0 test (Table 1).

Table 1 – Student performance based on Gold-MSI v.1.0 criteria

Research Criteria	Group 1					Group 2				
	M	SD	Min	Max	Cronbach's alpha coefficient	M	SD	Min	Max	Cronbach's alpha coefficient
Musical skills (average value):	48.3	8.5	4.3	4.9	0.792	46.9	9.7	3.6	4.5	0.672
Associative thinking	50.1	7.4	4.4	5.0	0.823	46.7	10.3	3.3	4.3	0.630
Auditory perception of sounds	47.4	9.0	4.5	4.8	0.794	47.2	9.2	3.8	4.5	0.705
Sense of musical rhythm	47.2	9.3	4.1	4.9	0.731	46.1	10.4	3.1	4.5	0.629
Musical memory	48.3	8.1	4.3	5.0	0.819	47.5	8.9	4.0	4.7	0.722
Student musical engagement	53.5	7.7	4.8	5.0	0.903	45.8	9.1	3.7	4.3	0.670
Professional competence	52.8	8.3	4.3	4.9	0.867	46.7	7.9	3.0	4.7	0.710

Emotional responsiveness to music	53.1	7.2	4.6	5.0	0.881	46.1	8.2	3.2	4.5	0.693
Overall level of musical development	51.7	8.6	4.5	5.0	0.849	45.9	8.6	3.8	4.5	0.672

Using the Gold-MSI v.1.0 test, researchers found that students in Group 1, who directly participated in training using digital technologies, developed a higher level of musical skills. This elevated level of musical skills is evident in the development of associative thinking, allowing for the adjustment of musical chords during melody execution for a higher-quality sound. Based on associative thinking, students could establish connections between sounds, ensuring clarity and expressiveness in sound production. Conversely, students in Group 2 could not freely engage in musical associations, impacting their vibrant execution of complex compositions. While both groups of students demonstrated a high level of musical memory development, Group 1 students could utilize learned materials during standard and improvised melody performances. Group 2 students utilized acquired musical information for sequential tasks that did not require a creative approach.

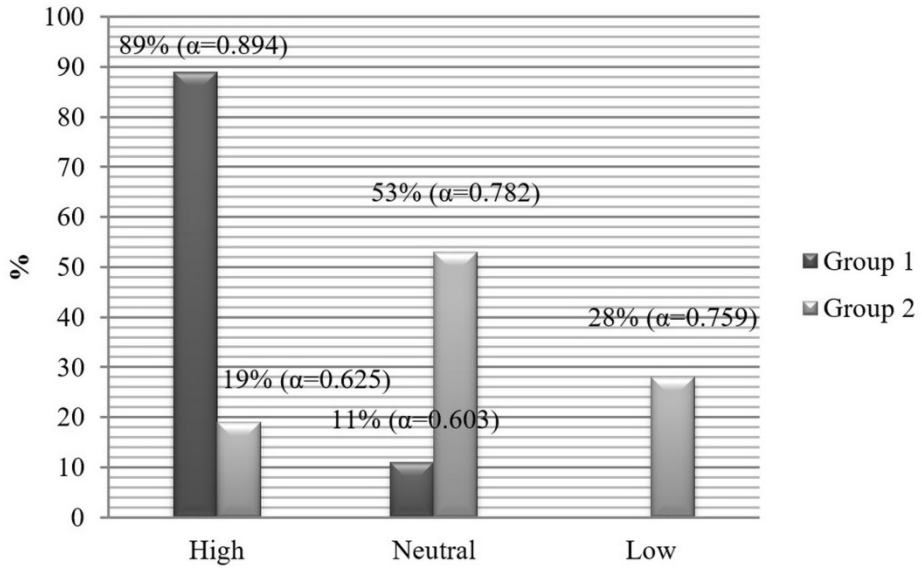
Auditory perception of sounds is linked to the ability to process information and perform instrumental melodies while maintaining intervals and expressive fragments. The sense of musical rhythm in Group 1 students was developed to a higher degree than in Group 2 students, allowing for the creation of intensity and brightness in piano interpretation.

In terms of student musical engagement, an advantage was observed in Group 1. Students were engaged in the learning process, as digital technologies influenced the diversity of instruction. Digital technologies enabled the coverage of a wide range of educational materials, impacting the development of practical skills. Creative teaching approaches influenced personal growth and the gradual development of individual piano playing styles.

The professional competence and overall level of musical development were also more pronounced among students in Group 1. These students developed skills in the precision of melody execution, relying on auditory and rhythmic capabilities. Overall, musical development manifested in the depth of the studied information, allowing for the distinction of specific periods in musical evolution. Emotional responsiveness to music (the ability of respondents to convey the composer's experiences through piano playing) enabled students in Group 1 to imbue their performances with personal experiences. This influenced the overall aesthetics and sensitivity of performance, contributing to the elevation of musical proficiency among students in Group 2.

The survey among respondents aimed to determine the quality of the provided instruction. During the survey, respondents were required to identify the advantages and challenges of such instruction (Figure 6).

Figure 6 – Quality of innovative instruction, based on student indicators



It was established that students in Group 1 perceived the instruction at a higher level, attributed to its organization, systematic nature, and the potential for fostering creative skills.

The high quality of instruction was also evaluated due to the gradual progression in practical skills, which did not necessitate adherence to standard teaching methods. Possible challenges in instruction could be related to the lack of freedom to choose other digital applications with which students were previously familiar. Primarily neutral attitudes towards the learning process were observed among students in Group 2, as they lacked the freedom in instruction and the opportunity to engage in more creative approaches. The instruction was based on a traditional approach, minimizing overall musical development.

4. Discussion

During piano instruction, auditory and sensorimotor feedback plays a crucial role in facilitating motor movements. Artificial intelligence technologies adjust pianists' finger movements, particularly in executing complex and rapid finger motions. Instruction should ensure continuous repetition of movements to enhance the quality of sequential playing (Furuya et al., 2023). Sensorimotor learning (development of piano skills through feelings and motor skills based on the performance of coordinated piano actions with the help of digital technologies) in musical instrument playing aids in overcoming difficulties encountered in traditional instructional methods. An example of such an application is ParoTone, which is known for its simplicity, wide range of capabilities, and portability. ParoTone allows learning specific melodies three times faster and chords five times faster. An additional advantage lies in its ability to combine multiple musical skills for development (Mita et al., 2023). Multimedia technologies offer students opportunities for comprehensive enhancement of musical education functions. Pianists can utilize various technical expression tools during piano instruction, which affect emotional transmission. Systematic instruction increases student motivation, impacting performance and expanding piano skills (Zheng et al., 2022). The presented works describe interactive learning, enhancing the quality of sequential piano playing. The focus in the

cited works and our article is finger motor skill development. In our study, digital technologies were adapted to the developed teaching approaches, involving meticulously planned piano instruction, contrasting with previous works that emphasized the selection of multimedia technologies for overall piano skill acquisition.

The quality of instrumental performance depends on the ability to facilitate students' independent preparation. Assessment of performance revealed that self-regulated learning influences pianists' success by developing skills in foresight. Students were able to cultivate individuality, impacting the emotional expression in piano playing. Developing creative and intellectual potential contributed to proficient performance and minimizing errors (Suzuki and Mitchell, 2022). Creating piano arrangements is essential for a deeper understanding of musical material during piano instruction. Using digital technologies in arranging influences students' creative development, offering opportunities for developing their compositional style and working with melody and tone. Pre-recognition of songs allows for creating quality arrangements, enhancing expressive performance (Cao, 2022). Computer technologies facilitate self-directed music education, stimulating the development of creative skills and subjective consciousness. Thus, instruction influences positive student perception and motivates them to acquire new knowledge. With computer technologies, students can learn to play multiple musical instruments simultaneously (drums, piano, guitar, etc.). They contribute to understanding the musical language, depicting harmony, color, and rhythm (Stavrou and Papageorgi, 2021). The presented works examine mechanisms of musical education based on independent learning and in-depth exploration of music education. In our article, the focus was on interactive learning and the possibility of providing collaborative education.

The study of African music necessitates consideration of the artistic peculiarities of compositions. African musical traditions are interconnected with European music, expanding the understanding of musical practices. Directed learning is essential

for acquiring musical knowledge. Enhancing students' creativity enables more expressive approaches to musical interpretation (Ligeti, 2022). Developing students' critical thinking is feasible through interactive educational concepts. Instruction should focus on a creative approach, fostering students' creative development. Critical thinking is particularly important for enhancing musicians' competence (Zhao et al., 2021). A promising method of music education could be the flipped classroom model with artificial intelligence. Students achieved high results based on the flipped classroom model, leveraging the high level of student engagement in the learning process. Instruction using the flipped classroom model influenced the ability of students to create harmonious harmonies based on developed imaginations, thinking, and musical memory. Achieving skills in harmonious harmonies affects the development of the aesthetics of piano playing, ensuring the conveyance of musical imagery (Lv, 2023).

Reviewing published scientific articles revealed descriptions of the positive influence of innovative teaching approaches on the development of musical skills. Additionally, the works describe skills that students have developed and how they impact the expressiveness of musical education. In our article, approaches to piano instruction were created by applying digital technologies such as Pianote, Smart Pianist, Firehawk, and Music Piano Master. The effectiveness of students in the control and experimental groups was determined through the Gold-MSI v.1.0 test. The test allowed for the assessment of developed musical skills, musical engagement, professional competence, level of emotional responsiveness, and overall level of musical development among students. Additionally, an evaluation of the quality of the instruction presented was obtained from the students.

5. Conclusions

The study aimed to determine the effectiveness of innovative pedagogy in music education. The results were obtained through a comparison of the performance indicators of the two groups.

The instruction of students in Group 1 involved utilizing innovative approaches, employing digital technologies (Pianote, Smart Pianist, Firehawk, Music Piano Master). The instruction aimed at developing piano-playing motor skills, which were reflected in the execution of correct movements and the enhancement of imagination. Exploring stages in working on musical pieces served as a preparatory stage for engaging with various repertoires. The instructional approach influenced thoroughly examining individual musical fragments, ensuring the proper musical structure and chord sequence. The development of melody intonation skills was linked to studying stylistic features of different compositions. This instructional approach impacted the initial formation of individuality in piano playing, which was further developed during the progression of work on musical pieces. Students in Group 2 studied the same topics as those in Group 1, albeit without the opportunity to utilize digital technologies.

Based on the Gold-MSI v.1.0 test, it became possible for the authors to determine the effectiveness of students from both groups. The test influenced the ability to assess the level of musical skills among the respondents, allowing for the identification of the development of associative thinking, auditory sound perception, sense of musical rhythm, and the development of musical memory among the students. Moreover, all indicators of the Gold-MSI v.1.0 test were higher for students in Group 1 than those in Group 2. The musical engagement of students in Group 1 (Cronbach's alpha coefficient was 0.903) was associated with various approaches in instruction and their interactivity. Digital applications contributed to a detailed elaboration of piano skills, reflected in the performance quality. Such an instructional approach also influenced the achievement of a high level of emotional responsiveness (0.881), the formation of professional competence (0.867), and the overall level of musical development (0.849) among students in Group 1.

Researchers found that students in Group 1 (89%) confirmed the high quality of the presented instruction, which was associated with well-organized instruction and motivation resulting from

using digital technologies. Students in Group 2 (53%) had a neutral attitude toward the instruction, which was linked to traditional methodologies. The study's practical significance lies in the potential use of practical, interactive approaches for piano instruction. The research prospects will examine the effectiveness of interactive technologies for piano and violin instruction.

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Research ethics committee approval

The study was conducted in accordance with the ethical principles approved by the Ethics Committee of Huaqiao University (Protocol № 3 of 11.09.2023).

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