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ABSTRACT

Artificial Intelligence (AI) technology can reshape music education to enable students to learn musical instruments and compose music in a fun and easy way. This article examines the effectiveness of AI-enabled music teaching. The study seeks to incorporate AI-powered chatbots into piano classes in seven music schools and evaluate their effect on student performance. The results show that students who used the given app achieved better results than those enrolled in conventional classes. Overall, exploiting AI resulted in a 15% increase in academic performance, but the intensity of training led to variation in achievements. With this app, the scores increased as follows: piano playing by 6.51%; solfeggio and music literature by 4%; and vocal signing by 0.56%. The integration of chatbots in music education opens new developmental prospects. Based on the present findings, AI can be successfully integrated into music education.

KEYWORDS

Algorithm; analytic hierarchy process (AHP); artificial intelligence; chatbot; messenger

1. Introduction

With technological progress and globalization changing the way society functions, it becomes increasingly vital to use modern technologies, especially Artificial Intelligence (AI) in education. AI has become an increasingly popular tool in recent years, which not only companies but also other entities (such as universities) like to exploit to their advantage (Bamigbola, 2021; Yam, 2019). It became part of the curriculum in natural, social, and technical disciplines. The very concept of artificial intelligence is not explicit or easily defined but is often used to refer to computers that mimic human thinking (Kong, 2020; Somasundaram et al., 2020). AI is also defined as a field of science that attempts to explain and emulate intelligent behavior using computational methods (Kazaka & Vilde, 2021). The knowledge of AI is also used to study, develop, and expand human intelligence, build simulations, design mobile applications, etc. (Kazaka & Vilde, 2021). More often, traditional methods of teaching are replaced or supported by modern technology. Thanks to technological advances, AI is one of the most exciting areas in computer science and electronics (Liang & Zeng, 2021). Some technologies aid art, creativity, and idea generation (Schiavio et al., 2021). AI encompasses a broad range of methods, including evolutionary algorithms, expert systems, heuristics, genetic algorithms, artificial neural networks, and fuzzy logic. The AI research has facilitated the creation of many solutions, which have later found practical applications (Imayo, 2021).

Academic institutions can exploit AI to support a variety of processes, including learning, research, and personnel management (Henriksen et al., 2021). Learners will benefit from using the Semantic Web (aka Web 3.0) in their learning journeys. What sets apart Web 3.0 from the second generation of Internet services (Web 2.0) is that it is decentralized, blockchain-based, and harnesses token-based economics. If Web 2.0 was supposed to help individuals without a computer education (non-programmers) understand information on the Web, then Web 3.0 is designed to provide mutual understanding and data exchange between computers and systems (Miah, 2011).

In a broader sense, Web 3.0 is a third-generation network combining the key technology trends, such as broadband adoption, mobile Internet access, mobile devices, semantic Web technologies, software-as-a-service business models, distributed computing, open technologies, and intelligent applications (Krainov et al., 2021). In Web 3.0, computers generate raw data through their own reasoning (Miah, 2011). Web 3.0 enables devices to exchange data with each other and even create new information. This new kind of machine intelligence will mature as the Internet grows.

As regards music, it is widely known that AI can assist anyone in the creation of unique compositions (Gouzouasis & Bakan, 2011). There is more, though. It can facilitate music teaching. The idea is as follows. The big data analytics associated with AI makes it possible to measure the musical achievements and actual skills level of any student by comparison in a big group. At the same time, in the process of deep learning, AI can rely on streaming assessments of teachers and compare variables related to the quality of assignment among many students. With this knowledge, AI can create its own neural network and generate an individual learning path for a student. Some scholars utilized AI features to model music perception (Wiggins, 1995); a new

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model for music teaching was based on the principle of human-computer interaction. Indeed, music education has nuances, including age-related ones (Chamberlain et al., 2021; Sunray, 2021). With young learners, for example, teachers typically use functional music, also known as music with a purpose. Exposure to musical rhythm was reported to help children's physical and mental development (Van den Hoogen et al., 2017). Music education in primary school should be student-oriented, and progress monitoring should occur systematically (Shang, 2019).

The use of AI is most often closely intertwined with different forms of online learning, making them more effective. A study concerning online music education demonstrated that online learning has motivated gifted students regardless of their location or gender (Ismail et al., 2021). Despite significant advances in online learning technology and pedagogical methods, it is still difficult to teach disciplines like music, dance, and art because they rely heavily on the traditional system of teaching that implies a close personal contact with the teacher. Using artificial intelligence that is capable of analyzing music performances and even the behavior and facial expressions of the performer provides educators with the opportunity to train AI-assisted musicians effectively (Li & Ismail, 2022). Computer-assisted learning is also highly valued by gifted learners, for whom learning music appears as a differentiated learning experience, increasing their motivation and enforcing their rights to a specific form of learning (Ismail et al., 2021).

To some extent, online learning happens in a digital environment to which music teaching methods adapt (Yusof et al., 2022). Previous research highlights the linkage between the quality of online learning and the level of computer competency at the start of training (Ismail et al., 2022).

The recent trends in music education are associated with AI. Out of many increasingly popular things, chatbots can successfully integrate into online learning programs, yet this practice is not common. More progress has been made toward incorporating new 3.0 technologies, such as Semantic Search Engines (Chen et al., 2021; Sabadash et al., 2018). Large international companies are now developing and producing massive intelligent robots for industrial and everyday usage (Huang & Yu, 2021). AI-assisted apps and robots can understand the speaking intentions of users and interact with them through their own neural networks (Lupker & Turkel, 2021). A gradual shift to AI-enabled music education was seen in infant music education (Lupker & Turkel, 2021). In brief, automated music players became emotion-based. They can identify a child's emotions from his/her speech and play functional music from a personalized library. It is also interesting how this library is created. The robots use music-information retrieval (MIR) algorithms to extract digital music audio information for automated technical analysis. The information is then classified based on the independent characteristics of each composition (Guo et al., 2020). In doing so, the AI creates a unique collection of materials suitable for early music education (Schwartz, 2014). Such robots act as music teachers a child may have at home (Zhang, 2020). Combined with the children's living habits, they use specific pitches and rhythms to accompany daily life and enhance music intelligence (Dan et al., 2003). Surely, AI can do more than that (Blackwell et al., 2021), and there are many new and innovative methods of teaching music using AI systems (Zhang & Lu, 2021).

In China, music education programs at elementary and secondary levels include three strands: listening (music appreciation lessons), learning basic theory and history of music, and performing (playing instruments, singing, and playing in an orchestra) (Kasabov, 2019). The current teaching situation is that students enjoy music, but this appreciation does not extend to music lessons. On top of that, there is a need for new teaching techniques, such as multimedia interactive teaching. To help students immerse deeper into the education process, Chinese teachers employ the Orff, Kodali, and Dalcroze approaches. Given the rapid advance of artificial intelligence, scholars suggested moving to AI-enabled 3D music classrooms, assuming that it would ignite enthusiasm in learners (Yu & Ding, 2020). The integration of digital technologies makes it possible to enhance creativity, develop research skills, and optimize the education process (benefits welcomed in inclusive education) (Ye, 2020). Many authors believe that AI will be helpful when integrated into vocational education (Hoey et al., 2018).

It takes time to develop a highly intelligent chatbot, for it builds on a machine learning mechanism (Yu & Ding, 2020; Zhang & Lu, 2021). Recently, the process of machine learning has been accelerated by exchanging accumulated big data between already existing AIs and by using heuristic algorithms that accelerate learning through the multivariate analysis of data from user interaction (Lupker & Turkel, 2021; Shang, 2019). As mentioned earlier, AI can assist artists in composing music. The latest popular AI technology for music is Orb Composer. This music composition software offers multiple music templates to work with. Among them are Piano, Strings, Ambient, Electro, Pop-Rock, and more. Users can also work with different parameters, such as tempo, tone, etc. (Yam, 2019). Because Orb is an AI-assisted tool, users do not have to be experienced musicians to try their hands as composers. The program creates music mock-ups automatically based on the user's musical ideas, which can later be refined by a professional.

In music education, AI helps to analyze the performance of individual users or a group of people; this information can serve as a platform to improve their technique (Ben-Tal et al., 2021; Kim & You, 2021). Algorithms can also be used to compare the work of a composer or a musician with a certain set of target examples, e.g., the most popular music trends (Kim & You, 2021; Zhang, 2020). Such systems remain rather narrowly focused on either facilitating or assisting professional musicians and have not yet gained widespread popularity as potential learning tools (Ben-Tal et al., 2021). The most famous AI-assisted programs are expert systems. They use extensive knowledge in the form of facts and procedures obtained from a real expert. The AI may also ease processes that affect education quality management. Such processes do not necessarily benefit the major activity (teaching and learning) but are vital for the proper functioning of the institution. They can be a function of legal or administrative regulations or requirements (Somasundaram et al., 2020). The contribution of this study is partly to help improve the use of AI and eliminate these gaps and limitations.

To design an intelligent system, a person must know what AI techniques to use, and those advance fast with the rise of computer science and electronics. The advancement of technology opens new prospects for the use of AI, including in university-led research projects to prepare experiments, carry out the investigation, and distribute the findings. Even though the AI techniques are complex, as interdisciplinary tools, they fit very well with the research purposes. Using them enables the creation of individual and integrated applications. Countless examples show that AI integration provides not only technical but also economic benefits (Ernst et al., 2019).

Moving toward Web 3.0 encourages academic institutions to employ chatbots in their daily practices. A bot is a software application programmed to replace any tasks a human would normally perform. A chatbot belongs to a special category of bots designed to have an intelligent conversation with people. Initially, those were simple scripts for moderating IRC channels and chats, but they became more complex with time. Chatbots are often used on web pages as virtual agents to replace human consultants and answer questions about services a particular company provides. Bots become better at emulating human behavior and relationships as AI develops.

The present study aims to incorporate AI elements into music education and look at what difference it makes. The contribution of this research lies in the simultaneous integration of two AI technologies: a chatbot and a neural network used to assess the process of decision-making regarding individual learning path. Studies using a dual approach to AI adoption are scarce; therefore, this article seeks to partially close this research gap. Statistical assessment and adoption of AI-enabled applications to optimize the education process were carried out using mathematical algorithms.

2. Methods

2.1. Research design and sample

This global study took place at the Hunan First Normal University between September 1 and December 30, 2020. The experiment lasted eighteen weeks in total. The study sample consists of piano learning app users from the following countries (Figure 1): China ($n = 98$), the USA ($n = 33$), the UK ($n = 33$), Hong Kong ($n = 33$), Thailand ($n = 20$), Australia ($n = 20$), Spain ($n = 17$), Japan ($n = 17$), Singapore ($n = 6$), and Malaysia ($n = 3$). Chinese users accounted for 35% of the total participants. This composition ensures that there is reliability in the study.

The OPC DA Test Client technology allows real-time data collection using remote equipment; here, sound and video recording devices were used to record student

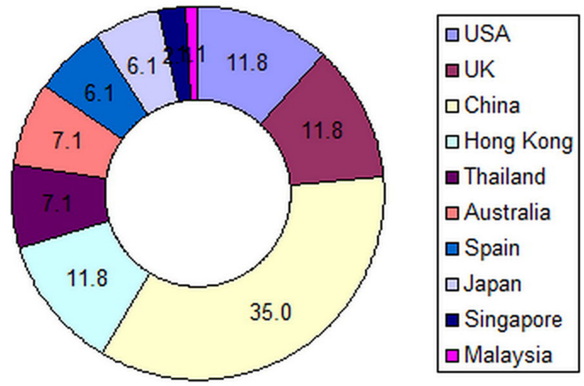

Figure 1. The percentage of piano learning app users by country.

performance (musical compositions or vocal exercises). The PC Worx interface allows the behavior of many devices to be programmed simultaneously and ensures optimal consistency between hardware and software when using multiple remote and networked devices together. With this technology, it is possible to make, compare and evaluate recordings of student performances under a single AI framework. It also allows providing new samples for further use in teaching.

After a student executes another exercise or finishes a conversation with the chatbot, the AI processes information obtained within the three-layer neural network framework to decide on the next step in training. The optimal choice is made by highlighting high marks given by the teacher and by identifying recordings that correspond to the best weighted result possible. Hence, better average performance means a higher quality threshold at each new step of training, but this increase occurs gradually and imperceptibly for each individual participant. By adjusting the quality threshold, higher engagement and motivation were achieved.

Given the non-linear nature of the AI algorithm, it acts as a "black box." In other words, the optimal algorithms found and applied during deep learning cannot be unambiguously described or presented, but their action can be verified by evaluating the final results (i.e., student progress).

2.2. Assessment procedure

The study assessed 98 piano students aged 14–17 across seven music schools in China. Students were enrolled in two 8-week learning programs. The traditional education program involved the performance of instrumental techniques, sight-reading, piano accompaniment, vocal and choral singing, classes in music literature and solfeggio. The elements of AI were incorporated into the standard curricula to enhance piano-playing, sight-reading, and vocal skills of the examined participants, as well as student performance in music literature and solfeggio classes.

The study weighted the following indicators to determine which had the most impact on learning: the method of teaching, content quality, learning goals and objectives, the tone of teaching, conditions for teaching and learning, prospects for inclusiveness, and teaching effectiveness. These indicators were selected based on the requirements for using AI in music education. The indicators were established by the AI during training and subsequently measured across iterations.

The teaching method comprises developmentally appropriate exercises with a specific number of intended repetitions. The content quality refers to the exercise selection criteria, the complexity level of music pieces and lyrics, and the quality of instructions. Learning goals and objectives were determined by the AI according to the main and intermediate learning goals outlined in the program and their compliance with student progress, teacher feedback, and exercise complexity levels. The teaching and learning conditions revolve around the frequency of communication, the number of errors detected during online conversations, and other technical parameters related to student-chatbot interaction. Teaching effectiveness was defined by measuring how well the student has performed while looking at the time they have started (whether it was before or after the instructions were given). The prospects for inclusiveness were determined by exploring how much progress each individual student has made compared to other participants while taking into account their personal characteristics. This composite measure was designed to determine the learning potential of those who differ from the average norm. The tone of teaching was determined by examining instruction texts along with the content of exercises and how both changed over time. The differences in student behavior were also investigated.

2.3. Chatbot building procedure

The piano learning chatbot was integrated into Telegram for students to easily access it. However, 10% of the participants found themselves in a situation where they had to activate a VPN first. The proposed chatbot was built using PC WORX and OPC DA Test Client. The chat bot code is presented below:

```
import telebot

import OpenOPC

from telebot import types

bot = telebot.TeleBot('1643672293:AA
GpuDusP6s0LJGsvgRIZ96gpCTWFTGIAtE')

@bot.message_handler(commands = ['start'])

def send_welcome(message):

bot.reply_to(message, 'Welcome to PLCInformer Bot.')

@bot.message_handler(commands = ['info', 'IO'])

def get_IO_info(message):

markup_inline = types.InlineKeyboardMarkup()

item_yes = types.InlineKeyboardButton(text = 'Yes', callback_
data = 'yes')

item_no = types.InlineKeyboardButton(text = 'No', callback_
data = 'no')

markup_inline.add(item_yes, item_no)

bot.send_message(message.chat.id, 'Do you want to start a
music lesson?', reply_markup = markup_inline)

@bot.callback_query_handler(func = lambda call: True)

def answer(call):

if call.data == 'yes': markup_reply = types.ReplyKeyboard
Markup(resize_keyboard = True)

item_inputs = types.KeyboardButton('Inputs')

item_variables = types.KeyboardButton('Variables')

item_outputs = types.KeyboardButton('Outputs') 30 markup_
reply.add(item_inputs,item_variables, item_outputs)

bot.send_message(call.message.chat.id, 'Choose what you want',
reply_markup = markup_reply)

elif call.data == 'no': pass

@bot.message_handler(content_types = ['text']) def get_
inputs(message): if message.text == 'Inputs': opc = Open
OPC.client() opc.connect('PhoenixContact.AX-Server.21') On_
all = opc.properties('TestResource.Main.ON_ALL', id = 2)

bot.send_message (message.chat.id, f' ON_ALL: {On_all}')
opc.close() elif message.text == 'Outputs': opc = OpenOPC.
client() opc.connect('PhoenixContact.AX-Server.21') Pump =
opc.properties('TestResource.Main.PUMP', id = 2)

bot.send_message (message.chat.id, f' PUMP: {Pump}')

opc.close() 31 elif message.text == 'Variables': opc = Open
OPC.client()

opc.connect('PhoenixContact.AX-Server.21')

Tin = opc.properties('TestResource.Main.TIN', id = 2)

Tout = opc.properties('TestResource.Main.TOUT', id = 2)

bot.send_message (message.chat.id, f' TIN: {Tin}')

bot.send_message (message.chat.id, f' TOUT: {Tout}')

opc.close()

bot.polling()
```

The influence of AI on the education process was measured using the AHP (Analytic Hierarchy Process) algorithm (Kong, 2020; Moussaoui et al., 2018). AHP is an accurate and time-tested approach to quantifying the weights of individual criteria to assess the relative magnitude of factors by pairwise comparisons. Participants were given the opportunity to compare the relative importance of each pair of items using a special questionnaire used in the AHP.

Artificial intelligence linked the indicator estimates with the actual results of learning (performance scores and teacher feedback). The chatbot produces scores quickly after each exercise and adapts its rating system accordingly. The weight categories are then compared according to the procedure described below; these categories change after each survey. Based on the results of the algorithm and the feedback offered by teachers or by students themselves the chatbot advised users to either repeat the previous exercise or move to the next one. The recommendations passed into the chatbot are the standard recommendations that teachers provide throughout the course or those given to the student earlier in the learning process.

2.4. Weighting procedure (standard AHP scale)

The weight of each indicator was calculated using standard AHP. The decision matrices consist of the elements ν_{ij}. The a_{ij} element represents the order of preference between the indicator j and the target. The ν_{ij} values are estimated through pairwise comparison.

The academic performance P of a particular student musician was calculated as follows. The initial level of academic achievement against the j indicator is denoted as $\nu_j(P)$. If the value of j is positive, then, after normalization by formula (3), it is expressed as $u_j(P)$:

$$u_j(P) = \frac{\nu_j(P) - \nu_j^{\min}(O)}{\nu_j^{\max}(O) - \nu_j^{\min}(O)} \tag{1}$$

where: $\nu_j^{\max}$ is the maximum value of j possible and $\nu_j^{\min}$ is the minimum value of j possible.

$$u_j(P) = \frac{\nu_j^{\max}(O) - \nu_j(P)}{\nu_j^{\max}(O) - \nu_j^{\min}(O)} \tag{2}$$

After consulting with the experts, the effectiveness of using AI to teach music was taken as a measure of having M levels. The grey clustering function of the effectiveness indicator j with respect to the k-th level of performance (Zhang, 2020) was $\varphi_j^k(u) = \varphi_j^k\left[u_j^k(a), u_j^k(b), u_j^k(c), u_j^k(d)\right]$. The critical points ($u_j^k(a)$, $u_j^k(b)$, $u_j^k(c)$, and $u_j^k(d)$) of the function $\varphi_j^k(u)$ were calculated according to Equation (3):

$$\varphi_j^k(u) = \left\{0 \;\; u \notin \left[u_f^k(a), u_f^k(d)\right]\right| \left|\left\{1 \;\; u \in \left[u_f^k(b), u_f^k(d)\right]\right|\right| \left\{\frac{u - u_f^k(a)}{u_f^k(b) - u_f^k(a)} \;\; u \in \left[\mathrm{u}_f^k(b), u_f^k(c)\right]\right| \tag{3}$$

Assume that with $u_f^k(a) = u_f^k(b)$, the grey clustering function represents the lowest academic achievement and is expressed as:

$$\varphi_j^k(u) = \left\{1 \;\; u \in \left[0, u_f^k(c)\right]\right| \left|\left\{\frac{u_f^k(d) - u}{u_f^k(d) - u_f^k(c)} \;\; u \in \left[u_f^k(c), u_f^k(d)\right]\right|\right|. \tag{4}$$

With $u_f^k(c) = u_f^k(b)$, the grey clustering function depicts moderate academic success and is expressed as:

$$\varphi_j^k(u) = \left\{0 \;\; u \in \left[0, u_f^k(a)\right]\right| \left|\left\{\frac{u - u_f^k(a)}{u_f^k(b) - u_f^k(a)} \;\; u \in \left[u_f^k(a), u_f^k(b)\right]\right|\right| \left\{\frac{u_f^k(c) - u}{u_f^k(c) - u_f^k(b)} \;\; u \in \left[u_f^k(b), u_f^k(c)\right]\right| \tag{5}$$

When $u_f^k(c) = u_f^k(d)$, the grey clustering function portrays the highest academic achievement and is expressed as:

$$\varphi_j^k(u) = \left\{1 \;\; u \in \left[u_f^k(b), 1\right]\right| \left|\left\{\frac{u - u_f^k(a)}{u_f^k(b) - u_f^k(a)} \;\; u \in \left[u_f^k(a), u_f^k(b)\right]\right|\right| \tag{6}$$

Therefore, the weighted fuzzy correlation coefficient of each indicator with respect to the k-th level of effectiveness will be as follows:

$$\xi^k(u) = \sum_{j=1}^{n} \left(\omega_f \varphi_j^k(u)\right) \tag{7}$$

Under the condition that:

$$\xi(u) = \max_{1 \le k \le M} \left(\xi^k(u)\right), \;\; 1 \le k \le M \tag{8}$$

the level of training effectiveness (expressed through academic performance) is the closest to the i-th level (conditional effectiveness).

2.5. Statistical analysis

All calculations and statistical analysis of data were performed using Statistica and MS Excel. The output includes the Mean, Median, Standard deviation, Variance, Range, and Quartile range. The Pearson's χ^2 statistic and statistical significance test were also applied. The results were considered reliable at $p \le 0.005$ and $\sigma \le 0.05$.

2.6. Ethical issues

The research was approved by the Ethical Committee of Hunan First Normal University. Both written and verbal consent for participation in research was received from students and their parents.

2.7. Limitations

When assessing the influence of AI integration on student performance, no regard was given to non-Chinese music schools. Students were enrolled in a blended course, and no attempt was made to teach music exclusively with the use of the AI-driven app.

3. Results

Table 1 and Figure 2 show student progress after eighteen weeks of training. Each app user had to practice each exercise (scale/arpeggio) at least three times weekly over the course. A specially developed training program contained 15–20 scales or arpeggios for each grade. Users who practiced over 1000 times improved the most throughout the course, with an average score change of 11.56 points. Users who practiced <1000 times showed smaller progress, with an average score change of 2.34–4.3 points.

Table 1 presents the *p*-values (second column on the right), confirming the statistical significance of the detected differences for learning outcomes with and without AI (all of them are significantly less than the $p \leq 0.05$ confidence interval), as well as the chi-square parameter (χ^2), indicating the closeness of the studied values to normal distribution. For the convenience of perception and reduction of space for publication, these two important statistical parameters were not taken out in a separate table but were entered into the table of descriptive statistics results.

According to the statistics presented in Table 1, the increase in each of the measured learning parameters in the groups that used AI to teach music with the chatbot is statistically significant and cannot be considered a random fluctuation.

The results of statistical analysis show satisfactory convergence.

Figure 3 shows the overall performance of piano students learning under different training modes. After eighteen weeks of the entry-level course (Grade 1), pianists using the AI-assisted app to enhance training exhibited a significant improvement with an average score change of 13.2 points. Grade 2–5 students also had good progress with an average score change ranging from 2.5 to 5.56 points. This trend suggests that AI-assisted apps not only can help beginners learn scales and arpeggios but also can promote higher-level training.

The results of the experiment revealed that AI-enabled activities had a stronger effect on piano skills than traditional learning (Figure 4). The difference in scores between traditional and AI-enabled piano lessons is 6.5%.

A weighing matrix was built, which evaluates the effectiveness of the AI-driven music teaching app. The results are presented as follows:

$$A = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 2 \\ 1 & 1 & 2 & 13 & 13 & 12 & 12 \\ 1 & 12 & 1 & 1 & 12 & 13 & 13 \\ 1 & 2 & 2 & 1 & 13 & 133 & 12 \\ 1 & 2 & 2 & 1 & 1 & 13 & 3 \\ 1 & 2 & 3 & 3 & 3 & 1 & 3 \\ 12 & 2 & 3 & 2 & 13 & 13 & 1 \end{bmatrix} = 8.698 \qquad (9)$$

The weight sequence is expressed as:

$$W = \{0.28;\ 0.16;\ 0.7;\ 0.3;\ 0.2;\ 0.3;\ 0.12\}, \qquad (10)$$

where weights for the following indicators are taken into account: the method of teaching (0.28), content quality (0.16), learning goals and objectives (0.7), the tone of the

Table 1. Academic performance comparison (descriptive statistics, *p*-value, and χ^2).

	Traditional learning	AI	MEDIAN var 1–3	SD var 1–3	SUM var 1–3	MIN var 1–3	MAX var 1–3	_25th% var 1–3	_75th% var 1–3	p	χ^2
All participants	24.5	28.81	28.81	42.97	154.31	24.5	101	24.5	101	$1{\cdot}10^6$	0.77
Practiced fewer than 500 times	22.32	26.62	26.62	44.81	150.94	22.32	102	22.32	102	$2{\cdot}10^6$	0.82
Practiced 500–1000 times	25.84	28.18	28.18	43.88	157.02	25.84	103	25.84	103	$1{\cdot}10^5$	0.72
Practiced more than 1000 times	26.88	38.44	38.44	41.59	169.32	26.88	104	26.88	104	$1{\cdot}10^5$	0.85

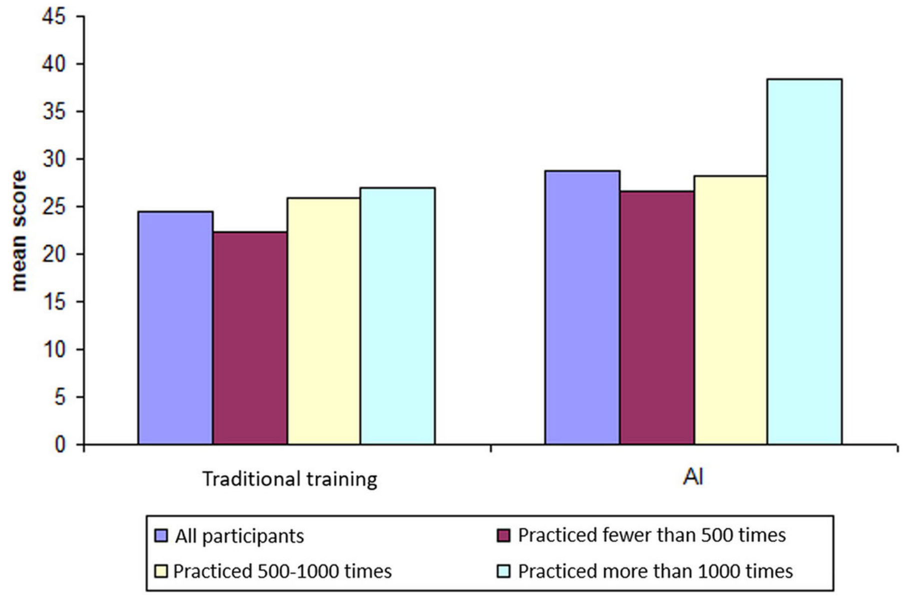

Figure 2. Comparison of overall academic performance in terms of training intensity.

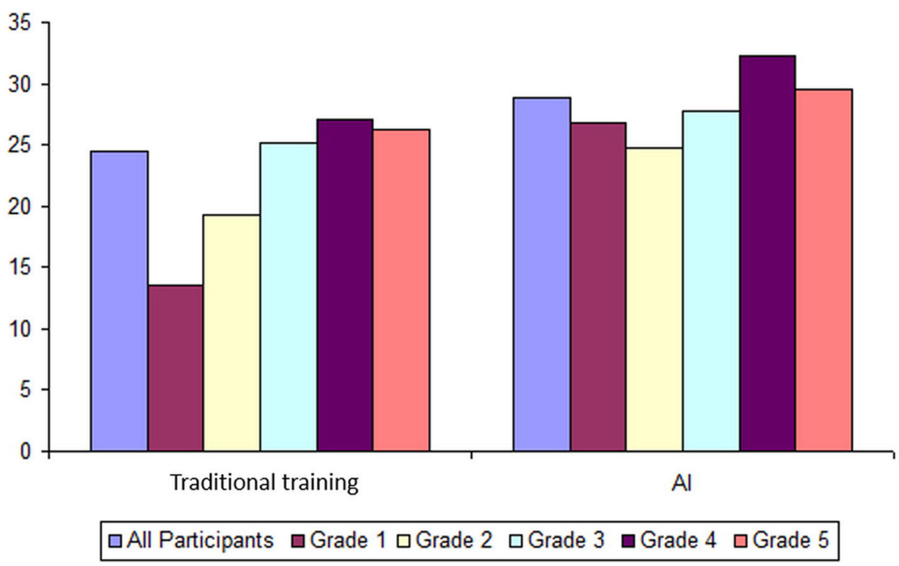

Figure 3. Comparison of post-training performance by grade.

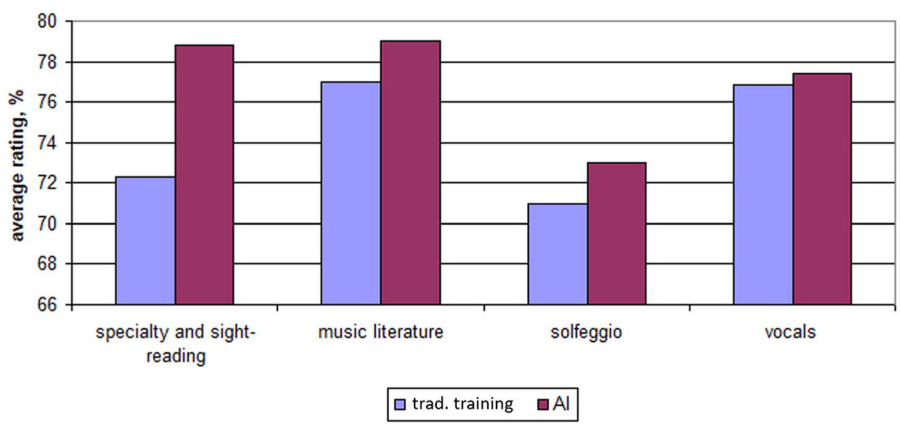

Figure 4. Scores by activity in traditional and AI-enabled classes.

teaching setting (0.3), conditions for teaching and learning (0.2), prospects for inclusiveness (0.3), and teaching effectiveness (0.12).

4. Discussion

The present findings suggest that brining AI into the music classroom shows promise in enhancing the teaching and learning process. At the same time, the existing research focuses more on non-educational applications, such as music genre recognition, differentiation between speech and music, music search, etc. Scholars also study the history of AI usage in music, highlighting its advantages and limitations; the applied aspects receive little attention as a result (Shang, 2019). Some surveys suggest that using AI can benefit gifted students (Yusof et al., 2022; Zhang, 2020). The effect, however, heavily depends on their computer competencies (Krainov et al., 2021; Li & Ismail, 2022).

Universities that seek to adapt their education programs to meet the needs of a broad audience should consider exploiting the latest technologies, including AI. Scientists need to be prepared because Web 3.0 technology will truly expand beyond classrooms. In Web 3.0 learning, students do not guide their own learning, but rather the AI does this for them by identifying their learning patterns and needs and using this information to build an individual learning path (Bamigbola, 2021). Web 3.0 will provide learners with tremendous opportunities to access global knowledge in many countries. Easier access to information degrades the old forms of communication between teachers and students. The need to adapt to the changing market requirements and the growing needs of the networked generation are forcing universities to create a communication environment that feels natural to younger generations, which means the integration of advanced technology.

The results of this study point to the promise of higher quality learning with AI, which coincides with the previous studies where AI has been applied as an element in classroom and online learning (Ben-Tal et al., 2021; Chamberlain et al., 2021; Chen et al., 2021). Because AI is located on a specialized server to which access is provided, the use of AI almost always requires online learning platforms. There are numerous eLearning platforms in the market that offer multiple functions, including the delivery of knowledge in the form of multimedia. The eLearning platforms enable communication between participants in the course and the instructor via discussion forums, one-to-one video calling, video conferences, etc. The most used eLearning platforms are Moodle, OLAT, Claroline, and Dokeos. These platforms use open-source software, but commercial systems can also be tailored to specific needs (Miah, 2011). Using the functionality of these platforms, music teachers can support the synchronous interaction of students during their orchestral or ensemble performance. From this perspective, AI appears to be the future of music education.

The integration of AI into music education is a ubiquitous trend but educators remain very cautious in moving toward AI-assisted learning, only targeting specific forms or aspects of education. In China, organizational processes essential to learning, such as recruitment, curriculum development, and delivery of student support services (Chamberlain et al., 2021), are for the most part computerized (Huang & Yu, 2021). The use of modern technology eases and speeds up teacher-student and peer-to-peer communication. In the current study, all users agreed that the AI-powered app they were offered could help them learn the music instrument. Of those, 95.83% admitted that the app enhanced their creativity and performance. After three months (eighteen weeks) of the experiment, 16.77% of the users said that the proposed app failed to boost their self-organization skills and overcome procrastination. Meantime, 91.66% agreed that the said app could improve their musical memory and build confidence in playing scales and arpeggios. Finally, 95.83% of the users said the app improved their muscle memory, motor skills, and piano fingering. As regards chatbots, they can benefit music schools in multiple ways. For instance, they improve the accessibility of information and support learning in real time. Given the current pace of life and the attitude to communication among younger generations, the above functions are crucial for building an image of a modern person. The results obtained shed light on a need to integrate music education and AI technology to improve the effectiveness of teaching. The proposed algorithms can be used in music apps and software to teach instrumental techniques and music theory.

5. Conclusions

This article explores the possibility of using AI in music education. A chatbot app designed in the study for piano learning was developed with the help of AI. It was used to teach instrumental techniques (piano playing) and sight-reading, vocal signing, music literature, and music theory (solfeggio). The experiments took place with the involvement of anonymous app users and piano students. Thus, 95% of the respondents said the integration of AI optimized the education process. At the same time, 16.77% of students disagreed that participation in AI-enabled lessons could spark a more serious attitude toward learning. The incorporation of chatbots improved student piano performance by up to 8%.

The effect of AI integration on the learning process was examined using the AHP method. The weights represent the following characteristics of the learning process that have been enhanced using the AI-driven app: the method of teaching (0.28), content quality (0.16), learning goals and objectives (0.7), the tone of the teaching setting (0.3), conditions for teaching and learning (0.2), prospects for inclusiveness (0.3), and teaching effectiveness (0.12).

The novelty of this study lies in the fact that it examines the weighted estimators of AI's impact on the efficiency of pianist learning and compares it with a traditional program. The findings suggest that when applied adequately, AI can be more deeply integrated into the training of musicians than was previously thought possible.

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Data availability statement

Data will be available on request.

References

Bamigbola, A. A. (2021). Web 3.0 tools and knowledge conversion by distance learners. *Regional Journal of Information and Knowledge Management*, *6*(2), 21–35.

Ben-Tal, O., Harris, M. T., & Sturm, B. L. (2021). How music AI is useful: Engagements with composers, performers and audiences. *Leonardo*, *54*(5), 510–516. https://doi.org/10.1162/leon_a_01959

Blackwell, A. F., Damena, A., & Tegegne, T. (2021). Inventing artificial intelligence in Ethiopia. *Interdisciplinary Science Reviews*, *46*(3), 363–385. https://doi.org/10.1080/03080188.2020.1830234

Chamberlain, A., Hazzard, A., Kelly, E., Bødker, M., & Kallionpää, M. (2021). From AI, creativity and music to IoT, HCI, musical instrument design and audio interaction: A journey in sound. *Personal and Ubiquitous Computing*, *25*(4), 617–620. https://doi.org/10.1007/s00779-021-01554-z

Chen, H., Li, L., & Chen, Y. (2021). Explore success factors that impact artificial intelligence adoption on telecom industry in China. *Journal of Management Analytics*, *8*(1), 36–68. https://doi.org/10.1080/23270012.2020.1852895

Dan, L., Naiyao, Z., & Hancheng, Z. (2003). A CAD system of music animation based on form and mood recognition. *Pattern Recognition and Artificial Intelligence*, *16*(3), 283–287.

Ernst, E., Merola, R., & Samaan, D. (2019). Economics of artificial intelligence: Implications for the future of work. *IZA Journal of Labor Policy*, *9*(1), 1–35. https://doi.org/10.2478/izajolp-2019-0004

Gouzouasis, P., & Bakan, D. (2011). The future of music making and music education in a transformative digital world. *The University of Melbourne Refereed E-Journal*, *2*(2), 127–154.

Guo, M., Su, H., & Yue, L. (2020). Ecology-focused aesthetic music education as a foundation of the sustainable development culture. *Interdisciplinary Science Reviews*, *45*(4), 564–580. https://doi.org/10.1080/03080188.2020.1820154

Henriksen, D., Creely, E., Henderson, M., & Mishra, P. (2021). Creativity and technology in teaching and learning: A literature review of the uneasy space of implementation. *Educational Technology Research and Development*, *69*(4), 2091–2108. https://doi.org/10.1007/s11423-020-09912-z

Hoey, J., Schröder, T., Morgan, J., Rogers, K. B., Rishi, D., & Nagappan, M. (2018). Artificial intelligence and social simulation: Studying group dynamics on a massive scale. *Small Group Research*, *49*(6), 647–683. https://doi.org/10.1177/1046496418802362

Huang, C., & Yu, K. (2021). Research on the innovation of college music teaching mode based on artificial intelligence. *Journal of Physics: Conference Series*, *1915*(2), 022051. https://doi.org/10.1088/1742-6596/1915/2/022051

Imayo, A. N. (2021). Altyn art magazine–A means to explore the culture, arts, and music education of Kazakhstan. *Pedagogy and Psychology*, *46*(1), 212–219. https://doi.org/10.51889/2021-1.2077-6861.28

Ismail, M. J., Anuar, A. F., & Loo, F. C. (2022). From physical to virtual: A new learning norm in music education for gifted students. *The International Review of Research in Open and Distributed Learning*, *23*(2), 44–62. https://doi.org/10.19173/irrodl.v23i2.5615

Ismail, M. J., Chiat, L. F., & Anuar, A. F. (2021). Music in film' for gifted students: The effect of differentiated learning on students' motivation. *Pertanika Journal of Social Sciences and Humanities*, *29*(4), 2709–2728. https://doi.org/10.47836/pjssh.29.4.33

Kasabov, N. (2019). Evolving and spiking connectionist systems for brain-inspired artificial intelligence. In *Artificial Intelligence in the age of neural networks and brain computing* (pp. 111–138). Academic Press. https://doi.org/10.1016/B978-0-12-815480-9.00006-2

Kazaka, L., & Vilde, I. (2021). Applicability of digital learning strategy 'Start Playing the Guitar!' in Solfeg.io music education app. *International Journal of Smart Education and Urban Society*, *12*(3), 68–78. https://doi.org/10.4018/IJSEUS.2021070106

Kim, H., & You, Y. (2021). Music composition with collaboratory AI composers. In *Proceedings of the Korean Society of Broadcast Engineers Conference* (pp. 23–25). The Korean Institute of Broadcast and Media Engineers.

Kong, F. (2020). Application of artificial intelligence in modern art teaching. *International Journal of Emerging Technologies in Learning*, *15*(13), 238–251. https://doi.org/10.3991/ijet.v15i13.15351

Krainov, G. N., Panov, A. I., & Zubkov, S. A. (2021). Challenges of digitalization for higher education in Russia. *SHS Web of Conferences*, *103*, 02011. https://doi.org/10.1051/shsconf/202110302011

Li, N., & Ismail, M. J. B. (2022). Application of artificial intelligence technology in the teaching of complex situations of folk music under the vision of new media art. *Wireless Communications and Mobile Computing*, *2022*(January), 1–10. https://doi.org/10.1155/2022/5816067

Liang, Q., & Zeng, Y. (2021). Stylistic composition of melodies based on a brain-inspired spiking neural network. *Frontiers in Systems Neuroscience*, *15*(Mar), 639484. https://doi.org/10.3389/fnsys.2021.639484

Lupker, J. A. T., & Turkel, W. J. (2021). Music theory, the missing link between music-related big data and artificial intelligence. *Digital Humanities Quarterly*, *15*(1), 1–2.

Miah, A. (2011). Towards web 3.0: Mashing up work and leisure. In *The new politics of leisure and pleasure* (pp. 136–152). Palgrave Macmillan. https://doi.org/10.1057/9780230299979_9

Moussaoui, F., Cherrared, M., Kacimi, M. A., & Belarbi, R. (2018). A genetic algorithm to optimize consistency ratio in AHP method for energy performance assessment of residential buildings—Application of top-down and bottom-up approaches in Algerian case study. *Sustainable Cities and Society*, *42*(August), 622–636. https://doi.org/10.1016/j.scs.2017.08.008

Sabadash, V., Gumnitsky, J., Lyuta, O., & Pochapska, I. (2018). Thermodynamics of (NH_4^+) cation adsorption under static conditions. *Chemistry & Chemical Technology*, *12*(2), 143–146. https://doi.org/10.23939/chcht12.02.143

Schiavio, A., Biasutti, M., & Philippe, R. A. (2021). Creative pedagogies in the time of pandemic: A case study with conservatory students. *Music Education Research*, *23*(2), 167–178. https://doi.org/10.1080/14613808.2021.1881054

Schwartz, B. (2014). Communicating science through the performing arts. *Interdisciplinary Science Reviews*, *39*(3), 275–289. https://doi.org/10.1179/0308018814Z.00000000089

Shang, M. (2019). The application of artificial intelligence in music education. In *International Conference on Intelligent Computing* (pp. 662–668). Springer. https://doi.org/10.1007/978-3-030-26969-2_62

Somasundaram, M., Junaid, K. M., & Mangadu, S. (2020). Artificial intelligence (AI) enabled intelligent quality management system (IQMS) for personalized learning path. *Procedia Computer Science*, *172*, 438–442. https://doi.org/10.1016/j.procs.2020.05.096

Sunray, E. (2021). Sounds of science: Copyright infringement in AI music generator outputs. *Catholic University Journal of Law and Technology*, *29*(2), 185–218.

Van den Hoogen, A., Teunis, C. J., Shellhaas, R. A., Pillen, S., Benders, M., & Dudink, J. (2017). How to improve sleep in a neonatal intensive care unit: A systematic review. *Early Human Development*, *113*(October), 78–86. https://doi.org/10.1016/j.earlhumdev.2017.07.002

Wiggins, G. A. (1995). Understanding music with AI—Perspectives on cognitive musicology. *Artificial Intelligence*, *79*(2), 373–385. https://doi.org/10.1016/0004-3702(95)90014-4

Yam, S. C. J. (2019). Understanding online information experiences: Simulated, personalized and epistemological. *Interdisciplinary Science Reviews*, *44*(1), 38–54. https://doi.org/10.1080/03080188.2018.1540682

Ye, F. (2020). A study on music education based on artificial intelligence. *IOP Conference Series: Materials Science and Engineering*, *750*(1), 012115. https://doi.org/10.1088/1757-899X/750/1/012115/

Yu, L., & Ding, J. (2020). Application of music artificial intelligence in preschool music education. *IOP Conference Series: Materials Science and Engineering*, *750*(1), 012101. https://doi.org/10.1088/1757-899X/750/1/012101

Yusof, R., Ismail, J., & Radzi, A. M. (2022). Online distance learning: A new learning approach in the Malaysian gifted education system. *FWU Journal of Social Sciences*, *16*(1), 28–46. https://doi.org/10.51709/19951272/Spring2022/3

Zhang, C., & Lu, Y. (2021). Study on artificial intelligence: The state of the art and future prospects. *Journal of Industrial Information Integration*, *23*(March), 100224. https://doi.org/10.1016/j.jii.2021.100224

Zhang, W. (2020). A study on the user acceptance model of artificial intelligence music based on UTAUT. *Journal of the Korea Society of Computer and Information*, *25*(6), 25–33. https://doi.org/10.9708/jksci.2020.25.06.025

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