

ОБЩЕСТВЕНИ КОМУНИКАЦИИ И ИНФОРМАЦИОННИ НАУКИ **PUBLIC COMMUNICATIONS AND INFORMATION SCIENCES**

ARTIFICIAL INTELLIGENCE IN MUSIC EDUCATION

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Abstract: *Artificial Intelligence (AI) is gradually becoming a significant component in music education due to the increasing demand for new technologies and their constant supply. While AI is an important tool, it remains a device, which makes sense only if it is contextualized. The efficiency of music education with AI depends very much on music theory and systemic circulation to research conversion methods between music media, identifying music videos, audio and emotion. AI could collect big music education data, model the teaching process, perform analytical and systemic research, and make quality suggestions on resource allocation. At the same time AI poses challenges related to the authorship and ownership of its products, liability and infringement of copyright protected content, attribution and regulations. Nevertheless, AI needs to be incorporated in any efficient music education model. While AI is gradually entering the creative space, it needs to be applied in a responsible manner, so as not to replace the human expression and reflect context.*

The article provides an overview of key concepts and research related to AI application in music education and analyzes the different uses of AI in teaching and learning. Against the background of existing research, it outlines the structural elements in music education and identifies the pros and cons of AI application in this field, its potential and limitations. Efficient music education and AI are closely related to the use of intellectual property hence the article pays specific attention to the challenges related to intellectual property rights evoked in the process of AI application in music education.

Keywords: *artificial intelligence, intellectual property, education, efficiency*

INTRODUCTION

Artificial intelligence (AI) is quickly becoming an inseparable part in virtually every field of our lives. From dealing with everyday tasks and managing our personal lives to performing tasks related to our professional activities AI becomes a necessity and influences our choices in conscious and unconscious manner. Music education is not an exception and AI is increasingly making its way into this field, which has traditionally been reserved for humans.

Technology has been closely associated with music and has revolutionized the music industry over time. The gramophone, radio transmissions, recording equipment, tape recorders, cassette recorders and CDs are just a few examples of the milestones in technology development, which made music one of the most popular and successful creative industries. In relation to music education probably the first examples of using rudimentary AI are linked to the 60ies of the XX century and the functions of the keyboard (Howie and Rosenblatt 2023). By introducing various contextual musical inputs technology opened up possibilities for emulating environments where education could be more effective.

The topic of AI in music education is an interdisciplinary one and it involves contributions from the fields of music, education, AI, cognitive psychology, the psychology of music, social psychology, anthropology, philosophy, linguistics, human computer interaction, mathematics, computer science and many other fields. AI in Education as a subject has its origins in the 70ies when the first works of Carbonell appeared (Carbonell 1970). It has its own developed methodologies, techniques and traditions. AI in music education is a subset of issues in AI education with an even more recent history.

Music education comprises two parts. One is the process of teaching and the second, inseparable part is learning. In both parts AI has made considerable progress and has become a useful tool for achieving

learning objectives and improving efficiencies. Its main contribution is in improving the engagement and communication between **the educator and the student while using the power of technology.**

The Evolution of AI and Technology in Teaching

With the advancement of technology music teachers have acquired new knowledge on how to build connections with their students, adapt their curriculum and the pedagogy. Teachers tried various individual approaches but results suggest more efficiency in streamlining teaching approach and adopting a single learning management system. Using curated technology resources provides more opportunities for collaboration both with other teachers and with students, while freeing more time and space for focusing on the development of content of the individual courses.

Teaching with AI techniques has now become more complete as contemporary scientific achievements and technology tools are enhancing the process and results of music education. AI was initially used in electronic music, where software applications considerably enhanced the process of music education. This was initially adopted predominantly in private educational institutions. According to the Chinese scholar Jing Wei, AI can provide an optimized environment for professional music education, which yields best results in a network teaching model. His research indicated that the AI enabled scores students' learning outcome rate was 95.2%, the efficiency ratio was 98.1%, the mean square error rate 17.9%, accuracy ratio 95.3% and the teaching performance analysis ratio was 90.7%. This impressive empirical data, obtained through Wei's case study, suggests unequivocally that AI technologies improve music education results (Wei 2019).

The concept of music and AI builds on a combination between music theory using platforms as a subject and AI analysis for studying transfers of the music media, including the identification of music records and audio identification. Research is focusing on such fields as perception, music collection, automated composition, automated recording, and music extraction (Farivar 2020). The results of research on teaching and education of music with AI is used for understanding and analyzing the creative process and improving technologies used for information analysis. AI enabled teaching patterns effectively increase teaching efficiency and performance and spare both teachers and students certain educational and learning functions and responsibilities such as correction of tests, collecting references, updating curriculum and many more. One of the most important outcomes is the increase of interactivity in music education. Students are more engaged and interested when teaching is based on innovation theory methods and AI applications as compared to conventional teaching modes (Billah 2021, Baratè 2020). This is a field of constant research – developing new student involvement strategies through technology.

Another important area with constant improvements is the reinforcement of a personalized approach with AI enabled teaching methods. When using teaching assistant format, personalized music teaching helps students learn faster and each individual student can receive special attention (May 2020). Teachers can identify the excellence and weaker points and stimulate the student innovative performance. Moreover, interactive education and teaching can be applied at every stage of the educational process – from introducing basic concepts, through practice and performance.

For AI-enabled education, music is not an easy area. The problem is that, in general, music demands creative and problem-solving approach both by students and teachers. Music is not a predictable outcome of the creative process. Looking at the advantages, AI-based educational method can offer students additional resources that enhance the passion in education and teaching activity and provide a platform to develop innovative ideas (Asaaf 2019). This is done with the use complex information technologies which are integrated with the educational process. Students can use advanced AI guidance to understand and improve training outcomes and performance abilities. When the educational process takes place in a network teachers can enhance musical abilities through the network teaching resources and platforms, which adds additional benefits in the process.

Interaction is a two-way street. It involves exchanges and discussions to analyze performance, the results of learning and the evaluation of progress. These actions can be carried out in an appealing environment which makes the process even more interesting. Evaluating the learning and teaching impact is a key element in education and teaching. Music teachers can assess more efficiently following different

methods and evaluating students. Some experiments show that instead of using a statistical modeling or other machine learning approaches, a rules-based AI system can give better results. The evaluation is not only based on the embedded theory, but also on the feedback, which adds an interactive feature and enhances the outcomes.

Overview of research

The research on the use of AI in music education has expanded only recently. On the one hand, this is explained by the increased supply and abundance of AI technologies. AI can do things which were unthinkable years ago. On the other hand, there is a notable increase in demand for AI technologies in all fields, incl. the music field. This match between increasing demand and constant supply creates a favourable environment for future dynamic developments in this field. Moreover, since the creative outcomes are unpredictable, they constantly generate demand for new technologies and new teaching and educational products.

Existing research is based on case studies and largely focuses on improving the environment, the performance, the perception and studying the effects produced on the students.

With regards to the environment scholars analyze the effects of instrument arrangements and recordings on music creativity outputs such as, for example, resulting compositions. Some scholars are studying the importance of music classification for music education. Ashraf, M. (Ashraf 2020) experimented with music files that could recover the original music properties and reduce functional categories. The model showed the integrated progress of the neural network against the extraction of functionality and time aggregation. Different information enhancement methods with audio signals were used to use fundamental approaches in extensive applications to improve education. The analysis included other music classification activities, linked datasets, including the condition classification, artist, and instrument recognition. Other studies focused on the use of mobile virtual reality in music education. The results indicated that using VR technology with conventional teaching methodologies could increase musical learning experience in active listening, concentration, and time. AI-enabled applications may evolve significantly and offer improved functionalities for music education (Degli Innocenti 2019).

As far as AI impact on performance is concerned, research has looked into the effects of the simulation of actual music performances. An example is the Google DeepMind project which produced the WaveNet algorithm. The program generates raw audio waveforms that sound highly natural and realistic and are manifested as speech, musical instruments, or a particular sound used to train the AI algorithm (Oord 2023). The WaveNet program trained the algorithm on samples of classical piano pieces and then produced new audio files from scratch in attempts to emulate live instrumentation. This research project compared samples of human-performed piano compositions to samples of piano compositions generated using WaveNet. The results indicated that 73% of participants were able to correctly distinguish the WaveNet sample from the human-performed sample. This shows that there are still improvements that must be made to AI before computer programs can entirely replace human performance (Hawthorne 2018).

Another important research dimension focused on composition. AIVA is one of the first music generating technologies, which can be used by musicians to compose music almost instantly and can easily be customized. An interesting element of this product is that it is linked to a copyright collecting society, which means that the product received copyright attributes and can be easily monetized through the system of copyright. Since AIVA many more AI products have appeared, offering assistance in music composition. This is analysed from a music education perspective (see Zulic 2019). With regards to music performance AI can preempt possible reactions, reinforce the link between the instrument and the emotional state of the performer, introduce elements of control over the instrument played, enhance, and amplify the performance. All these aspects are embraced in music education methodologies.

Regarding perception research has studied the process of how audiences experience concert music. For example, Elkoshi explored the experience of college music students when listening to several performance contributions of different forms. The course included interaction with the description of the music forms, components, and musical style. Students developed the ability to listen to various musical

talents representing all types of compositions. Teachers received immediate feedback automatically and were able to adjust the teaching process for improved structured music performance (Elkoshi 2020).

With regards to the effects on students, researchers have studied the impact of music education in terms of social, cultural, age and language specifics and its impact on social interactions. Zhaoran experimented with machine learning and wireless processing and examined the difference in participating in the music activity and the potential implications of culture, college, age, and language. The results showed that listening and enjoying at home develops positive social interactions, inspiration, and effective education in a certain field, content, and college music (Zhaoran 2021). Another scholar –Tu B. focused on the efficiency of online education. He analyzed distance music education course based on field-programmable gate arrays and wireless sensors. The wireless sensor indicated that students participated in online music education differently. In this experiment, wireless sensors interacted with the students, such as easy access and payment, from a functional perspective. The interactive composition technology drives artificial intelligence, while a computer uses music for a live performance. Several additional A.I. applications cover the way music is marketed and consumed depending on music composition, production, and performance (Tu 2020).

Wang studied the effect of comprehensive teaching platforms using field programmable gate arrays and neural networks to study the educational effects for students in advanced music systems courses. This research analyzed the means of increasing involvement of students in the learning process. The music education was analyzed using the neural network focusing on the intensity of the connections within these teaching networks. This process is referred to as network developing teaching. The application encouraged students to play music and achieved higher involvement, created an interesting atmosphere, bridging to some extent the lack of emotional depth which AI can produce. The experimental results obtained indicated high-efficiency ratio, student learning outcome rate, accuracy, mean square error rate, teaching performance to analyze ratio, false-positive rule, true positive rule and flexibility ratio (Wang 2022). A number of researchers have used Fuzzy Analytical Hierarchy Process (Fuzzy AHP). This method is based on intelligent assessment of qualitative and quantitative information on the basis of designed criteria. It has potential for improving decision-making processes. With regards to music education it has been applied to analyze the effects of instruction provided by the educator on the student/performer (Hong Yun, Alshehri).

One of the conclusions from the various research streams is that AI needs to be constantly improved to fit the context of the educational process. Technology is simply a tool, and a device is not useful if you cannot understand how a given outcome can be achieved in a particular context. Integrating technology in the teaching in an efficient manner puts a strong demand on music teachers to master technology and use it in the specific context of the educational process.

Key AI uses and tools in music education

Having discussed the main areas of research let's review some of the key practical AI uses and tools in music education:

- A more personalized approach to learning and practice

Just like mobile apps can be customized and personalized, AI tools can enhance a more personal approach to music education and practice. A number of platforms, such as Yousician or Melodics can offer interactive tutorials, monitor and evaluate progress and provide feedback. AI algorithms can identify strong and weak points and suggest practice sessions, which focus on the individual specifics of the student. This creates an engaging environment and results in more efficient training. The feedback provided instantly by the platform can reveal information on the music intonation, technique or accuracy in the performance which can improve the overall efficiency of the education in an improved personalized environment.

Chordify is an e-learning platform which can easily transform melodies and songs into chords. Its speed and user-friendliness are appealing to every beginner and it works well with different music genres. Moreover, it is not expensive and anyone can afford it. The technology used is based on deep neural networks. As with any other AI, it is trained on music works, their spectrograms, chord structures and

rhythm patterns. As a result of the training the AI can detect a pattern and apply it to new information – the music performed by the student, and generate the respective chord. Chordify has also a beginners guitar teaching app, which has become immensely popular and can also be used in guitar teaching. The company has also developed an AI-enabled guitar teaching app, aimed at guiding absolute beginners while learning their first chords. It recognizes what you play, then gives feedback to aid your performance. This is indicative of the additional learning avenues AI can open and the presence it could have in the future of music teaching.

- Virtual Music Mentors

The essence of the virtual mentor with AI is to offer the students the possibility to learn the styles of famous musicians and guide the students into mastering these styles without any physical presence. Examples of such applications are Zenph or the Music Room. (https://store.steampowered.com/app/431030/The_Music_Room/). The power of technology enables students to improve their composition skills, while learning from the great masters.

- Music Composition and Arrangement

While music composition remains a highly creative activity with human inputs, AI algorithms can play an important facilitating role. AI technologies analyse huge data bases, according to a set of defined criteria which can include theory, style, performance specifics, mood, etc. On this basis applications as Amper Music or Jukedeck are capable of producing new music ideas and add on features as harmonies, rhythm, effects, etc. This can be a great opportunity to test ideas for music composition and check their musical value with the help of AI. (<https://ampermusic.zendesk.com/hc/en-us>).

- Practice Tools

Any musician needs constant practice to perfection style, technique, understanding and knowledge of the musical work to be performed. With the help of AI the process of music practice, which is the cornerstone of music education can become much more interesting, engaging and efficient. Music practice can be progressive, adding on new features, levels of complexity, new instruments and effects. An example of such tools is The MusicMind Games app. (<https://www.musicmindgames.com/>).

AI lowers the barriers to entry for music creators by enabling high-quality production without the need for professional equipment (Gantchev 2023). There are multiple AI-powered programs capable of generating instrumental soundtracks based on text prompts. While these tools can indeed produce high quality recordings they will not replace the skills and professional touch typical for the professionals in the field.

The efficiency of music education with AI depends very much on music theory and systemic circulation to research conversion methods between music media, including identifying music videos, audio identification, and emotion. It also involves fields of study like perception, music extraction, and automatic design. In general, this is a cross sectoral analysis for music and technology. The AI information interaction, cloud computing, music-big data relationships, and the music-cloud interaction ensure that students understand music and AI. Music extraction is used for accessing music using limited music information. Limited music information such as words, ideas, components, or instances provides several musical knowledge equal to the music information; conventional music recovery involves message keyword deployment, collection of emotional music, software-based music implementation, and various reasons for music training and development. The findings are in the form of language, song, audio, or sequence. The automatic identification of music results performance is a technology for processing and identifying photographs of digital music results. It uses an advanced system to upload pictures of paper music into the application. The music's processing and recognition are performing features converted to a standard music format. It uses AI, image processing, model identification, computer vision theory, theory of music, and other aspects in detail. Media platforms such as virtual reality (VR) and increased reality (AR) have the potential to enhance learning in and outside of the classroom through the enhancement of collaboration or immersive approaches to visual learners. Although there is currently only limited use of music education, major advances in these areas can encourage innovation in teachers' use of media as a tool for learners.

AI could collect big music education data, model the teaching process, perform analytical and

systemic research, and make scientific decision-making regarding music education and the exact allocation of resources. The range of music education data is constantly increased and the processing time is constantly optimized. Aural examinations, such as recognizing and dictating rhythm patterns, musical intervals, melodic patterns, chord characteristics, and harmonic progressions, have been the primary focus of most music education programs in existence.

Intellectual property aspects

The issues related to intellectual property rights are becoming very pertinent in the discussion on AI. The main problem is that laws were made for humans and not for machines. We are trying to apply conventional concepts to a new phenomenon which did not exist at the time of drafting modern and prevailing copyright legislations around the world. The main issues on AI application in music education from the point of view of copyright compliance are:

- Is the underlying content cleared from copyright infringement?
- What is the status of the AI generated product from the point of view of authorship and ownership?
- What rights are exploited or generated in the process of creation of the database from which the AI is trained?
- What attribution is given to protected content?
- What rights are generated and owned in the interaction between the human author and the AI?
- Who is liable in the case of copyright infringement?

The main economic characteristics of AI is that as an input it represents a tool, which can be privately, corporately or publicly owned and can benefit from copyright or other form of IP protection. As an output AI results in a product, which generally does not qualify for copyright protection (Gantchev 2024).

The lack of common standards and regulations are not helping in finding answers to the legal questions on authorship and ownership. Considering the serious damages that may arise in case a new successful music education tool is created one should apply due diligence in selecting the training inputs for the AI and making sure all relevant rights are cleared.

It has to be noted that to the extent to which in music education some of the products of the AI, depending on the jurisdiction, may fall under the educational exception in copyright law, and would therefore not represent an infringement of copyright, as long as they are used only for educational purposes. However, exceptions in domestic law cannot allow unlimited use and reuse of copyrighted content for machine learning (ML). As Gervais points out the demand for material for ML purposes will almost certainly exceed the bounds of exception (Gervais 2020).

Elements of a model for music education

It is challenging to develop one single educational model for music. On the one hand, intelligent tutoring solutions are generally insufficient to teach an open-ended subject as music. On the other hand, an educational model is to be applied with nuances, depending on the context and the established objectives for the particular educational group.

Nevertheless, it appears that the following assumptions are indispensable for each model:

- The purpose of using AI is to increase student engagement in the learning process and the applied effort, which is needed for improving performance and information absorption.
- Teaching and learning need to be translated into an intelligent educational process in music education. Students need to absorb the knowledge of music optimally, consciously, and actively.
- AI applications are only a tool that music student can use to process and edit everything to improve music information processing and expand the selection of music information.
- Students in the classroom can be transformed from an inactive to an active position, not only listening to the teachers' explanations, but learning and understanding the music into an artificial intelligence system, appreciating the music, and experiencing the music that the teacher cannot experience.

What could be the structural elements in an AI supported educational course model?

The design of an online music education module will generally involve the following steps:

1. Creating the curriculum and defining the learning objectives – skills to be acquired, steps in the learning process, criteria for establishing achievements and teaching requirements for the module.

2. Designing the application for the online teaching platform. This involves choosing the general teaching technology for the system, incl. developing and designing the software for music performance teaching, using creative models, cognitive support frameworks, highly interactive interfaces and AI-based music tools. Ensuring connections between different operations through the AI module. Clearing intellectual property rights.

3. Developing the actual online teaching course tutorial, classification of inputs and developing an evaluation system, assessing student attributes of behavior, information, and additional achievements under the corresponding educational purpose. Organizing all styles of musical work in a network teaching system for music playback, the students can perform simulation teaching at a certain time that teachers are teaching playback material, and the student can teach each playback document. Video display and on-site guidance to teachers are exercised for presentations. Registering and clearing intellectual property rights.

4. Integrating teaching and development materials into the online course, technical adaptation for learning and sharing, incl. elements as stage presence emulation, onsite guidance and alike. Connecting the course library, the music library, and the tag library to the AI system for synchronization.

5. Monitoring the educational effect based on the students' understanding and ability to learn music through the module, tracking and reflection systems.

Pros and cons of AI uses in music education

To summarize, here are some of the key dimensions in which AI can assist music education:

- AI makes it more interesting and engaging for both students and teachers.
- AI tools transform abstract things into reality;
- AI tools shorten teaching time and free time allocation of other creative activities;
- AI broadens the scope of music information through software improvements of the processing ability for music data;
 - AI provides an efficient platform for communication and interaction;
 - AI promotes network education – through online learning and improved communication, music teaching is no longer in the classroom;
 - AI tools facilitate the distribution of music works;
 - AI can enhance practice, understanding and evaluating individual performance;
 - AI enabled tools can improve the understanding of the structure and use of the musical elements, their functions and the building of a new musical structure;
 - AI endorses teaching music basics as rhythm and note recognition, pitch training – play in tune with music composition, music recording and links to music content standards;
 - AI tools can help overcome such factors that negatively affect music education as funding (some music courses can be unaffordable for talented but disadvantaged students), timing (if students have to work dayshifts to support their families or fund education), space (best music schools maybe in far-away locations for many students).

Limitations

- AI plays a supporting role in music teaching, but cannot replace the emotional aspects of music teaching, such as music emotion and music content expression.
- Artificial intelligence in music education still needs to be widely recognized and accepted by the industry, it can function best when a certain scale is achieved.
- AI is not yet able to reflect context and its impact in the musical teaching. Only a teacher can understand why the student is in a particular emotional state which may affect the potential for efficient teaching and learning. Teachers can be supported by AI but will always have a leading role in at least three aspects. First, they keep a human connection and emotional bond with the students providing empathy, insights, and inspiration. Second, teachers can adapt in real time to the individual needs of the student,

observe their progress in real-time, take into consideration the context, which impacts on the student ability to learn and adapt. Thirdly, teaching is not just about passing knowledge and acquiring skills. The teacher has always been a fundamental institution in society which contributes to educating students how to be responsible and appreciate social values. In the context of generative AI, teachers can help students identify bias, they can teach them how to respect other people's rights and avoid copyright infringement. Students need to be aware of the possibilities of AI hallucinations, the vulnerability of the technology and unethical uses of AI technologies. Therefore, it is extremely important to invest in teacher development and provide support to teachers to become educators. Artificial intelligence can be an important tool for music educators, but the intellect of the teacher is much more important than the artificial intellect and is the decisive factor for quality education.

CONCLUSIONS

It is certain that the development and use of AI is going to be much faster than the adoption of previous disruptive technologies. The consequence of this is that music educators and students have to understand and master the AI technology if they want to make use of it in the music education process.

The use of AI in music education is indeed revolutionary. It adds on efficiency in the process of learning, practicing, and developing skills. A key advantage of AI is the possibility to separate physically the student and the teacher, create a personalized context, quick feedback, monitoring of progress and new practice environments. The students can thus advance at their own tempo, making use of a completely different environment with virtually endless possibilities. While AI can support teachers in the process of music education it cannot replace the teachers, who add the human interaction, adapt to the emotional state of the students, promote and develop their critical thinking and responsible behavior.

Meanwhile, AI can help students to absorb knowledge more efficiently. It optimizes such processes as grading, instructions and management of time and resources, enabling teachers to focus on more content intensive tasks. Teachers can use AI to support and improve student learning. AI-enabled platforms can help introduce and adapt to individual learning needs, develop creative thinking and improve musical skills.

While AI is gradually entering the creative space, it needs to be applied in a responsible manner, so as not to replace the human expression. This is a matter of concern of creators from different domains. Recently more than 150 organizations representing creative industries launched the "Human Artistry Campaign" (<https://www.humanartistrycampaign.com/>). The campaign developed "Core Principles for AI Applications in Support of Human Creativity and Accomplishment" which reflect serious concerns and are very relevant for the domain of AI enabled music education. While recognizing the empowering function of AI, the principles underscore the central role of human-created works and the need to secure copyright permission for the use of protected content. Ultimately, AI-enabled tools in music education should be built on the basis of respect for the principles, endorsed by the campaign.

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ИЗКУСТВЕНИЯТ ИНТЕЛЕКТ В МУЗИКАЛНОТО ОБУЧЕНИЕ

Резюме: Изкуственият интелект (ИИ) постепенно се превръща в значим компонент в музикалното обучение поради нарастващото търсене на нови технологии и тяхното постоянно предлагане. Въпреки че ИИ е важен инструмент, той си остава средство, което има смисъл само ако е контекстуализирано. Ефективността на музикалното обучение с ИИ зависи в много голяма степен от музикалната теория и системната връзка между изследването на методите за преобразуване между музикалните медии, идентифициране на музикални видеоклипове, аудио материал и емоции. ИИ може да формира големи бази данни за музикалното обучение, да моделира процеса на преподаване, да извършва аналитични и системни изследвания и да прави качествени предложения за разпределение на ресурсите. В същото време ИИ поставя предизвикателства, свързани с авторството и собствеността върху създаваните продукти, отговорността и нарушаването на защитено с авторски права съдържание, кредитирането на авторите и регулациите. Въпреки това ИИ следва да бъде включен във всеки ефективен модел на музикално

образование. Макар че ИИ постепенно навлиза в творческото пространство, той трябва да се прилага отговорно, за да не замества човешкото творчество и да отразява коректно контекста.

Ключови думи: *изкуствен интелект, интелектуална собственост, образование, ефективност*

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