Music Computer Technologies and Streaming Services in the development of Contemporary Musical and Creative Activities

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***Abstract*— In recent decades, musical and creative activities have undergone drastic changes under the influence of the rapid development of digital technologies. Music computer technologies (MCT) has become one of the key factors in the transformation of the music industry, combining software and hardware for creating, processing and distributing sound. At the same time, streaming services have developed rapidly, becoming the main channel for the consumption and distribution of music on a global scale. Streaming platforms such as Spotify, Apple Music, YouTube Music, Yandex Music, and others act not only as distribution tools, but also as active participants in shaping musical tastes and trends. Algorithmic recommendation mechanisms, a playlist system, listening analytics, and feedback from listeners significantly affect the structure and content of musical compositions. Many modern musical trends, such as lo-fi, ambient, glitch, hyperpop, syntwave, and others, have emerged and are actively developing in a digital ecosystem where the listener and the author interact directly and instantly. The development of MCT and streaming services is leading to a transformation of traditional roles in the music industry. A composer, a sound engineer, a performer, and a producer are increasingly combined in one person, and the boundaries between professional and amateur creativity are becoming less defined. This requires a rethinking of approaches to music education, professional training of a musician teacher and assessment of the artistic result of his students.**

***Keywords*— Artificial Intelligence (AI), Creating Music, Modern Musical Trends, Music Computer Technologies (MCT), Musical Education, Transdisciplinarity, Streaming Services in Music.**

I. Introduction

One of the key factors in the transformation of the music industry has become music computer technologies (MCT), which combines software and hardware for creating, processing and distributing sound [1-2]. At the same time, streaming services have developed rapidly, becoming the main channel for the consumption and distribution of music on a global scale.

MCT provides a wide range of tools for implementing creative ideas, from virtual studios and digital workstations (DAWs) to software synthesizers, samplers, and specialized audio processing plug-ins. They allow you to perform a full cycle of sound production — from recording and arrangement to mixing and mastering — without having to access traditional studio resources. This makes musical creative work accessible to a wider audience, promotes the growth of the number of independent authors and producers, and necessitates the mastery of these technologies at the operational level by musical educators of various specialties, whose professional activities involve a fairly wide range of educational and creative tasks aimed at musical education and the education of students in various musical educational institutions: universities, colleges and music teacher training schools, children's musical schools and children's schools of arts, and in the system of inclusive and additional musical education.

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The development of MCT and streaming services is leading to a transformation of traditional roles in the music industry. A composer, a sound engineer, a performer, and a producer are increasingly combined in one person, and the boundaries between professional and amateur creativity are becoming less defined. This requires a rethinking of approaches to music education, professional training of a musician teacher and assessment of the artistic result of his students.

II. The Influence of MCT on the Creative Activities of Musicians

Thus, modern achievements in the field of MCTs open up new perspectives and ways of creative expression, making the process of creating music accessible to a large number of

Manuscript received Aug. 10, 2025.

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people. This field is constantly evolving, providing more and more advanced and convenient tools for creating, processing and distributing music.

A number of studies note that the priority of the influence of a synergistic approach on the strategy of teaching musical art is now becoming increasingly obvious, which is due to the need to apply a transdisciplinary approach that takes into account multicomponent and multifactorial interactions between the components of subject knowledge included in the educational process and the implementation of the principles of openness, non-linearity and instability of the learning process within the context of its self-structuring and selforganization [3-5]. (The transdisciplinary approach to the study of musical phenomena, which is largely related to the identification of a holistic musical image and the further development of an integrative model for the semantic space of music, is considered as a fundamental underlying system of views in the formation of logical principles for the creation of new widely demanded musical and educational directions. A pivotal role in forming this transdisciplinary approach, based on the application of the mathematical theory of fuzzy sets in musicology and music education practice, is attributed by the authors to the Russian musicologist Mikhail Sergeyevich Zalivadny whose research interests encompassed such interdisciplinary areas as the application of mathematical research methods in musicology, formation of a integrative model for the semantic space of music, the use of MCT, which offers a new perspective on preserving, studying, and transmitting musical folklore, transforming folk music artifacts into a living, functioning organism through innovative sound manipulation, thereby expanding the possibilities for a composer's creative work [6-7].)

The relevance of this topic is determined by many factors. Among them, we note the main factor, in our opinion: there is a rapid increase in interest in the process of creating and processing music. This process is facilitated by the active digitalization of the creative environment. According to Spotify, more than 40,000 new music tracks are uploaded to the platform every day, which indicates the high dynamics of music content and a significant increase in the number of authors using digital tools for independent musical creation and production. This process is directly related to the availability of modern MCT, such as DAWs, virtual instruments, sample libraries, and cloud platforms for collaborative creativity.

Thus, the active use of MCT and streaming services in the development of modern areas of musical and creative activities are relevant and promising for their detailed study. They allow us to examine the trends shaping contemporary musical culture and determine the directions of its further development.

A. The development of the MCT became the most important factor in the transformation of musical creativity in the late 20th — early 21st centuries

A comparative historical approach to the study of the development of MCTs, a meaningful analysis of digital musical platforms, research on the mechanisms of streaming services and their impact on musical behavior and user interfaces (Spotify, Apple Music, SoundCloud, etc.), a critical analysis and interpretation of the phenomena of fan activism, streaming services and algorithmic aesthetics – all this allows us to obtain a comprehensive, objective picture of the influence of MCTs and streaming on modern forms of "musical utterance."

The development of the MCT became the most important factor in the transformation of musical creativity in the late 20th — early 21st centuries. Digital tools have not only changed the technical aspects of working with music, but have also radically influenced the nature of artistic thinking, the ways musicians interact with the audience, and the very structure of the music industry.

<u>Changing the process of creative activities of musicians</u>. Digital technologies have allowed musicians to abandon the traditional models of composing and studio work based on a rigid sequence of stages: composition — arrangement — recording — mixing. Now the creative process has become more flexible and non-linear. The use of DAWs, VST plug-ins and MIDI instruments provides the ability to edit tracks instantly. Music creation has become a dynamic, interactive process where every step of a composer can be instantly saved, changed or reinterpreted.

Moreover, digital environments have made it possible to combine a composer, an arranger, a performer and a sound engineer in one person. This has led to increased individualization of creativity and an increase in the number of author's projects, where one person is able to control all stages of creating a piece of music [8-15].

<u>Democratization of music production: the phenomenon of "bedroom producers."</u> One of the most important phenomena of the new musical reality has become the growth in the number of so-called bedroom producers, musicians who create professional music in home studios.

Due to the availability of powerful laptops, inexpensive audio interfaces, controllers, and an extensive database of software tools (VST plug-ins), the need for expensive studio sessions has significantly decreased.

Today, any creative person can record, mix and master music at home, competing in quality with professional studios.

The phenomenon of bedroom producers led to the rapid development of the independent scene: new artists began to distribute their music through streaming platforms without the mediation of major labels. This not only opened the way to self-realization for more musicians, but also enriched the musical culture with a variety of styles, genres and individual approaches.

<u>The emergence of new directions and formats of creativity.</u> MCT became a catalyst for the emergence of new genres and experimental forms of creativity, where sound began to be perceived not only as a carrier of melody, but also as an independent artistic element.

Live sets based on improvisation using DAWs and controllers, interactive audiovisual performances and installations, and works using artificial intelligence (AI) are all examples of how digital tools have expanded the boundaries of musical art.

<u>The transformation of the musician's role.</u> A contemporary musician is increasingly becoming a multifunctional author: he

is simultaneously a composer, sound designer, arranger, performer and sound engineer. This requires not only musical, but also technological skills, as well as the ability to continuously learn and adapt to rapidly changing digital environments.

Thus, MCT has not only expanded the technical capabilities of artists, but has fundamentally changed the way music is created, presented, and perceived in modern culture.

B. Interactive and immersive technologies in musical creative work

The development of digital technologies has opened up new forms of interaction with sound and the audience for musicians and sound designers. Interactive and immersive technologies such as virtual and augmented reality (VR/AR), as well as generative algorithms, are becoming important tools for musical creative work and creating a unique user experience.

Virtual Reality (VR) in musical creative work. VR technologies allow the listener to immerse themselves in fully created three-dimensional audiovisual spaces where sound and image exist in a single ecosystem.

Musicians can design concerts and installations in a virtual environment where each viewer moves freely and interacts with the elements of the space.

Examples of using VR in music:

• Virtual concerts (for example, performances in metaverses such as VRChat, Fortnite);

• Immersive clips and video works;

• VR applications for creating music, where the user interacts with virtual instruments in three-dimensional space (SoundStage, TheWaveVR).

Augmented Reality (AR) in music practice. AR allows you to overlay virtual musical objects and effects on the real world, expanding the experience of live performances or individual listening.

The use of AR in music includes:

• Mobile applications for interactive interaction with songs or albums (for example, to launch hidden layers of a composition through a smartphone camera);

• Concerts with elements of AR graphics integrated into stage shows;

• Development of training programs where learning to play musical instruments is complemented by real-time visual cues;

• Complex musical structures with minimal human involvement.

C. Generative music, algorithmic methods, and artificial intelligence

Generative music is music that is created by a system according to certain rules and algorithms without constant direct human involvement in each stage of sound formation. The term was first popularized by Brian Eno in the 1970s, when he experimented with automated sound creation processes. Generative systems can be simple or complex, based on mathematical models, neural networks, and other forms of algorithmic programming.

Algorithmic methods of musical creative work. Algorithms in generative music range from the simplest forms to the most complex intelligent systems. The most common approaches include:

• Stochastic processes are the use of random or semi—random methods (for example, the Monte Carlo method, Markov chains) to create melodies, harmonies, and rhythmic structures.

• Fractal algorithms — modeling musical structures based on repetitive geometric shapes and self-similarity.

• Rules of cellular automata — using systems like "Conway's life", where simple rules at the local level create complex global musical structures.

• Rule-based systems — descriptions of a musical language through a strict set of rules on the basis of which a composition is based.

Artificial intelligence in creating music. With the advent of machine learning technologies and neural networks, artificial intelligence (AI) has become actively used in generative music. The main applications of AI include:

• Melody and arrangement generation: AI learns from large datasets (for example, classical, jazz, and pop music corpora) and then synthesizes new compositions in the appropriate style.

• Stylization: Models like Google's Magenta or OpenAI MuseNet are capable of creating music styled after famous composers or certain genres.

• Interactive co-authorship: AI assistants help musicians generate ideas, develop phrases, and propose harmonic and rhythmic solutions in real time.

Popular AI-based generative music platforms and tools:

• AIVA (Artificial Intelligence Virtual Artist) is one of the first AI systems officially registered as a composer. Creates orchestral and cinematic compositions.

• Amp Music is a cloud—based platform for creating background and soundtrack music without the need for deep music knowledge.

• Magenta (Google Brain) is an open research project providing a library of tools for creating generative music using TensorFlow.

• OpenAI MuseNet is a neural network capable of composing complex musical compositions in various genres and styles, combining them with each other.

• Endlesss is a real—time collaborative generative music application.

Generative music, algorithmic methods, and artificial intelligence are powerful tools that are radically transforming contemporary musical creative work. They empower composers, producers, and sound designers by allowing them to create complex musical structures with minimal human involvement [16-18].

III. STREAMING SERVICES AS A FACTOR IN THE TRANSFORMATION OF THE MUSIC INDUSTRY

Personalization algorithms.

The development of streaming platforms is directly related to the intelligent personalization system. While technological mechanisms provide stable access to content, personalization algorithms create a unique user experience, turning music consumption into an individualized journey.

Basic principles of personalization. Streaming services analyze the behavior of each user to create individual recommendations. Data such as is collected and processed:

• Listening history;

• duration and frequency of track playback;

• Skipping and repeating songs; • interaction with playlists (adding, deleting tracks); •

• Activity in various genres and time patterns of listening.

This information is structured and used to build a profile of the user's musical preferences.

The main types of recommendation algorithms.

Streaming platforms use several classes of algorithms to generate recommendations:

Collaborative Filtering. It is based on the idea that users with similar musical tastes can recommend music to each other.

The algorithm analyzes intersections in the listening history of different users, identifying similar patterns.

Content-Based. Filtering It focuses on the characteristics of the tracks themselves: genre, tempo, mood, set of instruments, composition structure. The user is offered tracks that are similar in parameters to those already listened to or highly rated.

Hybrid Systems. They combine elements of collaborative and content filtering to improve the accuracy of recommendations. For example, Spotify uses hybrid approaches, complementing them with analysis of social networks and external trend data.

IV. Streaming Services and Machine Learning Models and Neural Networks

Modern streaming platforms are increasingly using the capabilities of machine learning and deep neural networks (Deep Learning and others) to process large amounts of user data and generate personalized music recommendations. Such systems do not just classify music by genre or rhythm, but identify subtle patterns in listener behavior and find connections between compositions that may not have obvious genre or stylistic similarities.

Deep learning allows recommendation algorithms to take into account a wide range of factors: from the time of day and geolocation to the nature of listening (full playback or early switching, repeating a track, adding to favorites, etc.). Based on these data, highly adaptive models are formed that can not only "guess" the user's taste, but also actively shape it, offering content that potentially broadens his musical horizons.

Especially revealing in this context is the OpenAI Jukebox system, a generative neural network trained on hundreds of thousands of hours of musical material in a wide variety of genres. This model is not only able to predict user preferences based on listening history, but also to reproduce stylistically reliable music in a given manner (for example, "in the style of Queen" or "modern soul with funk elements"). OpenAI Jukebox technology demonstrates how deep models move from simple content filtering to active participation in the creation of new musical forms.

Deep Learning. An example of the practical application of such models can be the work of Spotify, which uses the Spotify Deep Learning Recommendation System architecture. This system includes several levels of neural networks: one processes user data, the second processes the acoustic characteristics of tracks (tempo, spectral density, rhythmic structure), and the third dynamically adapts recommendations to the user's current activity.

Thanks to this approach, the platform offers tracks that the listener might not have searched for on their own, but is highly likely to perceive positively. The use of neural networks also allows us to go beyond the traditional genre typology, replacing it with behavioral or contextual categories. For example, recommendations may be based not on the genre of "indie pop" or "house," but on emotional or situational perception: "morning relaxation", "melancholy on a rainy day", "jogging rhythm."

Thus, neural networks not only enhance the accuracy of recommendations, but also become a new mediator between the musician and the listener, creating an individualized musical landscape. This radically changes the role of the algorithm: it is no longer just a filter, but an active collaborator of musical experience, capable of influencing the formation of tastes, behavior, and even the aesthetic preferences of the audience.

Algorithmic mechanisms in practice. The result of these systems is:

• Personalized playlists (such as Discover Weekly, Spotify's Daily Mix);

• Recommendations for new releases based on preferences;

• Dynamic radio stations formed around your favorite artist or genre;

• Contextual recommendations that adapt to the time of day, user activity, or user's mood.

Platforms are also actively using cold start, one of the key algorithms for music recommendations, especially for new users. When registering, the platforms do not have data about the listening history, preferences, or behavior of such a user, so the system cannot immediately issue personalized recommendations.

To overcome this barrier, streaming services use cold start solutions, which are the initial "heuristics":

• Surveys of musical preferences: students are asked to choose their favorite genres, artists, or tracks. This initial data allows you to quickly create a primary profile and suggest relevant playlists or collections.

• Popular genre patterns: In the absence of accurate information, the system may use demographic, regional, or behavioral generalizations (classical Russian music or, for example, Norwegian black metal).

• Hybrid approaches: platforms can additionally analyze which device, channel, or link the user came from (for example, if the click was from TikTok, the system will select trending pop and viral tracks).

After overcoming the "cold start" stage, recommendation systems are faced with another important task — finding the optimal balance between "exploitation" and "exploration" (exploration vs exploitation). This task is especially important for keeping users' attention and gradually expanding their musical horizons.

- Exploitation means that the system offers music that is close to the user's already known preferences — favorite genres, similar artists, similar timbres and song structures. This gives a high chance of "predictable satisfaction" and a positive reaction.
  - Exploration, on the contrary, involves the inclusion of new, previously unfamiliar compositions in the stream — perhaps from other genres, with a different structure, or from other cultural contexts. This creates opportunities to discover new content, broaden tastes, and increase overall engagement.

Intelligent algorithms, especially those based on machine learning and reinforcement learning, strive to dynamically balance these strategies. Too much exploitation leads to a "musical bubble" when the user listens to the same thing, and algorithms only reinforce this closed behavior. Overly active exploration leads to loss of interest and irritation if the recommendations turn out to be "alien" to the current taste.

Modern platforms such as Spotify, YouTube Music, and Deezer implement adaptive learning systems that track user reactions to "unexpected" tracks: whether a track has been listened to to the end, whether it has been added to a playlist, whether it has been skipped, and so on. These signals become the basis for the next step in personalization: the system "learns" to understand in which areas the user is inclined to experiment, and in which areas he prefers stability.

Thus, solving the problems of cold start and implementing the exploration vs exploitation approach are not just technical techniques, but an important part of building a trusting, adaptive and deeply individualized interaction between the user and the music platform.

Personalization algorithms have become one of the most important factors in the transformation of the musical experience in the digital age. They provide convenience and diversity for the user, support artists in the process of music distribution, but at the same time create new challenges related to the diversity of the music space and equal opportunities for all industry participants.

V. The Impact of Algorithms on Musical Preferences

The development of recommendation algorithms on streaming platforms has significantly changed the process of forming students' musical preferences. Previously, musical preferences were largely determined by the influence of the socio—cultural environment — radio, television, physical media, and personal recommendations — but in the era of digital services, algorithms have become active mediators between the user and musical content.

A. Algorithms as a new "Music Curator”

Recommendation systems of streaming platforms act as invisible curators, guiding the user's choice. Algorithms do not just passively reflect the existing preferences of listeners, but actively form them:

- The frequent suggestion of similar tracks enhances the student's propensity for certain genres and moods;
- Rotation of popular artists in playlists stimulates the growth of their audience;
- New releases get a significant advantage if they are included in algorithmic collections ("Release Radar", "New Music Friday").

Thus, algorithms influence what becomes the "norm" in the learner's musical experience.

B. The effect of the "preference bubble" (filter bubble)

One of the side effects of the algorithms is the formation of so-called "preference bubbles." This happens when the student receives recommendations based solely on his previous experience, without going beyond the usual genres, performers and moods. As a result:

- the likelihood of getting to know new styles and cultures decreases;
- the musical experience becomes more monotonous;
- creative and experimental artists find themselves in a less advantageous position compared to commercially successful genres.

This effect has been discussed in detail in the works of streaming model researchers (McDonald, 2020), which emphasizes that algorithmic personalization enhances the conformism of musical tastes.

C. Strengthening trends and stylistic unification

Algorithms tend to offer users the content that is most likely to be positively received. This leads to the strengthening and replication of certain trends.:

- An increase in the popularity of similar compositions that meet current standards of hits (for example, a certain track length, verse-chorus structure);
- The formation of dominant genre waves (for example, the growing popularity of trap or low-fi hip-hop);
- Simplification of the musical palette in the mass segment.

Thus, the commercial mechanisms of streaming services and the specifics of the algorithms contribute to the standardization of the music product.

VI. The Potential of Algorithms to Broaden Musical Horizons

Despite the existing risks, properly configured algorithms can also stimulate the discovery of new music and the expansion of musical preferences of trainees.:

- Contextual Playlists (For Example, "Songs To Explore" Or "Tastebreakers" From Spotify) Are Specially Created To Go Beyond The Usual Preferences Of The Student;
- The Mechanisms Of "Accidental Discovery" (Discovery Features) Offer Music From Unfamiliar Genres And Cultural Contexts;
- Curated playlists and editorial collections continue to play an important role in maintaining the diversity of the music

landscape.

Thus, the impact of algorithms on musical preferences is a two—way process: on the one hand, it leads to standardization and strengthening of dominant trends, and on the other, with a competent architecture of algorithms and interfaces, it creates opportunities for expanding the cultural horizons of the learner [19-26].

VII. Conclusion

MCTs and streaming platforms form the basis of the modern musical environment today. Their relationship is no longer limited to technical aspects — it covers all levels of musical creativity, from individual production to global distribution and perception of content. The analysis made it possible to trace how the transition from a physical medium to a digital access model affected musical culture, changing both the roles of industry participants and the very structure of interaction between the listener, the author and the system.

Within the framework of the theoretical sections of the work, the key concepts, stages of development and technical foundations of MCT were considered. It was shown how DWD, MIDI, VST plug-ins, and generative algorithms have become the foundation of a new musical paradigm in which composer, arranger, sound designer, and performer often merge into one person. This technological shift has led to an increase in the accessibility and individualization of creativity, expanding the boundaries of professional musical activities, including the possibility of implementing inclusive musical education (see, for example, in the works [27-28]).

Generative music, algorithmic methods, and artificial intelligence are powerful tools that are radically transforming contemporary musical creative work. They empower composers, producers, and sound designers by allowing them to create complex musical structures with minimal human involvement.

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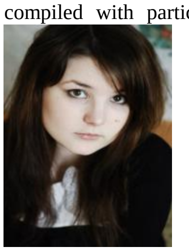

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