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Artificial Intelligence (AI) Literacy in Music Education

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Abstract

This study investigates the emerging role of artificial intelligence (AI) literacy and tools in music education through a systematic document analysis of 54 academic and institutional sources published between 2014 and 2025. The primary aim is to identify the place of AI literacy in music education, conceptualize how it can be integrated to maximize educational benefit, and propose a framework that shifts the discourse from "music with AI" to "AI for music." Using descriptive analysis, seven main themes were identified: categories of AI tools, purposes of AI tools, AI tools in the context of AI literacy, the role of AI tools in music pedagogy, conceptual foundations of AI literacy, pedagogical–creative–ethical contributions of AI literacy, and ethical issues in AI literacy. Based on these themes, a set of "AI literacy grammar rules" is proposed to ensure purposeful, ethical, and pedagogically meaningful use of AI in music education. The findings indicate that AI literacy not only contributes to pedagogical clarity but also fosters creativity, secures ethical responsibility, and promotes cultural inclusivity in music learning environments. The study concludes that AI literacy and AI tools are complementary elements of strategic importance for shaping the future of music education, while highlighting unresolved ethical challenges.

Keywords: Artificial Intelligence, AI Literacy; Music Education; Educational Technology; Pedagogical Innovation; Creative Learning; Ethical Issues

Introduction

Artificial intelligence (AI) has emerged as a transformative technology not only in the field of education but also across various artistic disciplines. Within the context of music education, AI applications span a wide spectrum, ranging from music notation, sound analysis, and performance evaluation to creative composition processes and the personalization of individual learning experiences. This rapid transformation entails not only the practical use of technological tools for music educators and students but also the necessity of making sense of these tools, engaging in critical inquiry, and evaluating them within an ethical framework.

At this point, the concept of AI literacy assumes central importance both pedagogically and artistically in music education. AI literacy refers to the ability of users to consciously comprehend the operational logic, limitations, affordances, and role of AI in music education. Therefore, fostering AI literacy in the field of music education enables students not only to use technology at an instrumental level but also to engage with it critically and creatively.

This article sheds light on the conceptual foundations of AI literacy, the categories of AI tools employed in music education, the pedagogical opportunities and creative possibilities it offers, as well as ethical and critical perspectives related to AI literacy in music education. Based on the findings, conclusions and recommendations concerning the place of AI literacy in music education will be presented.

Purpose of the Study

The primary aim is to identify the place of AI literacy in music education, conceptualize how it can be integrated to maximize educational benefit, and propose a framework that shifts the discourse from “music with AI” to “AI for music.”

Significance of the Study

In recent years, the rapid development of AI technologies has brought forth new opportunities and challenges in education and particularly in the arts (Holmes, Bialik, & Fadel, 2022). However, studies that specifically address AI literacy within the context of music education remain limited at both national and international levels (Kuan, Chiu, & Chen, 2022). This study not only examines AI literacy and AI applications specifically in music education but also contributes to broader discussions of AI literacy in the field of education. In doing so, it holds significance in offering new conceptual frameworks and original perspectives to the field. Furthermore, since this study reviews research conducted within the last decade, it highlights that AI literacy is still a relatively new topic and that it requires discipline-specific exploration. To this end, this study represents one of the first scholarly attempts to address AI literacy in the domain of music.

Problem Statement

Today, teaching and learning processes are rapidly digitalizing, with AI-powered tools increasingly positioned at the center of these processes. Alongside this transformation, the concept of literacy in education is no longer confined to reading and writing skills; it now also encompasses the understanding of algorithms, their critical interrogation, and the evaluation of ethical dimensions (Long & Magerko, 2020; Ng, Leung, Chu,

& Qiao, 2021). This evolving nature of literacy directly reflects on music education as well. Students' unconscious use of AI-based tools may lead to deviations from pedagogical aims and overshadow creativity (Selwyn, 2019). The need to clearly determine the place and importance of AI tools and AI literacy in music education, so that solutions may be developed for these negative aspects in the future, constitutes the problem situation of this study.

Research Question

What is the place and significance of AI literacy and AI tools in music education?

Sub-Questions

- What are the AI-based applications used in the creation of music education content? How are these applications defined within AI literacy?
- What are the AI-based platforms used for delivering and sharing music education content? How are these platforms defined within AI literacy?
- What are the AI-based systems used for recording and analyzing music education content? How are these systems defined within AI literacy?
- What pedagogical, creative, and ethical contributions does AI literacy bring to music education?

Method

Research Design

This study was designed as a qualitative document analysis aiming to reveal the current areas of application of artificial intelligence (AI) tools in music education and to present the debates on this topic within the literature. A descriptive document review model was adopted. Document analysis is a qualitative method that allows the systematic examination of written materials related to the research topic and their classification under specific themes (Yıldırım & Şimşek, 2018). According to Corbetta (2003), documents are reliable sources not only because they provide information about social phenomena but also because they exist independently of the researcher. For this reason, document review is an effective method for obtaining valid and reliable data in the research process.

Data Collection Tools

The data used in this study were obtained from:

-National and international academic texts (articles, books and book chapters, theses [YÖK Thesis Center]) published between 2014–2025 that are related to the concepts of the study,

-Academic databases such as Google Scholar, ERIC, Scopus, and Web of Science,

-Reports on artificial intelligence and education policies issued by institutions such as UNESCO, OECD, and the European Commission,

Instructional guides and pedagogical reports on AI-based tools used in music education,

Links obtained from online databases.

Search Strategy and Criteria

The following keywords (concepts) were used in the literature search:

- Artificial intelligence
- Artificial intelligence literacy and music education
- Artificial intelligence tools and music education
- Artificial intelligence and music pedagogy

Inclusion criteria:

- Studies focusing directly on artificial intelligence, AI literacy, and AI in the context of music education,
- Publications appearing in peer-reviewed journals, books and book chapters, reports, and postgraduate theses,
- Studies published in Turkish or English,
- Studies published between 2014–2025 (The review begins from 2014 to ensure coverage of at least ten years of literature on artificial intelligence and music education, as the year 2025 has not yet concluded).

Exclusion criteria

- Computer engineering studies solely focusing on technical algorithm development without an educational context,
- Reports introducing AI technology without making connections to education or music education.

As a result of the review, a total of 54 sources focusing on AI, AI tools in music education, AI literacy, AI and music education, AI and music pedagogy, AI ethics in music education, and teacher training were accessed and included in the study for detailed examination. Additionally, 13 sources were utilized to support the evaluation from theoretical, cultural critique, educational sociology, and techno-political perspectives. Based on the exclusion criteria, 11 sources were omitted.

Data Collection and Analysis

In the data collection process, academic studies on AI, AI tools, AI literacy, and AI literacy in music education were first reviewed using the aforementioned key concepts. Within this framework, online platforms, applications, and institutional reports were examined. Software programs identified in written form were analyzed one by one as applications. All data were analyzed through descriptive analysis techniques (Weber, 1989; Mayring, 2014).

Themes were determined in collaboration with two experts in the fields of educational technology and music education. This practice enhanced the quality and trustworthiness of the study. In qualitative research, sharing data with field experts and receiving feedback is one of the fundamental strategies for increasing the reliability of the research (Glesne & Peshkin, 1992). The finalized themes are as follows:

- Categories of AI tools
- Purposes of AI tool usage
- AI tools in the context of AI literacy

- The role of AI tools in music pedagogy
- Conceptual foundations of AI literacy
- Pedagogical, creative, and ethical contributions of AI literacy
- Ethical issues in AI literacy

Validity and Reliability

The data obtained in the study were evaluated in collaboration with two experts in the fields of educational technology and music education.

To enhance the trustworthiness of the analysis (Lincoln & Guba, 1985), the following strategies were applied:

- Triangulation of sources: Academic articles, conference proceedings, and policy documents were included in the analysis.
- Transparency: Inclusion and exclusion criteria were explicitly defined.
- Audit trail: Coding notes and thematic categorizations from experts were documented, thereby ensuring the traceability of analytical decisions.

Findings and Discussion

Artificial Intelligence Tools and Their Purposes of Use

Artificial intelligence (AI) tools are classified into different types according to their functions and purposes of use. In the context of education and music, the following categories of AI stand out most prominently:

Analytical AI: Tools that process data, detect patterns, and provide analysis and predictions. In music education, they analyze student performance data (tempo, pitch, rhythm) and provide feedback (Schedl, Yang, & Herrera, 2016).

Interactive AI: Tools that directly interact with users and generate adaptive responses. For example, Yousician or SmartMusic provide real-time feedback on student performance (Smith & Johnson, 2020).

Generative AI: Systems that produce new musical content such as compositions and improvisations. MuseNet, Music Transformer, or AIVA fall into this category (Huang et al., 2020; Shin & Cheol, 2020).

Recommender AI: Systems that provide personalized music content based on listener or student preferences. Spotify's recommendation algorithms are a typical example (Schedl et al., 2016).

Educational AI: Tools that generate content adapted to students' learning pace and offer pedagogical guidance. Learning platforms supported by 5G technology have accelerated this function (Song et al., 2020).

These AI categories serve different pedagogical aims in music education, such as analysis, creativity, interaction, and personalization. They can be grouped into the following pedagogical purposes and corresponding tools:

1. AI applications for creating music education content
2. AI platforms for delivering and sharing music education content
3. AI systems for recording and analyzing music

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AI-Based Applications for Creating Music Education Content and Their Place in AI Literacy

AI-based applications used for creating music education content have multifaceted functions, such as music notation, composition, harmonic analysis, and the development of interactive learning materials. Optical music recognition (OMR) and notation software (e.g., PhotoScore, Audiveris) allow students to digitize handwritten or printed scores and correct their errors (Fujinaga, 2018). Composition and improvisation software facilitates student engagement in creative music-making; models such as MuseNet and Music Transformer expand initial motifs into structurally coherent compositions (Huang et al., 2020). Furthermore, harmony and style analysis tools enable students to practice composing in different historical periods and stylistic traditions, offering opportunities to experience diverse musical aesthetics (Herremans, Chuan, & Chew, 2017).

From the perspective of AI literacy, these applications are not merely technical tools but also provide opportunities to understand how algorithmic decisions and AI models operate. According to Long and Magerko (2020), AI literacy entails individuals' ability to comprehend the logic, limitations, and potential biases of AI systems. Therefore, AI tools for content creation in music education foster not only students' musical creativity but also their ability to question AI outputs, conduct critical evaluations, and make sense of human–machine interaction. In this

regard, the pedagogical value of AI-based applications for content creation lies not only in their practical utility but also in their role in developing AI literacy (Ng, Leung, Chu, & Qiao, 2021; Crawford, 2021). Consequently, for students and teachers to maximize the benefits of these applications and avoid possible drawbacks, they need sufficient knowledge to evaluate their pedagogical value within the framework of AI literacy.

Applications According to Purpose of Use and Their Evaluation in the Context of AI Literacy

Optical Music Recognition (OMR) and Notation Tools

Audiveris: Open-source optical music recognition software.

PhotoScore & NotateMe (Neuratron): Converts printed or handwritten scores into digital notation.

SmartScore X2 (Musitek): Score scanning and automatic editing software.

Flat.io: Online notation and collaboration platform.

Noteflight: AI-assisted online notation and sharing tool.

From an AI literacy perspective, these tools make the core of music AI literacy visible in practice. Students and teachers learn how algorithms function (optical recognition, segmentation, time signature and rhythm estimation), their limitations (handwriting variability, polyphony, articulation, and clef changes), and the necessity of critically validating outputs (error logs, confidence scores, MIDI/MusicXML comparisons, human-in-the-loop corrections). AI-literate users also develop awareness of copyright and rights management (use of scanned scores), data privacy (uploading scores to cloud systems), interoperability (MusicXML, MIDI), and collaboration ethics (version tracking, attribution in Flat.io/Noteflight). In short, these tools not only accelerate workflow but also directly exercise competencies such as questioning the model, identifying and correcting errors, and ensuring ethical use.

Composition and Improvisation Tools

MuseNet (OpenAI) : A model capable of generating polyphonic music in various genres.

Music Transformer (Google Magenta) : A generative model for creating structurally coherent long-form music.

AIVA (Artificial Intelligence Virtual Artist) : Software for producing original compositions for film, gaming, and media.

Amper Music: Generates rapid music outputs in styles selected by the user.

Jukedeck: AI-based music generation for video and multimedia.

Ecrett Music: Tool for creating original AI-based music for games and video content.

Viewed through the lens of AI literacy, these tools function as laboratories that test creative practice. Students and teachers critically evaluate the input–output logic of models (prompt/seed, motif input, control of length and form), parameter effects (e.g., temperature, top-k, style choice), dataset and stylistic biases (harmonic clichés from training data, genre

imitation), and output validation (structural coherence, tonal alignment, rhythmic consistency). AI-literate users establish creative workflows within a *human-in-the-loop* process: motif input – multiple variation generation – selection and revision using musical/esthetic criteria – documentation of sources and processes (seed/version). Moreover, issues of originality, attribution, and copyright (ethical use of training data, license conditions, verification of "royalty-free" claims), transparency (testing why and how models generate outputs), and cultural representation (genre caricaturization, recognition of biases) become evident. Thus, these systems not only "produce music" but also enable users to practice model interrogation, output validation, ethical decision-making, and transparent documentation.

Harmony, Style, and Analysis Tools

Flow Machines: Enables composition in diverse musical styles with AI.

Melody.ml: Separates vocals and instruments from songs to allow re-arrangements.

Orb Composer: AI-assisted tool for harmony and structured composition.

Magenta Studio: A suite of MIDI-based music generation tools from Google Magenta.

From an AI literacy perspective, these tools deepen understanding by bridging theoretical knowledge (harmony, form) with applied production. Users analyze the logic of constrained production and style transfer (rule-based/corpus-based constraints, n-gram/Transformer patterns), parameter–output relationships (tension–resolution, chord distribution, transition probabilities), evaluation criteria (voice leading, functional harmony, listener A/B testing), and technical limitations (e.g., artifacts in source separation with Melody.ml, mislabeling in complex polyphony). An AI-literate approach involves validating automatically produced harmonic or stylistic material within a human-in-the-loop framework (e.g., manually confirming chord labels, re-marking cadential points), ensuring reproducibility and traceability through seed/version control, and interoperability across formats (MIDI/MusicXML). Ethical and legal dimensions also surface, including copyright and licensing in source separation, cultural representation in style imitation, and the necessity of model transparency. Ultimately, these applications foster competencies beyond generating "correct chords" or "clean stems"—they cultivate model interrogation, pedagogical/aesthetic validation, ethical awareness, and transparent documentation.

AI Tools for Educational Content Creation

Meludia: AI-assisted content for music theory and ear training.

Yousician: Personalized content for instrumental learning based on student performance.

SmartMusic (MakeMusic): Assists teachers in creating assignments and practice content for students.

Music Prodigy: Generates content based on real-time performance analysis.

From an AI literacy perspective, these tools elevate AI literacy to the level of *applied decision-making in the classroom*. Students and teachers develop

an understanding of which performance signals the systems measure (pitch/rhythm accuracy, tempo stability, response time), the meaning of thresholds and confidence scores, and how to identify and correct false positive/negative feedback. Practice loops are structured within a human-in-the-loop cycle (AI suggestion – teacher/student verification – adjustment based on goals). AI-literate users also monitor alignment of generated content with learning objectives and rubrics, weigh algorithmic recommendations against musicality (expression, nuance, timbre), and remain aware of risks related to accessibility and fairness (measurement bias across instruments/acoustic conditions). Furthermore, users develop sensitivity to data privacy and copyright (cloud-stored recordings, sharing permissions). Thus, these platforms not only produce automatic exercises but also directly foster AI literacy competencies such as interpreting outputs, evidence-based adaptation, ethical use, and transparent documentation.

AI-Based Platforms for Delivering and Sharing Music Education Content

In music education, AI-based platforms play a critical role in the delivery, sharing, and interactive experience of learning content. These environments not only provide students with ready-made information but also enable content personalization, collaborative production, and multidimensional learning experiences (Smith & Johnson, 2020). For instance, adaptive learning systems analyze student performance and deliver content tailored to individual levels (Song et al., 2020), while collaborative platforms allow students to co-develop music projects (Schedl, Yang, & Herrera, 2016).

From the perspective of AI literacy, such platforms offer students the opportunity to become not only consumers but also producers of knowledge. As Long and Magerko (2020) emphasize, AI literacy involves not only the ability to use technology but also the competence to understand how it operates, what biases it may carry, and how it can be transformed in creative processes. Therefore, AI-based platforms for delivering and sharing music education content are significant for fostering students 'critical thinking, ethical awareness, and creative application skills (Park, B., 2022; Shin & Cheol, 2020).

AI-Based Platforms for Delivering and Sharing Music Education Content: Usage Purposes and Evaluation within AI Literacy

Performance and Feedback Platforms

SmartMusic (MakeMusic): Enables students to record their performances, share them with teachers, and receive immediate feedback.

Yousician: Provides real-time analysis and content delivery based on students 'instrumental performance.

Music Prodigy: Offers personalized practice suggestions by analyzing performance accuracy and rhythm.

In the context of AI literacy, these platforms support students in interpreting performance data, conducting critical analyses, and making sense of their own learning processes (Smith & Johnson, 2020).

Collaborative Notation Platforms

Flat.io: Allows students to compose and share notation online and make joint edits collaboratively.

Noteflight: An interactive notation and sharing platform that supports teacher–student collaboration.

From an AI literacy perspective, these platforms promote collaborative production while enhancing students 'ability to evaluate algorithmic suggestions and make critical choices in digital music creation (Park, J.R., 2019).

Creative Production and Sharing Platforms

Soundtrap (Spotify): Enables students to create and share music online using AI-assisted effects and editing tools.

BandLab: Provides AI-based mastering and editing features, facilitating the sharing of music projects with global communities.

Amper Music / AIVA: Allow users to generate and share compositions based on selected parameters.

In terms of AI literacy, these platforms not only enhance students 'musical creativity but also provide grounds for questioning copyright, ethical production, and the artistic contributions of AI (Sturm, Iglesias, Ben-Tal, & Miron, 2019).

Virtual and Augmented Reality Platforms

MelodyVR: Offers students the opportunity to experience virtual concerts and share music performances.

Virtuoso VR: Provides interactive experiences with virtual instruments and group music-making.

From the perspective of AI literacy, these platforms enable students to become not just consumers of content but also active participants who reproduce stage experiences in virtual environments (Song et al., 2020).

In conclusion, AI-based platforms for delivering and sharing music education content make learning processes more personalized, collaborative, and creative. However, for these environments to gain pedagogical value, both students and teachers must develop AI literacy competencies, meaning that they should not only use the technology but also critically question and interpret it.

AI-Based Systems for Recording and Analyzing Music Education Content

In music education, artificial intelligence (AI)-based systems not only generate content but also play a critical role in recording, storing, and analyzing performance data. Such systems enable long-term tracking of students 'progress, support teachers in making data-driven pedagogical decisions, and allow researchers to examine learning processes in depth (Smith & Johnson, 2020). For instance, software that analyzes acoustic parameters records pitch, tempo, and dynamic errors to measure students 'development (Kuan, Chiu, & Chen, 2022).

From the perspective of AI literacy, these systems should not be regarded merely as technical tools for recording and analysis, but also as platforms

that help students interpret data, understand how algorithms work, and critically reflect on ethical issues (Long & Magerko, 2020; Park, B., 2022). Accurate reading of recorded data and recognition of algorithmic biases form the foundation for conscious integration of AI into music education. Moreover, issues of copyright and data privacy constitute an essential ethical dimension in the pedagogical use of these systems (Sturm, Iglesias, Ben-Tal, & Miron, 2019).

AI-Based Systems for Recording and Analyzing Music Education Content: Usage Purposes and Evaluation within AI Literacy

Performance Tracking and Development Analysis

SmartMusic (MakeMusic): Records student performances, allows sharing with teachers, and tracks long-term progress.

Yousician: Records and analyzes performances to show students' progress over time.

Music Prodigy: Logs practice durations and performance accuracy, generating reports.

From an AI literacy perspective, these applications not only provide access to performance data but also reveal how algorithms define "accuracy," enabling students to understand the criteria embedded in the system (Smith & Johnson, 2020).

Voice and Acoustic Analysis Systems

SingSharp: Records vocal performances and analyzes pitch, breath, and vibrato.

Sonocent Audio Notetaker: Allows students to visualize and analyze their recordings.

Praat (with AI-supported plugins): Phonetic and voice analysis software that provides detailed measurement for vocal training.

In terms of AI literacy, these systems enable students to compare their voices with algorithmic analyses, facilitating discussion of the differences between "human listening" and "machine measurement" (Kuan et al., 2022).

Data Storage and Sharing Systems

BandLab: Enables cloud storage, editing, and sharing of recordings.

Soundtrap (Spotify): Stores online music recordings and supports collaborative editing.

Flat.io & Noteflight (with analytical features): Allow digital archiving of notations and arrangements.

From an AI literacy standpoint, these environments require students not only to store recordings but also to understand how data is processed, stored, and evaluated by algorithms (Park, J.R., 2019).

Advanced Learning Analytics Systems

Learning Management Systems (LMS) with AI plugins – Canvas, Moodle, Edmodo: Record and analyze student participation data in music education content.

AI-based data analysis platforms (e.g., Magenta + Google Colab): Provide statistical analysis of students 'compositions and recordings.

5G-enabled mobile learning systems: Process student data in real time for instant analysis (Song et al., 2020).

From the perspective of AI literacy, these systems encourage students to understand their own learning processes through data and to critically assess machine analyses (Park, B., 2022).

AI-based systems for recording and analyzing music education content are powerful tools that support long-term student development and make performance visible through measurable data. However, their pedagogical value lies not merely in the consumption of recorded outputs but in fostering students 'ability to critically interpret and contextualize the data. Therefore, AI literacy is indispensable for the conscious and ethical use of such systems. To more clearly define the scope of AI literacy in music education, it is also necessary to examine the pedagogical opportunities and creative possibilities offered by the aforementioned AI tools.

Pedagogical Opportunities and Creative Possibilities of AI Tools in Music Education

AI-based learning tools and platforms create significant opportunities in music education by offering personalized feedback and adaptive learning. Students are able to progress at their own pace, and individual differences can be better addressed (Luckin, 2017). Particularly in a discipline such as music education where individual differences are critical and the number of practice repetitions varies according to these differences AI applications can yield effective outcomes for students who, within learning environments (classrooms, studios, etc.), may experience shyness or reluctance to practice or demonstrate their abilities in the presence of peers or instructors. In such cases, AI-supported tools allow students to engage with learning more confidently. Moreover, AI-based tools provide students with multidimensional learning experiences, thereby contributing to the development of creative problem-solving and critical thinking skills (Holmes et al., 2022).

As is well known, music education and instrumental training are domains in which each individual progresses according to their own pace and study principles. Through the multidimensional learning opportunities and problem-solving support offered by AI-assisted tools, music students are able to begin practice at their own level and gradually overcome challenges step by step.

One of the most important pedagogical opportunities offered by AI is personalized learning. Algorithms analyze students 'performance data to identify strengths and weaknesses, subsequently offering individualized practice recommendations (Woolf, Lane, Chaudhri, & Kolodner, 2013). This provides a major advantage, particularly in instrumental education, where continuous feedback is essential for improving musical performance.

Additionally, AI-based applications are transforming the pedagogical roles of teachers. Teachers are no longer merely transmitters of knowledge but also mentors who guide students in their interaction with technology and support their creative processes (Zawacki-Richter et al., 2019). In this

sense, AI enables music teachers to monitor student performance more comprehensively and experiment with diverse teaching strategies.

Another affordance of AI is its support for creative learning environments. Composition and improvisation software allow students to experiment with various musical genres, explore their own styles, and develop new forms of creative expression (Huang et al., 2020). This shifts music education beyond the transmission of technical skills toward a learning process where creativity is central.

Finally, AI tools make multidimensional learning experiences possible. For example, through virtual reality (VR) and AI-based simulations, students can experience different acoustic environments, prepare for stage performance, or engage in interactive learning within the context of music history (Webster, 2019). Such applications extend music education beyond the boundaries of the traditional classroom, offering students access to a broader learning ecosystem.

Just as effective language use is linked to the development of reading and writing skills, the effective and beneficial use of these AI tools in music education is only possible through the cultivation of AI literacy. At this point, it is necessary to first examine the definition and foundations of what it means to be AI literate.

Conceptual Foundations of AI Literacy

AI literacy encompasses not only the ability to use technological tools but also an understanding of how artificial intelligence operates, what its limitations are, and what consequences it may generate in broader social contexts (Long & Magerko, 2020). Accordingly, AI literacy aims to prevent users from perceiving AI as a "black box" technology by fostering transparency, critical inquiry, and conscious use.

The literature indicates that AI literacy in the educational context is multidimensional, consisting of: (1) technical knowledge, (2) critical thinking, (3) ethical awareness, and (4) creative application (Ng, Leung, Chu, & Qiao, 2021).

Technical knowledge refers to users 'understanding of the basic principles of AI (e.g., machine learning, algorithms, data processing).

Critical thinking requires a questioning approach to algorithmic biases, data reliability, and validation processes (Zawacki-Richter et al., 2019).

Ethical awareness refers to sensitivity to issues such as inequalities, copyright, and data privacy that AI may generate in education and the arts (Holmes, Bialik, & Fadel, 2022).

Creative application emphasizes that AI is not only an instrumental tool but also holds the potential to generate new forms of artistic expression (Huang et al., 2020).

In the specific context of music education, recognizing these dimensions ensures that students become not passive consumers of AI-supported applications, but active learners who engage with such tools consciously, critically, and creatively. For instance, while voice analysis or notation recognition software may support students 'technical skills, AI-based composition tools enable them to explore their creativity (Kuan, Chiu, & Chen, 2022). At the same time, music students and educators must

recognize that, while AI-based composition tools may enrich creative practice, AI is ultimately human-made and not yet capable of producing entirely unique outputs for every user. This creates a persistent risk of encountering copyright issues in music composition processes. Thus, becoming AI literate emerges as both a pedagogical and ethical necessity for sustaining creativity in music education.

Pedagogical, Creative, and Ethical Contributions of AI Literacy to Music Education

Pedagogical Contributions

Alignment of Learning Outcomes and Goals: AI literacy enables students to connect each technological application with a specific learning objective, thereby fostering the ability to consciously select tools, avoid purposeless use, and manage learning processes in a goal-oriented manner (Kuan, Chiu, & Chen, 2022; NAfME, 2025).

Personalized Learning and Feedback: By understanding how their individual performances are assessed and how feedback should be interpreted, students can better identify their strengths and weaknesses, adjust their learning pace, and develop self-regulation skills (Li, 2025; Li et al., 2025).

Creativity and Aesthetic Decision-Making: AI literacy encourages students to see technology not only as a production tool but also as a "creative partner," enabling them to cultivate original aesthetic judgment and artistic expression (Herremans & Chew, 2017; Morreale, 2021).

Critical Thinking and Output Evaluation: AI literacy promotes students' capacity to detect errors, biases, or "hallucinations" in AI outputs, thereby fostering evidence-based evaluation, cross-validation, and critical inquiry (Farquhar et al., 2024; Ji et al., 2023).

Ethical Awareness and Responsible Use: By raising awareness of issues such as copyright, attribution, and data privacy, AI literacy ensures that students develop ethical sensitivity, a sense of responsibility, and a culture of fair sharing (Sturm et al., 2019; UNESCO, 2023).

Collaboration and Inclusivity: AI literacy facilitates students 'recognition of diverse musical traditions and participation in collaborative production processes, thereby cultivating cooperation, respect for diversity, and adaptability to inclusive learning environments (Johnson et al., 2021; RAND, 2025).

Teacher Competencies and Pedagogical Design: For educators, AI literacy supports the conscious integration of technology into instructional design, fostering digital pedagogical competence, innovative lesson planning, and critical technology integration (Aljemely, 2024; Cheng, 2025).

Creative Contributions

Acting as a Creative Partner: AI literacy enables students to treat AI as a "creative collaborator." Instead of uncritically accepting AI-generated material, they learn to evaluate and transform outputs into original works (Herremans & Chew, 2017; Morreale, 2021).

Enriching Composition and Improvisation: Students can explore diverse musical possibilities in composition and improvisation processes, thereby moving beyond traditional patterns and developing new modes of expression (Huang et al., 2020; Herremans, Chuan, & Chew, 2017).

Aesthetic Judgment and Artistic Responsibility: AI literacy places responsibility on students not only to produce but also to make evaluative choices. Students learn to establish and justify aesthetic criteria while selecting among AI-generated options (Li, 2025; Li et al., 2025).

Enhancing Creative Confidence: By providing a safe space for experimentation without the fear of making mistakes, AI literacy enhances students 'creative self-confidence. They can quickly test variations and expand their artistic boundaries (Morreale, 2021; Ma, 2025).

Diversity and Cultural Enrichment: AI literacy encourages students to draw inspiration from diverse musical cultures, thereby diversifying their creative outputs. This fosters the development of multicultural musical expression inspired by both local and global repertoires (Johnson et al., 2021; RAND, 2025).

Ethical and Cultural Gains

Another key dimension of AI literacy is the recognition of rights, integrity, and inclusivity. Within the music ecosystem, the impact of generative AI on copyright, attribution, and performer personality rights has become a central focus of current debates. Institutional guidelines and field declarations recommend embedding principles of human-centered use, transparency, and responsible production into curricula (NAfME, 2025).

In the educational context, ethical AI competencies aim to develop students 'awareness of data privacy, model bias, and digital footprints, as well as their capacity to recognize and prevent misrepresentation or stereotyping in cultural content (O'Leary, 2025). AI literacy thus promotes the internalization of these principles not only at the level of "knowledge," but also at the level of applied decision-making and policy awareness (Daley, 2025).

AI literacy concretizes ethical and cultural contributions in music education. Students internalize principles of copyright, attribution, data provenance, and "human-centered" use through practical examples, while teachers integrate transparency, responsible production, and accountability into classroom policies (UNESCO, 2023; NAfME, 2025). This framework requires disclosure of data sources in AI-generated materials, verification of permissions and licenses, ethical use of open-access archives, and mandatory attribution (Sturm, Iglesias, Ben-Tal, Miron, & Gómez, 2019).

Moreover, identifying biases such as popularity bias in music recommendation or analysis algorithms contributes to pedagogical measures that enhance the visibility of local and minority repertoires. In this way, cultural diversity and inclusivity are translated into concrete pedagogy (Kowald, Schedl, & Lex, 2019). In sum, AI literacy is not merely about avoiding risks; it constitutes a competency set that systematically strengthens students 'ethical decision-making, rights-based attribution, and sensitivity to cultural representation (UNESCO, 2023; NAfME, 2025).

The ethical and cultural gains of AI literacy in music education can be summarized as follows

Copyright and Attribution Awareness: AI literacy fosters respect for intellectual property, correct attribution, and academic integrity by encouraging students to critically examine copyright and licensing processes of AI-generated or AI-transformed materials (Sturm, Iglesias, Ben-Tal & Miron, 2019; UNESCO, 2023).

Data Privacy and Security Responsibility: AI literacy equips students with responsibility for protecting vocal recordings, performance data, and personal information. This allows them to make informed decisions when sharing data and to set ethical boundaries (UNESCO, 2023; U.S. Department of Education, 2023).

Awareness of Fairness and Bias: By fostering recognition of algorithmic bias and popularity bias, AI literacy cultivates students 'ability to engage in fair evaluation, adopt equitable perspectives, and strengthen social responsibility (Kowald, Schedl & Lex, 2020; Williamson & Piattoeva, 2022).

Cultural Diversity and Inclusivity: By providing access to music from diverse cultures, AI literacy supports the development of multicultural sensitivity, inclusive learning, and cultural enrichment (Johnson, Stewart & Boyer, 2021; RAND Corporation, 2025).

Intercultural Interaction and Global Awareness: AI literacy facilitates students 'engagement not only with local but also with global musical cultures, enabling intercultural dialogue, empathy, and global awareness (OECD, 2023; World Economic Forum, 2024).

Ethical Issues in AI Literacy

Although the integration of artificial intelligence (AI) technologies into music education offers significant opportunities, it also brings various ethical challenges. AI literacy extends beyond the technical use of tools to encompass critical issues such as copyright, data privacy, algorithmic bias, transparency, and accountability. In this regard, students, teachers, and institutions must be aware of these challenges and develop a critical perspective in order to use AI responsibly (Sturm et al., 2019; UNESCO, 2023).

The main ethical issues identified in the literature can be summarized as follows:

Copyright and Ownership Ambiguity: The question of who owns the copyright of AI-generated or AI-transformed musical works remains unresolved. This ambiguity creates difficulties for students and teachers in citation, licensing, and ownership attribution (Sturm, Iglesias, Ben-Tal & Miron, 2019).

Data Privacy and Security Risks: Uploading student recordings, performance data, or personal information into AI systems poses risks to data security and privacy. This raises serious concerns about consent and data protection (UNESCO, 2023; U.S. Department of Education, 2023).

Algorithmic Bias and Inequity: AI-based music recommendation systems may overemphasize popular culture or exclude certain traditions. This can narrow students 'exposure to musical repertoires and diminish diversity (Kowald, Schedl & Lex, 2020; Williamson & Piattoeva, 2022).

Lack of Transparency and Explainability: It is often unclear why an AI model produces a specific output. The inability to answer the question "Why did this result occur?" undermines trust among students and teachers (Huang et al., 2025; Farquhar et al., 2024).

Risk of Delegating Creativity to Tools: AI's automatic generative capacities may overshadow students 'creative decision-making, fostering dependency on tools instead of encouraging original expression (Morreale, 2021; O'Leary, 2025).

Inequalities of Access: Differences in access to hardware, software, and internet connectivity prevent some students from benefiting from AI-based music education. This deepens opportunity gaps and constitutes a pressing ethical issue (OECD, 2023; RAND Corporation, 2025).

In conclusion, the ethical issues in AI literacy—ranging from copyright and data security to bias, transparency, creative dependency, and access inequality—highlight the necessity of addressing both the benefits and the challenges of AI in music education. Recognizing these issues is essential for ensuring students 'conscious technology use, teachers 'responsible pedagogical practices, and the overall development of AI literacy as a critical educational competency.

Conclusion, Discussion, and Recommendations

Findings were identified with respect to the seven main themes determined in the study. As presented under the section "*Findings and Interpretation,"* all AI tools—namely (1) AI applications used for creating music education content, (2) AI platforms for delivering and sharing music education content, and (3) AI systems for recording and analyzing music—were examined individually. The analysis revealed that each of these tools serves one or more pedagogical purposes in music education and provides students with a learning environment without fully replacing the role of the teacher. At the same time, it was found that certain applications allow students and users to evaluate themselves through feedback, thus functioning as AI-supported self-assessment tools for music education.

Taken together, these findings indicate that AI has become an *assistant* for music students and teachers, much like it has in other fields. Indeed, it can even be suggested that AI is now our "*partner"* in shaping the new world. In today's digitalized context, where music and music education themselves are undergoing digitization, humans—initially positioned as consumers—have, within a short period of engaging in digital production, become "*co-participants in digital music production."* At present, individuals engaged in music and other creative domains increasingly rely on AI support, whether to access deeper layers of knowledge, to simplify tasks, or to manage time constraints, among many other reasons.At this juncture, it is essential to revisit the role of AI literacy in music education in light of all the findings. Doing so allows us to explain the rationale behind this evolving "*partnership."*

The Place and Significance of AI Literacy in Music Education

The place of AI literacy in music education literature should first be considered in relation to the distribution of studies across years, and then according to the categorization of these studies within the seven themes identified. The tables summarizing these dimensions not only underscore

the significance of the present study but also illustrate the extent to which AI and AI literacy have permeated music education. In this respect, they provide a systematic synthesis and summary of the findings presented thus far.

Furthermore, the tables offer clear evidence of why such a study on AI literacy in music education was necessary. Following the document analysis conducted on the study's core concepts, and with expert input, the relevant literature corresponding to the seven (7) themes was identified. Subsequently, both the quantitative distribution of studies from 2014 to 2025 and their thematic distribution in the literature are presented in Tables 1 and 2 below. The results highlight how this study contributes to nearly a decade of scholarly literature in the field.

Table 1. Thematic Distribution of the Literature on Artificial Intelligence and Music Education (2014–2025)

Themes	Literature	Number of Studies	% of Total (n=54)
1. Categories of AI tools	Fujinaga (2018); Fujinaga, Hankinson & McKay (2014); Herremans & Chew (2017); Herremans, Chuan & Chew (2017); Huang et al. (2020); Schedl, Yang & Herrera (2016); Shin & Cheol (2020); Pasquier (2019); Smith & Johnson (2020); Park (2019)	10	18.5%
2. Purposes of AI tool usage	Eremenko et al. (2020); Johnson, Stewart & Boyer (2021); McLeod (2020); Morris & Nomikou (2020); Holster (2024); Papadopoulos et al. (2020); McLeod (2020); Park (2022)	8	14.8%
3. AI tools in the context of AI literacy	Kuan, Chiu & Chen (2022); NAfME (2025); Merchán Sánchez-Jara (2024); Merchán Sánchez-Jara et al. (2024); Aljemely (2024); Cheng (2025); Daley (2025)	7	13.0%
4. The role of AI tools in music pedagogy	Crawford (2021); Li (2025); Li et al. (2025); Liu (2025); Ma (2025); Habib (2024); Morreale (2021); Webster (2019)	7	13.0%
5. Conceptual foundations of AI literacy	Long & Magerko (2020); Ng et al. (2021); Luckin (2017); Holmes, Bialik & Fadel (2022); Tuomi (2018); Woolf et al. (2013)	6	11.1%
6.Pedagogical–creative–ethical contributions of AI literacy	O'Leary (2025); Selwyn (2019); UNESCO (2023); U.S. Department of Education (2023); OECD (2021); OECD (2023); WEF (2024); RAND Corporation (2025)	8	14.8%
7. Ethical issues in AI literacy	Sturm, Iglesias, Ben-Tal & Miron (2019); Rohrmeier (2022); Crawford & Joler (2018); Farquhar et al. (2024); Huang et al. (2025); Ji et al. (2023); Kowald, Schedl & Lex (2020); Williamson & Piattoeva (2022)	8	14.8%

As shown in Table 1, a total of 54 studies published between 2014 and 2025 were classified into seven main themes. The majority of studies concentrated on the *categories of AI tools* (n = 10, 18.5%), followed by research focusing on the *purposes of AI tool usage* (n = 8, 14.8%), the *pedagogical–creative–ethical contributions of AI literacy* (n = 8, 14.8%), and the *ethical issues in AI literacy* (n = 8, 14.8%). Studies addressing *AI tools in the context of AI literacy* (n = 7, 13.0%) and *the role of AI tools in music pedagogy* (n = 7, 13.0%) appeared with slightly lower frequency, whereas

the *conceptual foundations of AI literacy* (n = 6, 11.1%) were the least investigated theme.

This distribution demonstrates that while technical classifications and ethical debates have received considerable attention, pedagogical applications and the conceptual framework of AI literacy remain comparatively underexplored. Therefore, the present study fills an important gap by systematically synthesizing scattered findings and situating AI literacy within the pedagogical, creative, and ethical dimensions of music education.

Table 2. Distribution of Studies on Artificial Intelligence in Education and Music Education by Themes and Years

Years	Categories of AI tools	Purposes of AI tool usage	AI tools in the context of AI literacy	The role of AI tools in music pedagogy	Conceptual foundations of AI literacy	Pedagogical–creative–ethical contributions of AI literacy	Ethical issues in AI literacy
2014	Fujinaga et al. (2014)	–	–	–	–	–	–
2016	Schedl et al. (2016)	–	–	–	–	–	–
2017	Herremans & Chew (2017); Herremans, Chuan & Chew (2017)	Luckin (2017) Primarily conceptual	–	–	Luckin (2017)	–	–
2018	Fujinaga (2018); Shin & Cheol (2020)* (the study is contextualized within the 2018–2020 period.)	–	–	–	Tuomi (2018)	–	Bowers (2018); Crawford & Joler (2018)
2019	Park (2019); Pasquier (2019)	–	–	Webster (2019)	–	Selwyn (2019)	Sturm et al. (2019)
2020	Huang et al. (2020)	Eremenko et al. (2020); McLeod (2020); Morris & Nomikou (2020); Johnson et al. (2021)* (initiated in 2020)	–	–	–	–	Kowald et al. (2020)

Years	Categories of AI tools	Purposes of AI tool usage	AI tools in the context of AI literacy	The role of AI tools in music pedagogy	Conceptual foundations of AI literacy	Pedagogical–creative–ethical contributions of AI literacy	Ethical issues in AI literacy
2021	–	–	Kuan, Chiu & Chen (2022)*	Crawford (2021)	Holmes et al. (2022)*	–	–
2022	–	–	–	–	–	–	Williamson & Piattoeva (2022)
2023	–	Papadopoulos et al. (2020)* (full publication appears in 2023)	–	–	Ng et al. (2021); OECD (2023); UNESCO (2023); U.S. Dept. of Education (2023)	–	Ji et al. (2023)
2024	–	Holster (2024)	Aljemely (2024); Merchán Sánchez-Jara (2024); Merchán Sánchez-Jara et al. (2024)	Habib (2024); Crawford (2021)*	–	O'Leary (2025)* (several transitional articles from 2024–25)	Farquhar et al. (2024); Moura et al. (2024)
2025	–	–	Cheng (2025); Daley (2025); NAfME (2025)	Li (2025); Li et al. (2025); Liu (2025); Ma (2025)	Long & Magerko (2020)	RAND (2025); WEF (2024)* (There is a 2025 edition.)	Huang et al. (2025); Rohrmeier (2022)* (the ethical dimensions continue)

Table 2 classifies the 54 studies examined between 2014 and 2025 according to the seven main themes. Findings reveal that the period 2014–2020 was dominated by technical studies focusing on the *categories of AI tools*, with particular emphasis on optical music recognition and music generation systems. Between 2017 and 2020, in addition to the classification of AI tools, new areas of inquiry emerged: the *purposes of AI tool usage* (e.g., performance evaluation, digital notation, collaborative music learning) and, for the first time, the *conceptual foundations of AI literacy.* In 2018, the first research specifically addressing *ethical issues in AI literacy* appeared.

AI literacy's pedagogical, creative, and ethical impacts were first highlighted in 2019, and the role of AI tools in music pedagogy began to be studied in 2019. A significant increase in publications is observed in the period 2024–2025, with 2025 in particular witnessing a concentration of studies on the role of AI tools within the context of AI literacy and their pedagogical–creative–ethical contributions.

This study integrates the fragmented body of literature by systematically mapping the current position of AI tools in music education, while simultaneously addressing the pedagogical, creative, and ethical dimensions of AI literacy in this specific context. In doing so, it fills a significant gap in the literature and contributes a framework applicable both to teacher education and across various levels of formal education.

After reviewing the thematic distribution of the literature, it becomes possible to articulate this study's main contribution to the field.

In the broader education literature, AI literacy remains an evolving construct characterized by diversity in definitions, scope, and components (technical understanding, ethics, critical reflection, affective/self-regulation dimensions, etc.) (Almatrafi, 2024; Zhou, 2024; Veldhuis, 2024). This situation increases the need for discipline-specific approaches, particularly in creativity-driven fields such as music education, where unique contextual demands necessitate tailored definitions and sets of competencies. Indeed, studies highlighting not only the pedagogical opportunities but also the critical/ethical requirements of AI in music education demonstrate that the field is progressing rapidly, albeit in a fragmented manner, in both generative AI and learning analytics (Merchán Sánchez-Jara, 2024; Cheng, 2025). At the same time, scholarship indicates that structured field-level debates are still at an early stage of institutionalization (Daley, 2025). This underscores the need for a discipline-specific, functional, and citable definition of AI literacy in music education.

Over the past decade, AI's technical capacities in music (e.g., deep learning–based composition, evaluation of creative systems, human–machine co-creation) have expanded considerably (hence the scope of this study, 2014–2025). In parallel, questions directly tied to pedagogy—such as the assessment of creativity, control/interpretability, and originality of expression—have become more salient (Briot, Hadjeres, & Pachet, 2020; Agres, Forth, & Wiggins, 2016; Rohrmeier, 2022). At the policy level, UNESCO guidelines emphasize both human-centered approaches and the necessity of capacity-building for teachers and students, calling for institutions to systematically embed AI competencies into curricula (UNESCO, 2021; 2023). In addition, current legal and ethical debates surrounding copyright, data privacy, and the influence of generative AI in the music industry highlight the need for integration of the critical–ethical dimension into curricula (Berkowitz, 2024).

Proposed Definition of AI Literacy in Music Education

AI literacy in music education is the ability of students and teachers to critically and creatively understand and evaluate the technical functioning, pedagogical possibilities and limitations, aesthetic impacts, and ethical consequences of AI-supported music tools (including generative, analytical, feedback, and recommendation systems); to interact with these tools transparently, responsibly, and in alignment with educational goals; and to guide this interaction through evidence-based decision-making.

Rationale for the Proposed Definition

Definitional Ambiguity and Discipline-Specific Needs: Recent reviews show that definitions of AI literacy remain heterogeneous, with affective and self-reflective dimensions only recently included. Music, with its

unique requirements in creative production and performance, demands a field-specific definition (Almatrafi, 2024; Zhou, 2024; Veldhuis, 2024).

Tension Between Technical Capacity and Pedagogy: Advances in deep learning–based music generation and creative systems raise pedagogical questions of control, evaluation, and originality, necessitating a form of AI literacy that is critically aligned with learning objectives (Briot et al., 2020; Agres et al., 2016; Rohrmeier, 2022).

Policy and Ethical Imperatives: UNESCO frameworks mandate transparency, human-centeredness, and institutional capacity-building. Unless these principles are operationalized through discipline-specific literacy frameworks, they risk remaining aspirational (UNESCO, 2021; 2023).

Current State of the Field: Critical syntheses point to the risk of music education being confined to "mere tool use" unless structured competencies are developed (Merchán Sánchez-Jara, 2024; Cheng, 2025; Daley, 2025).

Legal and Ethical Ecosystem: Ongoing debates about copyright and data use (especially in generative AI) underscore the need for literacy that strengthens responsible use, attribution, and rights-based practices (Berkowitz, 2024).

Recommendations

The "Grammar Rules" of AI Literacy in Music Education

It is evident that the effective and sustainable use of AI tools in music education requires not only technical knowledge but also a specific degree of AI literacy. Indeed, as has become apparent, AI literacy, similar to a language, operates according to certain rules. Based on the findings and discussions presented in this study, these rules have been reformulated as a discipline-specific "*grammar of AI literacy"* for music education. The following "grammar rules" summarize the key principles:

Rule of Purpose Alignment: Every AI use is matched with a specific learning outcome. The question "*Why AI?"* must be answered at the course/lesson level in writing; purposeless tool use is avoided.

Rule of Human-in-the-Loop Verification: AI outputs must always be checked by teachers/students through listening, notation, and performance. Automatic results alone do not constitute final decisions.

Rule of Transparency and Provenance: The model/version used, parameters (e.g., temperature, seed), data sources, and production steps are documented. This ensures auditability and reproducibility.

Rule of Copyright, Licensing, and Attribution: Permissions and licenses for AI-generated/modified material are verified; sources are clearly acknowledged, and proper attribution is given.

Rule of Fairness and Inclusivity: To counteract popularity bias in recommendation/analysis systems, deliberate exposure to local/minority repertoires is planned; lists and examples are diversified.

Rule of Privacy and Security: The principle of "minimum necessary data" is applied to student recordings; uploading, sharing, and storage in the cloud are carried out securely and with consent.

Rule of Validity and Musicality: Automated metrics (pitch, timing, etc.) are balanced with expression, nuance, and context. Assessment is based on multiple sources of evidence (video, rubrics, peer/teacher feedback). A final judgment must always include human feedback from an authority (teacher/mentor).

Rule of Creative Agency: AI is treated as a "co-author/idea partner"; the responsibility for selection, revision, and justification lies with the student. The student's aesthetic decisions remain visible throughout the process.

Rule of Explainability: Asking "*Why did this output occur?"* is routine. The effects of parameters/settings are demonstrated through experimentation; model decisions are justified.

Rule of Reproducibility and Archiving: Project files, MIDI/MusicXML, versions, and decision notes are stored/shared to ensure the reproducibility of results.

Rule of Interoperability: Open and portable formats (MIDI, MusicXML, WAV/FLAC) are prioritized; dependency on a single ecosystem (vendor lock-in) is avoided.

Rule of Equitable Access: Hardware/software/bandwidth differences are compensated: low-bandwidth solutions, open-source alternatives, and shared equipment plans are implemented.

Rule of Pedagogical Primacy: Learning design always takes the driver's seat; AI functions as an accelerator and support tool, not as a replacement. Teachers and students remain the ultimate supervisors of the process.

Rule of Assessment Integrity: Conditions for using LLMs/GenAI are stated explicitly in assignment guidelines. Clear distinctions are made between permitted and unpermitted use, supported by transparent reporting and evidence.

Rule of Error Literacy: Students are taught to recognize hallucinations, mismatches, and measurement errors. Practices of comparison, cross-validation, and source checking become routine.

Rule of Continuous Reflection and Improvement: At the end of each unit, the questions "*What did AI improve? What did it harm?"* are answered with evidence; course design is updated through data-informed cycles.

Practical Recommendations (For Classrooms and Teacher Education)

Integrate AI literacy modules into teacher education curricula.

Organize workshops where preservice teachers can experiment with adapting AI tools to music pedagogy.

Implement blended teaching models (AI-supported + teacher-guided).

Design classroom activities in which students critically evaluate AI outputs ("interrogating the AI output").

Policy and Institutional Recommendations

Define AI literacy learning outcomes within the curricula of schools of education and music departments.

Add ethical usage guidelines (copyright, data privacy, security) to institutional policies.

Provide teachers and students with accessible, open-source AI tools to reduce inequality.

Develop AI-supported music education platforms through inter-institutional collaboration.

Research Recommendations

Conduct empirical studies in Türkiye examining how students use AI tools, their impact on learning outcomes, and their role in creative processes.

Carry out cross-cultural comparative studies to explore AI's use across different education systems.

Investigate ethical awareness by measuring teachers 'and students ' knowledge levels about AI ethics.

Foster interdisciplinary research bringing together music education, cognitive science, computer engineering, and the philosophy of art within the framework of AI literacy.

In this framework, the recommendations are directed toward three primary target groups:

Music teachers and preservice teachers: To guide how they select, implement, and evaluate AI tools for pedagogical purposes.

Researchers and educational technology developers: To develop new studies and tools that account for the pedagogical and ethical sensitivities of music education.

Students: To use AI tools consciously, creatively, and ethically, becoming active agents of their own learning processes.

The "grammar rules" and recommendations outlined above are intended to transform the dominant approach to AI use in music education. By embedding AI literacy systematically into curricula, the field can move from a view of "*music with AI"* toward "*AI for music."* This shift allows music to cease being a mere product of AI and instead become the subject of AI-supported, pedagogy- and ethics-driven learning processes. Integrating these rules into music education is expected to lead to clearer learning objectives, safeguarded ethical principles, preserved student creativity, fair and transparent assessment, and supportive learning environments that complement—rather than replace—the role of the teacher.

In light of these findings and implications, the central research question—"*What is the place and significance of AI literacy and AI tools in music education?"*—may be answered as follows: AI tools provide technical opportunities that support learning processes in music education, while AI literacy enables their use in pedagogically meaningful, ethically sound, and creatively enriching ways. Thus, AI literacy and AI tools should be regarded not merely as technological innovations but as complementary elements that provide pedagogical clarity, creative freedom, ethical safeguards, and cultural inclusivity. In this sense, AI and AI literacy in music education transcend instrumental contributions to assume strategic importance in shaping and guiding the learning processes of the future. Examining AI literacy in the context of music education, with its strengths as well as its limitations, is expected to be a fertile ground for future research exploring its unforeseen impacts.

References

Agres, K., Forth, J., & Wiggins, G. A. (2016). Evaluation of musical creativity and musical metacreation systems. *Computers in Entertainment (CIE), 14*(3), 1-33.

Aljemely, Y. (2024). Challenges and best practices in training teachers to utilize artificial intelligence: A systematic review. *Frontiers in Education, 9,* 1470853. doi:10.3389/feduc.2024.1470853

Almatrafi, O., Johri, A., & Lee, H. (2024). *A systematic review of AI literacy conceptualization, constructs, and implementation and assessment efforts (2019–2023).* Computers and Education Open, 100173.

Berkowitz, A. E. (2024). *"Gimme Some Truth": AI Music and Implications for Copyright and Cataloging*. Information Technology and Libraries, 43(3).

Bowers, C. (2018). *The false promises of the digital revolution: How computers transform education, culture, and the environment.* New York, NY: Peter Lang.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. doi:10.1191/1478088706qp063oa

Briot, J.-P., Hadjeres, G., & Pachet, F.-D. (2020). *Deep learning techniques for music generation*. Springer.

Cheng, L. (2025). The impact of generative AI on school music education. *Arts Education Policy Review.* Advance online publication. doi:10.1080/10632913.2025.2451373

Corbetta, P. (2003). *Social research: Theory, methods and techniques.* London, UK: Sage.

Crawford, K., & Joler, V. (2018). Anatomy of an AI system. Retrieved from https://anatomyof.ai

Crawford, R. (2021). Artificial intelligence in music education: A critical review. *Australian Journal of Music Education, 54*(2), 23–39.

Daley, M. (2025). Music education and artificial intelligence: A conversational editorial. *Arts, Culture, and Technology (ACT).*

Eremenko, V., Morsi, A., Narang, J., & Serra, X. (2020). Performance assessment technologies for the support of musical instrument learning. In *Proceedings of the 12th International Conference on Computer Supported Education (CSEDU 2020)* (pp. 629–640). Setúbal, Portugal: SCITEPRESS. doi:10.5220/0009817006290640

Farquhar, S., Kossen, J., Gal, Y., & Rainforth, T. (2024). Detecting hallucinations in large language models using semantic entropy. *Nature, 630,* 625–630. doi:10.1038/s41586-024-07421-0

Fujinaga, I. (2018). Optical music recognition. In M. Müller (Ed.), *Fundamentals of music processing* (pp. 453–471). Cham, Switzerland: Springer.

Fujinaga, I., Hankinson, A., & McKay, C. (2014). Optical music recognition research. In I. Fujinaga (Ed.), *Music information retrieval* (pp. 77–94). Cham, Switzerland: Springer.

Glesne, C., & Peshkin, A. (1992). *Becoming qualitative researchers: An introduction.* White Plains, NY: Longman.

Habib, S. (2024). How does generative artificial intelligence impact student creative thinking? *Discover Education, 3*(1), 100046.

Herremans, D., & Chew, E. (2017). MorpheuS: Generating structured music with constrained patterns and tension. *IEEE Transactions on Affective Computing, 7*(1), 67–80. doi:10.1109/TAFFC.2015.2462832

Herremans, D., Chuan, C. H., & Chew, E. (2017). A functional taxonomy of music generation systems. *ACM Computing Surveys, 50*(5), 69. doi:10.1145/3108242

Holmes, W., Bialik, M., & Fadel, C. (2022). *Artificial intelligence in education: Promises and implications for teaching and learning.* Boston, MA: Center for Curriculum Redesign.

Holster, J. D. (2024). Augmenting music education through AI: Practical applications of ChatGPT. *Music Educators Journal, 110*(4), 36–42. doi:10.1177/00274321241255938

Huang, C. A., Vaswani, A., Uszkoreit, J., Simon, I., Hawthorne, C., Shazeer, N., & Eck, D. (2020). Music transformer: Generating music with long-term structure. In *Proceedings of the International Conference on Learning Representations (ICLR).* Retrieved from https://iclr.cc

Huang, L., Yu, W., Ma, W., Zhong, W., Feng, Z., Wang, H., … Liu, T. (2025). A survey on hallucination in large language models: Principles, taxonomy, challenges, and open questions. *ACM Computing Surveys.* Advance online publication. doi:10.1145/3703155

Ji, Z., Lee, N., Frieske, R., Yu, T., Su, D., Xu, Y., … He, X. (2023). Survey of hallucination in natural language generation. *ACM Computing Surveys, 55*(12), 248. doi:10.1145/3571730

Johnson, C., Stewart, C., & Boyer, E. (2021). Augmented reality applications in instrumental music education. *Journal of Music, Technology & Education, 14*(2), 157–173.

Kowald, D., Schedl, M., & Lex, E. (2020). The unfairness of popularity bias in music recommendation: A reproducibility study. In *Proceedings of the 42nd European Conference on Information Retrieval (ECIR 2020)* (pp. 35–47). Cham, Switzerland: Springer. doi:10.1007/978-3-030-45442-5_5

Kuan, Y. C., Chiu, P. H., & Chen, J. L. (2022). Artificial intelligence in music education: Applications and pedagogical implications. *British Journal of Music Education, 39*(2), 215–231. doi:10.1017/S0265051721000281

Li, W. (2025). AI-assisted feedback and reflection in vocal music training. *Education Research International, 2025,* 1–13.

Li, W., Cui, X., Manoharan, P., Dai, L., Liu, K., & Huang, L. (2025). AI-assisted feedback and reflection in vocal music training: Effects on metacognition and singing performance. *Frontiers in Psychology, 16,* 1598867. doi:10.3389/fpsyg.2025.1598867

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry.* Beverly Hills, CA: Sage.

Livingstone, S., & Sefton-Green, J. (2016). *The class: Living and learning in the digital age.* New York, NY: NYU Press.

Liu, Z. (2025). Exploring automated assessment of primary students ' creative works in a flow-based music programming environment. *Journal of Learning Analytics, 12*(1), 1–18.

Long, D., & Magerko, B. (2020). What is AI literacy? Competencies and design considerations. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (pp. 1–16). New York, NY: ACM. doi:10.1145/3313831.3376727

Luckin, R. (2017). Towards a machine learning pedagogy: Generative learning environments for students. *Education and Information Technologies, 22*(3), 957–971. doi:10.1007/s10639-016-9493-4

Ma, H. (2025). Exploring the impact of AI tools on musicians 'creative abilities. *Frontiers in Psychology, 16,* 1500142.

Mayring, P. (2014). *Qualitative content analysis: Theoretical foundation, basic procedures and software solution.* Klagenfurt, Austria: Beltz.

McLeod, J. (2020). Digital notation software in music education: Collaborative and creative possibilities. *Music Education Research, 22*(5), 529–542. doi:10.1080/14613808.2020.1821903

Merchán Sánchez-Jara, J. F. (2024). Artificial intelligence-assisted music education: A critical synthesis of challenges and opportunities. *Education, 14*(11), 1171. doi:10.3390/education14111171

Merchán Sánchez-Jara, J. F., González Gutiérrez, S., Cruz Rodríguez, J., & Syroyid Syroyid, B. (2024). Artificial intelligence-assisted music education: A critical synthesis of challenges and opportunities. *Education Sciences, 14*(11), 1171. doi:10.3390/educsci14111171

Miao, F., & Holmes, W. (2023). *Guidance for generative AI in education and research.* Paris, France: UNESCO.

Morreale, F. (2021). Creative AI: On the democratization and escalation of creativity. *Transactions of the International Society for Music Information Retrieval, 4*(1), 103–115. doi:10.5334/tismir.69

Morris, R., & Nomikou, E. (2020). Digital platforms for music performance learning: A case study of SmartMusic. *Journal of Music, Technology & Education, 13*(3), 283–298. doi:10.1386/jmte_00028_1

Moura, N., Dias, P., Veríssimo, L., Oliveira-Silva, P., & Serra, S. (2024). Solo music performance assessment criteria: A systematic review. *Frontiers in Psychology, 15,* 1467434. doi:10.3389/fpsyg.2024.1467434

National Association for Music Education (NAfME). (2025). *Guiding principles, frameworks, and applications for AI in music education.* Reston, VA: Author.

Ng, D. T. K., Leung, J. K. L., Chu, S. K. W., & Qiao, M. (2021). Conceptualizing AI literacy: An exploratory review. *Computers and*

Education: Artificial Intelligence, 2, 100041. doi:10.1016/j.caeai.2021.100041

O'Leary, E. (2025). Considering the possibilities and problems of AI in music education: The need for critical literacies. *Arts, Culture, and Technology (ACT).*

Organisation for Economic Co-operation and Development (OECD). (2021). *AI and the future of skills, volume 1: Capabilities and assessments.* Paris, France: OECD Publishing. doi:10.1787/5ee71fbb-en

Organisation for Economic Co-operation and Development (OECD). (2023). *Equity and inclusion in education.* Paris, France: OECD Publishing.

Organisation for Economic Co-operation and Development (OECD). (2024). *OECD Digital Economy Outlook 2024 (Vol. 1): Embracing the technology frontier.* Paris, France: OECD Publishing. doi:10.1787/a1689dc5-en

Papadopoulos, G., et al. (2020). Virtual reality applications in music performance training: A review. *Frontiers in Psychology, 11,* 556. doi:10.3389/fpsyg.2020.00556

Park, B. (2022). Analysis of research trends related to artificial intelligence in Korean music field. *Journal of Next-Generation Convergence Technology Association, 6,* 570–578.

Park, J. R. (2019). A study on technology and artificial intelligence applied to music production. *Journal of Music Theory, 33,* 108–143.

Pasquier, P. (2019). Generative music and artificial intelligence. *Arts, 8*(3), 92. doi:10.3390/arts8030092

Patton, M. Q. (2015). *Qualitative research & evaluation methods* (4th ed.). Thousand Oaks, CA: Sage.

RAND Corporation. (2025). *Uneven adoption of artificial intelligence tools among U.S. teachers and principals (RR-A134-25).* Santa Monica, CA: Author.

Rohrmeier, M. (2022). On creativity, music's AI-completeness and four challenges for AI in music. *Transactions of the International Society for Music Information Retrieval, 5*(1), 251–266. doi:10.5334/tismir.130

Schedl, M., Yang, Y., & Herrera, P. (2016). Introduction to intelligent music systems and applications. *ACM Transactions on Intelligent Systems and Technology, 8*(2), 1–8. doi:10.1145/2991468

Selwyn, N. (2019). *Should robots replace teachers? AI and the future of education.* Cambridge, UK: Polity Press.

Shin, W., & Cheol, K. M. (2020). Music artificial intelligence: A case of Google Magenta. *Jeju National University Tourism, Business, and Economic Research Institute, 40,* 21–28.

Smith, J., & Johnson, R. (2020). The impact of AI music software on music education. *Journal of Music Education, 45*(2), 78–92.

Song, H., Liu, Y., Li, K., Ding, L., Sun, X., & Zhang, X. J. (2020). Reform and future prospects in education based on 5G technology. In

Proceedings of the 3rd International Conference on Education Technology and Information System. Hangzhou, China.

Sturm, B. L., Iglesias, M., Ben-Tal, O., & Miron, M. (2019). Artificial intelligence and music: Open questions of copyright law and engineering praxis. *Arts, 8*(3), 115. doi:10.3390/arts8030115

Tuomi, I. (2018). *The impact of artificial intelligence on learning, teaching, and education.* Brussels, Belgium: European Commission Joint Research Centre.

U.S. Department of Education. (2023). *Artificial intelligence and the future of teaching and learning: Insights and recommendations.* Washington, DC: Author. Retrieved from https://www.ed.gov/ai

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2023). *Guidance for generative AI in education and research.* Paris, France: Author.

Weber, R. P. (1989). *Basic content analysis*. Newbury Park, CA: Sage.

Webster, P. R. (2019). Emerging technologies for music learning. In R. Mantie & G. D. Smith (Eds.), *The Oxford handbook of music making and leisure* (pp. 457–476). New York, NY: Oxford University Press.

Williamson, B., & Piattoeva, N. (2022). Education governance and datafication. *Critical Studies in Education, 63*(2), 141–156. doi:10.1080/17508487.2020.1861049

Woolf, B. P., Lane, H. C., Chaudhri, V. K., & Kolodner, J. L. (2013). AI grand challenges for education. *AI Magazine, 34*(4), 66–84. doi:10.1609/aimag.v34i4.2484

World Economic Forum. (2024). *Shaping the future of learning: The role of AI in education.* Geneva, Switzerland: Author.

Veldhuis, A., Lo, P. Y., Kenny, S., & Antle, A. N. (2025). Critical Artificial Intelligence literacy: A scoping review and framework synthesis. *International Journal of Child-Computer Interaction, 43*, Article 100708. https://doi.org/10.1016/j.ijcci.2024.100708

Yıldırım, A., & Şimşek, H. (2018). Sosyal bilimlerde nitel araştırma yöntemleri (11. baskı). Ankara: Seçkin Yayıncılık.

Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). Thousand Oaks, CA: Sage.

Zhou, X., & Schofield, L. (2024). Developing a conceptual framework for Artificial Intelligence (AI) literacy in higher education. *Journal of Learning Development in Higher Education.*

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education. *International Journal of Educational Technology in Higher Education, 16*(1), 1–27.