

AI-POWERED MUSIC THERAPY FOR EDUCATION

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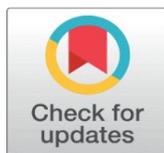
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ABSTRACT

The artificial intelligence (AI) has offered new possibilities to improve the sphere of music therapy as the means of adaptive support within the educational settings. The traditional music therapy methods are useful but very stagnant and cannot be scaled and personalized. This paper suggests an adaptive music therapy program that will be driven by AI and will help individuals regulate their emotions, maintain engagement, and be ready to learn in classroom, inclusive education, and online classes. It is a closed-loop architecture based on the uniting framework of multimodal learner sensing, affective computing, cognitive state modeling, music information retrieval, and reinforcement learning. Experimental assessment shows that adaptive music interventions based on AI are more effective than no-music and stable music interventions in reducing the stress proxy, enhancing long-term engagement, and increasing the ability to re-engage with learning activities in learners. The results indicate the relevance of individualized and context-based therapeutic intervention based on the learning and psychological theory. The research paper confirms that AI-driven music therapy is a scalable and emotionally intelligent tool of educational support, and it provides both practical and theoretical contributions to the affective learning systems.

Keywords: Artificial Intelligence, Music Therapy, Affective Computing, Adaptive Learning, Educational Technology, Emotional Regulation, Reinforcement Learning

1. INTRODUCTION

Music therapy has been acknowledged as a successful pedagogical intervention and therapeutic intervention to help children in the cognitive development process, emotional regulation, attention control, and social interaction during school. Its use is found in the early childhood education sector, special education, inclusive class rooms, and in the field of higher education whereby structured musical stimulus is applied to influence the state of readiness to learn, memory consolidation, motivation and emotional wellbeing [Bhandarkar et al. \(2024\)](#). Yet, traditional methodologies of music therapy in education are largely therapist-led, manually edited and restricted in ability to scale, customize and respond in an environmentally dynamic manner to the ever-changing cognitive and emotional conditions of learners [Chen and Huang \(2022\)](#). Such restrictions are especially acute in any heterogeneous classroom, digitally mediated classroom and in large-scale system of education where individualized therapeutic treatment is hard to maintain. The recent developments in artificial intelligence (AI) can provide a revolutionary solution to these limitations, allowing data-driven, adaptive, and personalized music therapy systems to be used in an educational environment [Dai and Ding \(2021\)](#). AI-based music therapy represents a combination of computational models of emotion, cognition, and learning with intelligent music analysis and generation methods that are used to provide responsive therapeutic engagement in relation to the real-time needs of learners. Using multimodal sources of data, including audio-cues, behavioral interactions, physiological responses, and contextual learning data, AI systems will be able to learner's affective and cognitive state and dynamically control musical parameters to achieve optimal therapeutic and educational results [Gandolfo and Hugues \(2021\)](#).

Figure 1

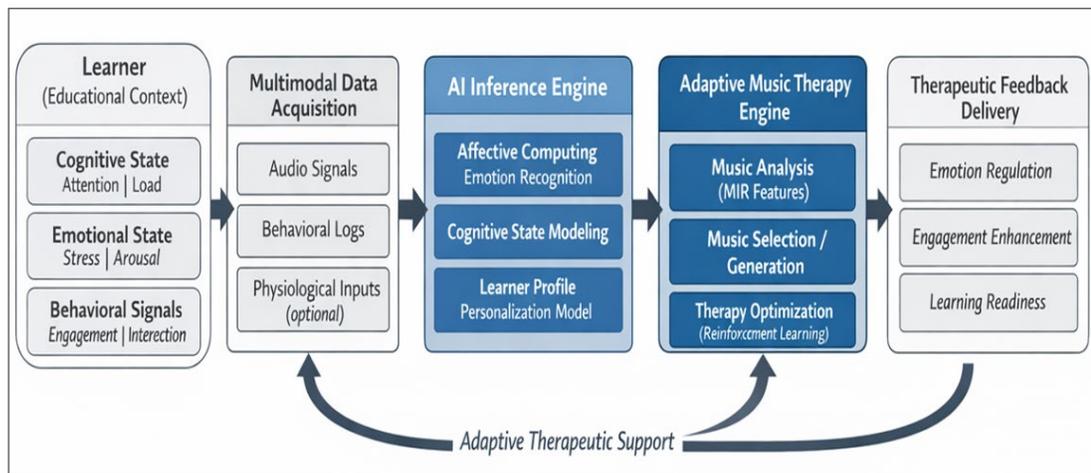


Figure 1 Conceptual Framework of AI-Powered Music Therapy for Education

The effectiveness of learning in educational settings depends on the emotional regulation and cognitive preparedness in educational contexts. Knowledge acquisition and retention can be greatly affected by stress, anxiety, lack of attention, and dysregulation of emotions [Jiang \(2022\)](#). The AI-based music therapy systems have the potential to be operating as intelligent support layers, continuously tracking the states of the learners, and offering adaptive interventions through music to stabilize the emotions, lessen the cognitive load, and boost engagement. Since artificial intelligence-based systems use learning algorithms, unlike fixed playlists or pre-determined therapeutic methods, they can change their intervention plan over time, thus facilitating personalization in the long term and long-lasting effects [Johnels et al. \(2023\)](#). Moreover, the overlap of AI and music therapy is also consistent with the new paradigms of the learner-centered and emotional education. The intelligent tutoring systems, remote learning and digital classroom may incorporate adaptive music therapy systems, which can offer therapeutic scaffolding, albeit non-invasive and effectively. These systems are especially applicable in the context of inclusive learning, where the learner with diverse cognitive, emotional, and sensory needs needs adjusted support systems. Through automating assessment, personalization, and intervention aspects, AI-based music therapy eliminates the need to have constant human supervision and, nevertheless, upholds therapeutic fidelity [Kobus et al. \(2022\)](#).

The paper is an inquiry into design, implementation, and evaluation of AI-based music therapy systems in a learning context. It seeks to formalize a groundwork of the incorporation of intelligent music-based therapeutic interventions in learning settings, examine their pedagogical and emotional effects, and define issues, as well as, challenges of ethics, privacy, and accessibility. By way of this investigation, the research paper establishes AI-based music therapy as an adaptive, scalable, and transformative music therapy tool to improve well-being and [Sikri et al. \(2024\)](#) educational performance among learners in contemporary learning ecosystems.

2. BACKGROUND AND RELATED WORK

Music therapy is a field of investigation that has had very much research in the support area both in education and even in the clinical fields with a lot of evidence to support that music therapy has been effective in enhancing attention, emotional control, memory, motivation, and even social interaction among learners [Lee and Liu \(2021\)](#). Music therapy has been used in educational levels in early childhood education, special education, and inclusive classes and in higher education in which musical stimuli are used as a non-verbal aid to achieve emotional stability and cognitive preparedness. Conventional methods are usually therapist guided and either through structured listening, improvisation or guided musical exercise. Although these approaches are pedagogically useful, they are very reliant on the expert facilitation, subjective evaluation, and manual adaptation of the data, limiting both scalability and consistent individualization of musical features in various learner populations in the music technology field, music information retrieval and machine learning have allowed automated analysis of musical features in relation to tempo, rhythm, harmony, timbre and expression of emotion [Li et al. \(2021\)](#). Deep learning models have been effectively used to recognize music emotion, classify moods and model user preferences, and generative AI methods have been used to compose adaptive music and recommend it. The applications of these developments have been prolific in entertainment and wellness applications but translation into organized educational music therapy has been very haphazard and of limited scope [Sampaio \(2023\)](#).

Table 1

Table 1 Comparative Overview of Music Therapy Approaches in Educational Contexts			
Dimension	Traditional Music Therapy	AI-Assisted Music Systems	Adaptive AI-Powered Music Therapy
Mode of Intervention Sciancalepore et al. (2022)	Therapist-led sessions using pre-designed musical activities and guided listening	Semi-automated systems using curated playlists or rule-based music selection	Fully automated and adaptive therapeutic interventions driven by AI inference and learning models
Personalization Level Tramontano et al. (2021)	Limited personalization based on therapist observation and experience	Moderate personalization using user preferences or basic behavioral data	High-level personalization using real-time cognitive, emotional, and behavioral state modeling
Adaptability Venugopal and Madhusudan (2017)	Static or manually adjusted over time	Partially adaptive with predefined rules or thresholds	Continuously adaptive through learning algorithms and feedback-driven optimization
Data Utilization Williams et al. (2020)	Qualitative observations and session notes	Audio features and basic interaction data	Multimodal data including audio, behavioral logs, physiological signals, and contextual learning data
Scalability in Education Xu (2022)	Low scalability due to dependence on trained professionals	Moderate scalability for digital and remote learning environments	High scalability across classrooms, online platforms, and inclusive education settings

Traditional music therapy, as it is presented in [Table 1](#), focuses on human knowledge and sensitivity to context but cannot be scaled and needs to be responsive in the real-time. The music systems supported by AI have certain elements of automation and personalization through preferences, but they are mostly fixed and not related to cognitive and emotional changes in learners [Yang et al. \(2022\)](#). In comparison, adaptive AI-enabled music therapy is a paradigm shift through the incorporation of affective computing, learner modeling, and adaptive music intelligence in a closed loop system. These systems keep on learning based on multimodal data, which allows them to maintain personalization and be aligned to therapeutic and educational goals. Although the interest in the use of AI in therapeutic applications has increased, most current research is based on clinical rehabilitation or mental health support as opposed to integrating AI in education [Zheng and Dai \(2022\)](#). In addition, ethical aspects, privacy protection, accessibility, and inclusivity are

usually regarded as secondary issues. The above gaps show that there is a need to have a coherent, learner-based system that integrates AI-driven music therapy into the learning ecosystems.

3. THEORETICAL FOUNDATIONS OF MUSIC-BASED THERAPEUTIC LEARNING

Architectural specifics of AI-based music therapy education apparatuses rely on the priori learning, psychological, and neuroscientific concepts, which elaborate on the effects of music on cognition, emotion, and conduct. Music acts as an effective controller of attention, arousal, memory and affect, and therefore, it is effective in the use of therapy of learning interventions. These principles, together with artificial intelligence, can be implemented into dynamically responsive data-driven components of the system that adjusts to the dynamically changing cognitive and emotional conditions of learners. This part is a summary of the main theoretical cornerstones and their connection to the functional aspects of the suggested AI-driven music therapy framework. There is music-based therapeutic learning that is based on Cognitive Load Theory (CLT). CLT highlights that to facilitate effective learning, intrinsic, extraneous and germane cognitive load must be balanced. During learning, learning and memory may be affected by the increased level of stress or anxiety, thus overwhelming working memory. Manipulation of tempo, harmony, and rhythm in therapeutic music has the potential to decrease extraneous information processing through soothing learners and ensuring focus. Continuous state inference, which is part of an AI-based system, facilitates the adaptive adjustment of musical aspects to assist in the learning process without the introduction of new cognitive loads. Theories of emotional processing, especially the Arousal-Valence Model, also describe the effect of music on learning. This model is a reflection of the emotional states in the dimensions of arousal and valence, in which the optimal learning would take place on the moderate arousal and positive affect. Music inherently influences emotional conditions, whereas affective computing using AIs enables real-time identification of emotions of learners. The AI-based music therapy can improve emotional regulation and engagement by matching musical treatment with the desired arousal-valence states.

Figure 2

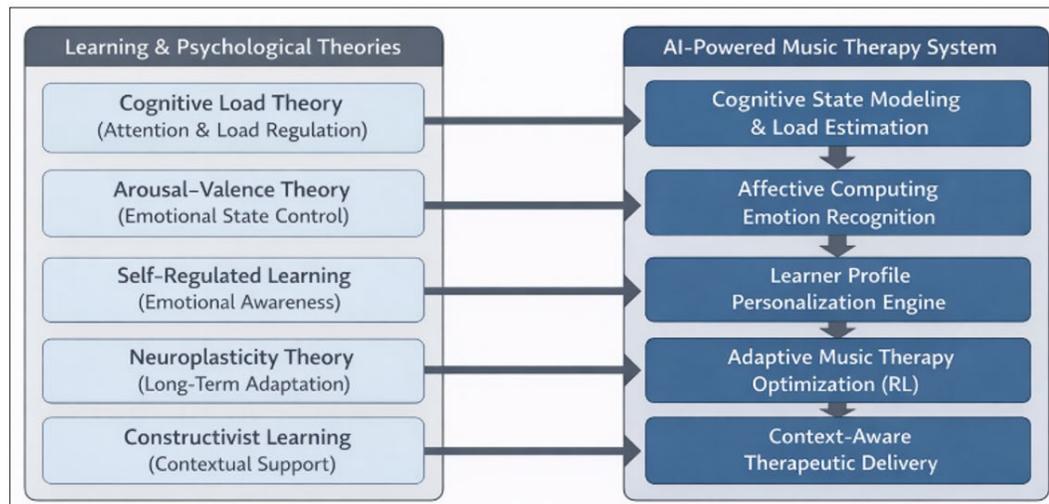


Figure 2 Mapping of Learning and Psychological Theories to AI-Powered Music Therapy System Components

Lastly, the Self-Regulated Learning (SRL) theory is used to inform the framework as it focuses on the ability of learners to observe and manage their mental and emotional activities. Music therapy aids SRL in enhancing emotional awareness, regulation of stress and motivation. Similar feedback loops powered by AI enable the response to therapeutic interaction to be continuously adapted to, and self-regulation scaffolding can be personalized without requiring cognitive effort. Based on the system design premises of these complementary theories, AI-based music therapy is no longer ad hoc or entertainment focused but rather a scientifically informed educational intervention. The formalization of the correspondence between theory and system architecture can guarantee a high level of pedagogical validity, enhance the interpretability, as well as reinforce the argument in favor of including adaptive music therapy into the current educational ecosystems.

4. ADAPTIVE MUSIC THERAPY STRATEGIES IN EDUCATIONAL SETTINGS

The artificial intelligence-based adaptive music therapy is an engaging learner-centered intervention, which is context-dependent, meaning it dynamically reacts to cognitive and emotional needs in educational environments. Based on the system architecture and algorithmic pipeline, AI-assisted music therapy is operationalized in three main settings, including classroom learning, inclusive and special education, and online or distance learning. In all the settings, the idea is to increase learning preparedness, self-control, and involvement without interfering with the learning process. Adaptive music therapy is applied as a non-intrusive ambient or micro-intervention in a classroom setting. Strategies are also developed over time in order to fit the teaching styles and classroom dynamics. Adaptive music therapy is very individual in an inclusive and special education setting. Constant observation and profiling of learners allows intervention to be done individually with consideration of the sensitivities of the learners to tempo, rhythm and complexity. They facilitate anxiety reduction, attention control, and emotional self-control as an assistant tool that supplements the human-centred support without undermining the accessibility and autonomy. In remote and online learning, adaptive music therapy deals with disengagement, exhaustion and isolation. Based on interaction data on the online platforms, the system provides personalized music-based micro-breaks or soundscapes and adjusts both intervention timing and nature in response to time to maintain focus and emotional regulation.

Figure 3

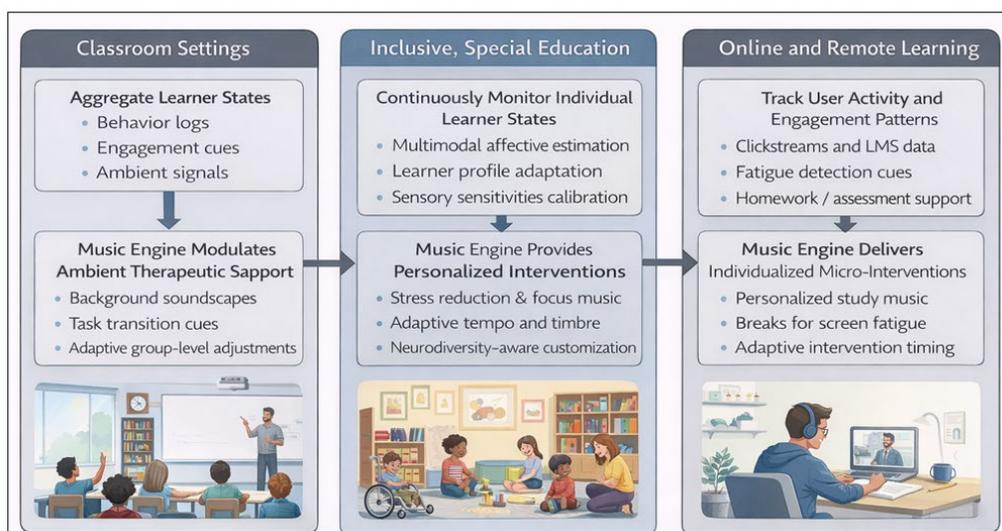


Figure 3 AI Model Taxonomy for Therapeutic Music Intelligence

In every teaching context, ethical and pedagogical protection is part of adaptive music therapy strategy development. The constraints of interventions are an attempt to avoid excessive use, distract less, and cultural and contextual appropriateness. The music therapy does not stand as an alternative to the instruction or human support but as a smart layer of scaffolding that facilitates an emotional situation to learn. Transparency and controllability are ensured because educators and learners can increase or decrease the intensity of interventions, may choose to stop when they wish and receive aggregated responses about the performance of the system. Altogether, the presented adaptive strategies prove the idea that AI-assisted music therapy can be easily incorporated into diverse learning systems. The framework allows the scaling of the intervention as well as its therapeutic applicability because, by structuring the granularity of interventions along with the contextual needs, i.e., ambient support in the classroom, personalized assistance in inclusive education, and individualized control in online learning, the framework is scalable. This versatility makes AI-based music therapy an effective and viable instrument of education of the emotionally intelligent.

5. SYSTEM ARCHITECTURE FOR AI-POWERED MUSIC THERAPY

The proposed AI-driven music therapy system is a closed, learner-focused system that will constantly monitor learner state, predict cognitive, emotional states, and provide live adaptive music-based interventions to improve

learning preparedness, interest, and emotion management. In contrast to fixed playlist strategies, the system realizes the cognitive load regulation, arousal-valence management, self-regulated learning, and long-term personalization, using modular, theory-based elements. Interactions of learners and context are recorded so that interventions should be context-sensitive and less intrusive. These signals are preprocessed and converted to stable multimodal features which promote real time inference. The cognition load, attention stability and emotional state are estimated by the AI inference layer relying on behavior and affective indicators, whereas a learner profiling module allows personalization, relying on previous responses.

Figure 4

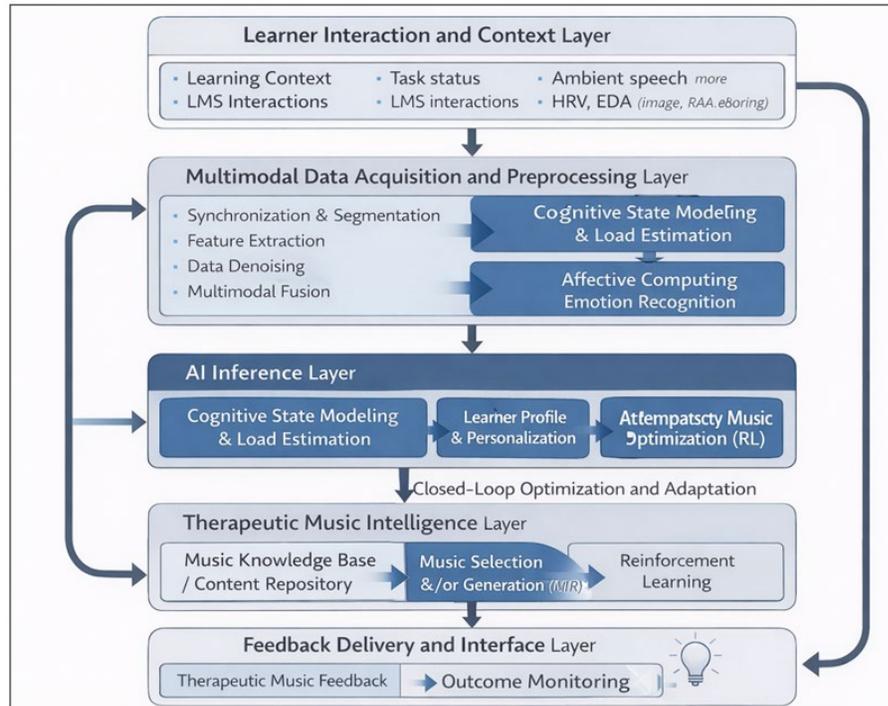


Figure 4 AI Powered Music Therapy System Design

A music intelligence layer is derived to generate therapeutic decisions, and it chooses or customizes music according to perceived needs of the learner and pre-established intervention policies. Close loop adaptation process re-establishes strategies as time progresses with response of the learners which can be optimized through time with safety and pedagogical limitations. Lastly, the music-based feedback is provided by non-disruptive means, and optional reflective prompts and aggregated analytics are provided to the educators. The architecture described in general offers a scalable and decipherable channel to apply AI-based music therapy to the education system.

6. EXPERIMENTAL DESIGN AND EVALUATION METHODOLOGY

The evaluation methodology is designed in such a way that it evaluates not only the therapeutic outcomes, including emotional regulation and engagement stability, but also educational support outcomes, including learning readiness and task persistence. In order to achieve ecological validity, experiments are carried out in the classroom and inclusive education and online learning conditions based on multimodal data on learners and longitudinal assessment models. The experimental testing is based on the multimodal data that is gathered during pilot deployments and controlled learning. The data sources aim to identify the non-intrusive behavior of learners, their affective conditions, and contextual learning. The data of behavioral interaction are obtained on the basis of classroom interfaces and learning management systems where the interaction dynamics and the course of the tasks are recorded. It makes the inference of the affective signals based on the audio based features and the physiological indicators are introduced as optional when they are available. Contextual data give situational awareness that is required in the selection of adaptive interventions.

Table 2

Table 2 Dataset Composition and Data Sources			
Data Category	Data Source	Examples of Features	Role in System
Behavioral Interaction Data	LMS logs, classroom interfaces	Response latency, inactivity duration, error patterns, task transitions	Cognitive load estimation, engagement modeling
Audio-Based Affective Data	Microphone / ambient audio	Pitch variance, energy contours, rhythm stability	Arousal-valence emotion inference
Physiological Signals (Optional)	Wearable sensors	Heart rate variability, electrodermal activity trends	Stress and arousal proxy estimation
Contextual Learning Data	Course metadata, session logs	Task type, learning phase, learning modality	Context-aware intervention selection

As it can be seen in Table 4, the dataset design focuses on multimodal complementarity which enables the system to make reliable predictions of the learner state when some of the modalities are missing. There are ethical protection measures such as informed consent, anonymization and access control which are practiced during the data collection and storage. An evaluation is based on comparative mixed-method protocol, which involves within-subject and between-group analysis. There are three experimental conditions to which learners are subjected to, namely, (i) no music-based intervention, (ii) static or rule-based music support, and (iii) fully adaptive AI-powered music therapy. Such circumstances are used to similar learning activities in order to separate the impact of adaptive music interventions. Different educational situations have different protocols to indicate context constraints and learning interactions. Classroom research gives more attention to patterns at the group level, inclusive education to individualized paths, and experiment research in online learning at long-term asynchronous behavior.

Table 3

Table 3 Experimental Protocols Across Educational Scenarios			
Educational Scenario	Experimental Design	Intervention Conditions	Evaluation Duration
Classroom Learning	Group-level, session-based comparison	No music, static music, adaptive AI music therapy	Multiple classroom sessions
Inclusive / Special Education	Individual-level, longitudinal	Personalized adaptive therapy vs baseline support	Extended multi-session
Online / Remote Learning	Individual, asynchronous evaluation	Adaptive micro-interventions vs static playlists	Longitudinal self-paced study

The design of the protocols makes sure that the pedagogical practices are consistent between conditions and that it is possible to reliably attribute the effects that are observed to the adaptive music therapy and not to instructional variance. Measures of evaluation are chosen to address the two-fold aims of therapeutic efficiency and academic assistance. The metrics of engagement and affective measures are used to measure the stability of attention and consistency of interactions and emotional regulation and stress recovery, respectively.

Table 4

Table 4 Consolidates the Evaluation Metrics Used in the Study and Their Corresponding Objectives.			
Metric Category	Metric Name	Description	Objective
Engagement Metrics	Attention stability, inactivity reduction	Measures sustained learner engagement	Learning readiness
Affective Metrics	Arousal stability, stress proxy reduction	Estimates emotional regulation effectiveness	Therapeutic impact
Learning Support Metrics	Task recovery time, readiness indicators	Reflects ability to resume learning	Educational support
Personalization Metrics	Policy convergence time	Measures speed of adaptive optimization	Long-term effectiveness
System Performance Metrics	Inference latency, intervention frequency	Evaluates deployability and intrusiveness	Real-world feasibility

Combined, [Table 4](#) give a clear and well-organized summary of the experimental system, allowing it to be reproduced and allows a reviewer to understand. This evaluation model is supported by longitudinal analysis and baseline comparisons, making it possible to make an inflexible evaluation of AI-based music therapy as an adjusting, emotionally intelligent assistance tool in school settings.

7. DISCUSSION

The findings reveal that adaptive AI-based music therapy is always better in improving the engagement of the learners, lowering the stress levels, and increasing the readiness to learn, compared to no-music and static music therapies. These results prove that music therapy use in educational institutions is the most effective when it is dynamically adjusted to both the cognitive and emotional condition of learners but not as a background factor. In theory, the identified gains are consistent with the provisions of the Cognitive Load Theory and Self-Regulated Learning. Adaptive music interventions seem to help decrease extraneous cognitive load by regulating emotional arousal, as well as alleviating stress proxies, so that learners are able to maintain attention and better cope with task difficulty. Emotion-sensitive nature of the musical features in the system promotes the best arousal-valence conditions, which justifies the importance of affective regulation as the condition of successful learning. The decrease in the level of stress and the growth of the involvement emphasize the capacity of the system to balance between calmness and alertness, which is a crucial need in school. Moreover, the positive changes in learning preparedness imply that adaptive music therapy promotes the resiliency of learners and their ability to resume their work, especially in an inclusive and online classroom where emotional pressures tend to be higher. Longitudinal adaptation is important as demonstrated by the system perspective of the effectiveness of the closed-loop personalization and reinforcement-based optimization. Its outcomes also indicate that this adaptive intelligence can be implemented in real-time, which does not involve a lot of unnecessary computational cost, hence being useful at scale. In general, the results place AI-based adaptive music therapy in a promising perspective as a theoretically informed method of providing educational assistance, which is emotionally intelligent. Although there are limitations associated with affective measures that use proxies and cultural differences, the findings are a solid basis of future large-scale and longitudinal research.

8. CONCLUSION AND FUTURE SCOPE

This paper provided a systematic design of the adaptive music therapy based on AI in teaching environments, implementing learning theory, affective computer, music recognitions, and closed loop optimization as the part of the single system architecture. The proposed approach argued benefits over the traditional and static music interventions through systematic design and experimental testing and showed clear benefits on enhancing learner engagement, decreasing stress, and increasing learning readiness in classroom-based, inclusive education, and online learning settings. The results attest to the fact that music therapy is most effective as a means of education when it is context-observant, individualized and responds dynamically to the cognitive and emotional conditions of learners. This is achieved by basing system elements on the proven theoretical frameworks including the Cognitive Load Theory, Arousal-Valence modeling, and Self-Regulated Learning, which can transform music therapy into a supportive background intervention rather than an emotive learning scaffold. The findings further indicate that adaptive music interventions can be implemented in real time at a cost that does not interfere with pedagogical flow and this makes the framework viable in a practical manner to modern learning ecosystems. In the future, there are many directions that can provide promising prospects to research. There is a need to conduct large-scale longitudinal studies to measure long-term learning outcomes and change behavior. Affective inference could also be improved by integration with neuroadaptive interfaces, e.g. EEG or advanced biosensors. Also, responsive music modeling and interpretable AI systems would increase inclusivity, trust and adoption. In general, AI-based music therapy is one of the most promising and scalable directions of emotionally intelligent and learner-oriented education.

CONFLICT OF INTERESTS

None.

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