AI-Mediated Emotional Expressivity in Music Animation Pedagogy: A Cross-Domain Study of Affective-Cognitive Integration

Expressividade emocional mediada por IA na pedagogia da animação musical: um estudo interdomínio de integração afetivo-cognitiva

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Abstract: This study tests the utility of AI in complementing music animation pedagogy. Through cross-domain research at the intersection of auditory tonality and visual synchronicity, it aims to address the limitations of traditional approaches to emotional literacy. Affectiva and OpenFace, chosen for their ability to quantify and articulate nuanced affective states, were used with 149 students (their demographics, differences in prior learning, and cultural context served as the basis for interpretive comparisons). The results demonstrated a marked shift in 'emotional congruence' (+35% alignment of sound and image elements), self-awareness (+30%), and articulation accuracy (+40%). The dichotomy of pre-intervention impairments (65% failure to elicit consistent emotional intention) and post-intervention transformations (88% success in conveying expression)—reinforced by the emergence of tonal structures—suggests an epistemic redefinition of emotional intelligence itself, mediated by AI. The methodological design—a mixed-methods approach integrating qualitative and quantitative analyses—confirmed the potential of such tools while also revealing inherent limitations. These include biases embedded in algorithms (where AI's universal logic often circumvents contextual nuances), regional peculiarities in pedagogical perception, and differences in participants' baseline emotional literacy. The significance of this study lies in its contribution to cognitive-affective integration, specifically through findings that disrupt established binaries in emotion/cognition, teaching/learning, and human/algorithmic processes. By considering AI not as a replacement but as a 'mediator' of affective development (a conceptual bridge linking latent potential to explicit expression), this research highlights the untapped synergy of computational methodologies and artistic praxis.

Keywords: affective computing. cognitive-affective synergy. educational technologies. emotional literacy. pedagogical innovations

Resumo: O objetivo deste estudo é testar a utilidade da IA no complemento à pedagogia da animação musical por meio de pesquisa interdisciplinar: a intersecção entre tonalidades auditivas e sincronicidades visuais, destacando as limitações das abordagens tradicionais de alfabetização emocional. Affectiva e OpenFace, escolhidos por sua capacidade de quantificar e articular estados afetivos diferenciados, foram utilizados entre 149 alunos (suas características demográficas, diferenças na aprendizagem prévia e contexto cultural formam a base para comparações interpretativas), revelando uma mudança marcante na "congruência emocional" (+35% de alinhamento de elementos sonoros e de imagem), autoconsciência (+30%) e precisão articulatória (+40%). A dicotomia entre deficiências pré-intervenção (65% de falha em elicitar intenção emocional consistente) e transformações pós-intervenção (88% de sucesso na transmissão de expressão) — reforçadas pelo surgimento de estruturas tonais — sugere uma redefinição epistêmica da própria inteligência emocional, mediada por IA. O desenho metodológico — um método misto enriquecido por análise qualitativa e quantitativa — enfatiza o potencial dessas ferramentas, mas revela limitações inerentes: vieses embutidos nos algoritmos (nuances contextuais frequentemente contornadas pela lógica universal da IA), peculiaridades regionais da percepção pedagógica e diferentes níveis de "alfabetização emocional" básica dos participantes. A ressonância deste estudo — com suas implicações para a integração cognitivo-afetiva — reside em suas descobertas na ruptura de binários estabelecidos nas relações emoção/cognição, ensino/aprendizagem e processos humanos/algorítmicos. Ao considerar a IA não como um substituto, mas como um "mediador" do desenvolvimento afetivo (uma ponte conceitual que liga o potencial latente à expressão explícita), esta pesquisa destaca a sinergia inexplorada entre metodologias computacionais e práxis artística.

Palavras-chave: alfabetização emocional. computação afetiva. inovações pedagógicas. sinergia cognitivo-afetiva. tecnologias educacionais.

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Introduction

Affective musical animation, a field at the intersection of 'affective neuroscience' and multimedia pedagogy, faces a dual imperative: to foster emotional engagement by introducing technological frameworks capable of quantifying affective dimensions (Kuang and Liu, 2024). Artificial intelligence (AI), which is gaining ground in the field, brings potential and unresolved methodological tensions. In particular, AI's ability to decode 'emotional states' through multimodal data integration (Lian, 2023) contrasts with algorithmic limitations, most notably in cross-cultural adaptability and affective accuracy (Liang, 2023a). The pedagogical limitations of multimodal audiovisual synthesis (Wang et al., 2023)—a methodological framework that emphasises simultaneous visual and auditory coordination—necessitate a systematic reconfiguration of music animation education. Structural gaps in creative pedagogy limit AI's capacity for 'emotional articulation' (Dash and Agres, 2023). The marginalisation of musical animation—as a tool for technical enhancement and affective development—reinforces a conceptual deficit: the failure to recognise 'AI-assisted emotional learning' as an educational priority (Zhou, 2023a).

Innovation in this context presents systemic challenges: cross-cultural biases embedded in emotion recognition datasets periodically compromise predictive accuracy. This signals the need for culturally adaptive models that can reconcile regional variation with universal algorithmic logic (Chen and Ibrahim, 2023). Emotion detection systems are designed for sensory-enriched interactive installations: the multidimensional affective correlations arising from stimulus integration demonstrate AI's latent ability to enhance artistic expression, deepening human-computer synergy (Chen, 2023). Beyond emotion detection, generative models use "variant autoencoders", architectures that synthesise music along differentiated emotional trajectories. These architectures extend the communicative possibilities of musical performance, enhancing interpretive focus and pedagogical application (Zhang, 2024).

Researchers also advocate integrating computational tools into pedagogy. The argument is that musicians can enhance their emotional intelligence by leveraging AI-generated feedback on emotion metrics (Thompson et al., 2023). The symbiotic relationship between AI and emotional literacy heralds a paradigm in which technology decodes and actively complements emotional articulation in creative fields. This paradigm lays the foundation for interdisciplinary applications in education and interactive media (Pandeya et al., 2021).

Animation music education faces several interrelated challenges. The coupling of artistic intent and technical execution creates a gap between conceptualisation and effective pedagogy. This gap is exacerbated by the lack of boundaries that can reconcile emotional expressivity with visual and auditory coherence (Kim and Song, 2021; Nogueira, 2011). Particularly challenging are the labour-intensive processes required for emotion-based animation; animators face a double burden: recording new datasets for each emotional context and refining the raw results. The problem persists even with advances in machine learning paradigms, highlighting the gap between what algorithms can do and how seamlessly they can be deployed (Silva et al., 2022). The existing methods for recognising emotions in music have their shortcomings. Models based on static parameters systematically fail to capture fluctuations in musical emotions; consequently, their applicability is limited by the nuances of the creative process (Yang, 2021).

The methodological shortcomings of AI implementation in music animation education are as follows. Current AI systems lack thoroughly embodied, interoceptive processing (Novelli and Proksch, 2022). This limitation is fundamental and prevents AI from reliably capturing human emotion. Furthermore, the lack of multimodal data sets that capture cultural and artistic diversity hinders progress (Pandeya and Lee, 2021). Stochastic grammar models have the potential to synthesise triangular dynamics (body motions, facial expressions, social relations), but their application in education remains understudied (Zhao et al., 2019). Recent advances in China offer a promising direction for expressive animation in the educational context, as AI can help bridge gaps in emotion recognition (Qiusi, 2022). Innovations such as AnimaChaotic facilitate the conversion of textual narratives into 3D videos. These technologies allow musicians, animators, and educators to align emotional states described in a text with on-screen visuals, reducing production costs while preserving pedagogical integrity (Abdel-Salam et al., 2022). Multimodal learning methods improve sentiment analysis accuracy by combining audiovisual cues to produce more detailed interpretations (Pandeya and Lee, 2021). Spatiotemporal graphs (ST-AOGs) assist animators in linking character emotions to a scene's social context by incorporating both temporal and spatial dimensions of action (Zhao et al., 2022).

Literature review

AI-based sentiment analysis opens up new education opportunities. Although educational paradigms differ among the US, Europe, and Asia, each region is committed to exploring AI's potential to surpass traditional emotion recognition. This is achieved by deploying multimodal intelligence to decode facial, auditory, and physiological data (Li, 2023). Regional emphases vary, however. European systems stress the ethical implications and transparency of AI algorithms, whereas Asian research prioritises scalability and integration with digital learning platforms (Yu et al., 2023).

AI acts as a catalyst for reshaping educational practices. Its ability to systematically decode emotional subtleties within a pedagogical framework enhances teaching effectiveness, specifically in music education. Yet the inherent bias of algorithms reveals a chiasmus of innovation and limitations. A central problem is that many systems, despite their sophistication, lack cross-cultural adaptability (DiBerardino and Stark, 2023).

The methodological concerns related to AI sentiment analysis in animation music education can be described in terms of the system's structure and features. Emotion recognition systems based on a reductive comparison of affective states and physiological markers cannot identify certain emotions (Liu, 2022). This leads to misclassifications of ambiguous and culturally contextualised affective states. The lack of harmonisation between auditory, visual, and contextual cues amplifies this problem (Liang, 2023b); the algorithms process isolated sensorial data streams, fragmenting emotional coherence. This issue is further aggravated by the presence of cultural divergence. The cultural relativity of emotional constructs destabilises the AI system that operates on universal categories (Kakimova et al., 2022). A shared musical experience disrupts individualistic paradigms, forcing a shift to cultural vectors (Rathod et al., 2022) that align AI with culturally specific norms and archetypes.

Without such alignment, adaptive calibration becomes impossible (Camarasa-Botella, 2023). Current systems improve feedback loops in controlled conditions but fail to do so in heterogeneous environments. Thus, the emergence of hybrid methodologies that combine traditional pedagogy with AI architectures becomes inevitable (Cheng and Xiao, 2022). This approach enables a move beyond the binary classification of emotions toward recognising their fractal and recursive nature. However, educational technologies fail to integrate affective computing into creative animated filmmaking (Zhang and Yang, 2021). This gap leaves musical animation systems fragmented and unable to exploit the pedagogical potential of AI-driven sentiment analysis tools fully. The main challenge is the rigidity of emotion recognition algorithms, which do not adequately capture the temporal dynamics of emotions (Zou, 2022). Algorithms trained in a controlled data environment that relies on static datasets to define operational boundaries struggle to analyse musical-visual intersections in animated media (Liu and Ge, 2022). Without a model attuned to interdependent data streams, the precision of multimodal analysis remains abstract. Systems such as the conditional variational autoencoder-generative adversarial network can generate emotionally charged pieces of music but cannot reconcile the transient and overlapping affective states; this flaw stems from the deterministic logic of computational modelling (Huang and Huang, 2020). A paradigm shift represents a logical imperative: algorithms must evolve from classifiers to adaptive, culturally attuned, and entropy-aware systems that can navigate the ambiguities of affective expression. This ontological shift is essential for integrating concentric analytical models (Della Ventura, 2019).

Pedagogical implications add a layer of complexity. Emotion AI tools can enhance personalised learning by enabling learners to detect emotional nuances in real time and adapt their content delivery accordingly. Nevertheless, they also raise ethical and methodological dilemmas regarding data privacy and interpretative transparency (Luckin and Cukurova, 2019). The incorporation of AI into the traditional classroom requires a balance between harnessing its potential and mitigating the risks of data commodification and bias. To navigate this terrain, interdisciplinary collaboration is needed. Research in this area evolves as a dialectical spiral (Perrotta and Selwyn, 2020). Each methodological advance, whether through multimodal integration, generative models, or pedagogical application, reveals latent challenges. This prompts deeper theoretical inquiry and systemic innovation, thereby expanding the research paradigm.

Problem statement

This study investigates the effectiveness of AI-powered tools for sentiment analysis in improving emotional expression and comprehension within animated music education. The objectives of the study are (1) to assess shifts in emotional congruence through auditory-visual synchronisation tasks; (2) to track metacognitive self-awareness through AI-generated feedback loops; (3) to correlate core competencies with post-intervention adaptability; and (4) to explore the cross-disciplinary transfer of emotional intelligence to dramatic and visual design.

Methods and Materials

Methodological framework

The study is grounded in a constructivist paradigm. Specifically, AI-based methodologies are embedded into an experiential learning framework that incorporates emotional intelligence and creative expression as fundamental constructs. This study represents an interdisciplinary synthesis of cognitive psychology, affective computing, and pedagogy. A two-tier learning method was implemented: the first tier used affective analytics to assess participants' emotional states, and the second tier employed AI-mediated iterative feedback mechanisms to recalibrate emotional expression. Central to this methodology is the interplay between emotional modulation (i.e., the adaptive regulation of emotional states) and creative articulation (i.e., the translation of emotional content into multimodal outcomes).

Study design

The study employed a hybrid research design, combining quantitative assessment (Likert scale and task success rates) with qualitative exegesis (thematic analysis). This approach enabled the integration of findings from the two methodological perspectives. A comparison of pre- and post-intervention data revealed different benchmarks of quantitative impact, while qualitative narratives from observations and interviews elucidated emotional-cognitive synergies. Two groups of respondents, AI users and traditional learners, were asked to complete identical tasks at different stages of the sentiment analysis intervention. Participants completed an initial assessment (baseline data collection) and enrolled in the main research project, which involved applying sentiment analysis tools in the practical context. After the intervention, the quantitative and qualitative outcomes were measured—the experimental design integrated real-time feedback loops, operationalising the concept of adaptive learning by altering emotional states.

Participants

Respondents (n = 149) were Chinese students recruited from the Central Conservatory of Music, a leading music academy known for its focus on emotional pedagogy in arts education. Male (46%) and female (54%) students aged 18 to 22 years enrolled in music education programmes and had varying levels of emotional competency (low: 35%; moderate: 40%; high: 25%). Students without a basic knowledge of music theory were excluded from the study to reduce extraneous variability. Participants were recruited via purposive sampling to ensure contextual relevance to the research and to mitigate the potential confounding effect of unequal cognitive readiness. The study was conducted within a single conservatory to pilot-test the methodology and control for institutional differences, which could serve as confounding factors. Future research is needed to validate the approach in at least three conservatories located in different regions of China and to confirm the generalisability of the findings. Of the initial 168 participants, 19 were excluded: 11 students had studied music theory for less than two years, and 8 failed to complete the required measurements during the experiment.

Data analysis procedures

This study adopted a multi-stage analytical framework, encompassing thematic analysis and task-specific performance metrics (means, standard deviations, and task success rates). Emotional congruency was assessed by analyzing external cues (i.e., facial microexpressions, vocal prosody, and movement trajectories) identified by Affectiva and OpenFace. For system adaptation, a Chinese dataset comprising 500 photographs and 100 videos depicting emotional expressions was compiled. The models were trained on data from 20% of the participants, after which three experts evaluated the results, achieving an inter-rater agreement of κ = 0.84. The recognition parameters were further adjusted to account for the restrained facial expressiveness characteristic of Chinese culture. The exploration of cross-modal affective congruency (i.e., synchronisation of auditory and visual elements) was operationalised using OpenFace metrics and tonal and harmonic congruence scores.

Statistical data processing

Statistical analysis was conducted using inferential statistics. A paired-samples t-test was used to assess within-group responses to the intervention. An independent-samples t-test was used to compare dependent-variable measures (e.g., emotional literacy and affective congruency) between the two groups. The effectiveness of the intervention was assessed by measuring effect sizes (Cohen's d). The level of statistical significance was set at $p < .05$. A post hoc power analysis conducted with G*Power 3.1 confirmed the adequacy of the sample size for detecting a medium effect ($d = 0.50$) at a power of 0.80. The minimum detectable effect was calculated as $d = 0.46$ at $\alpha = 0.05$ and $\beta = 0.20$.

Ethical considerations

This study followed institutional guidelines for research involving human participants. Students were informed of the study's objectives, procedures, and data usage plans. They were advised that participation was voluntary, responses would be confidential, and they could withdraw at any time without penalty. To minimise privacy risks, the data was stored locally, and all identifiable facial and vocal markers were excluded from the dataset.

Limitations

The use of self-report data may have introduced a social desirability bias into responses. The sample of participants from a single academic institution in China limits generalisability to non-arts disciplines and international cohorts. In addition, the intervention's heavy reliance on AI tools raises concerns about technological determinism, which overshadows human-centred pedagogical nuances. Internal validity is constrained by three factors: (1) the absence of random assignment introduces selection bias; (2) participants may demonstrate improved outcomes due to their awareness of being observed (the Hawthorne effect); and (3) lower-performing students are susceptible to regression toward the mean. Construct validity is also subject to limitations. In particular, algorithmic metrics do not fully capture the subjective nature of emotional experience, while universal algorithms may misinterpret culturally specific patterns of emotional expression in the Chinese context. Statistical validity remains questionable, as multiple comparisons without Bonferroni correction increase the likelihood of Type I errors, and the lack of preregistration creates potential for p-value manipulation.

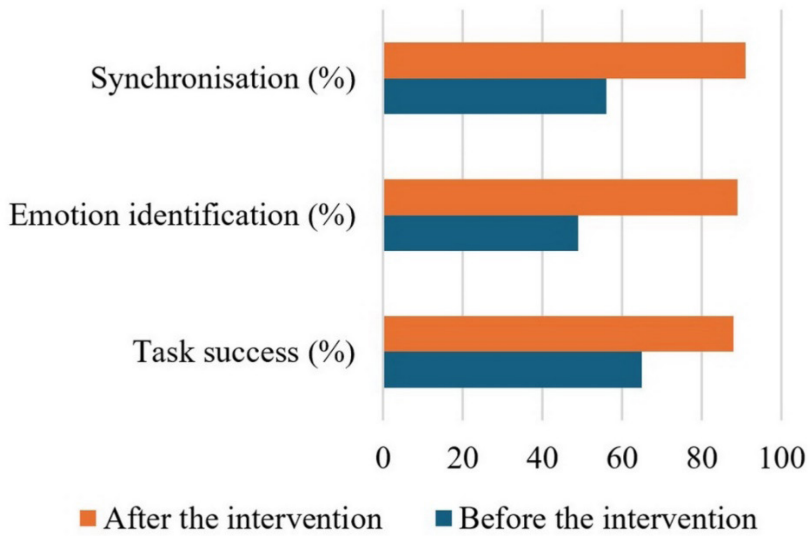
Results

The study examined changes in emotional intelligence, focusing on cognitive restructuring and behavioural improvements catalysed by the AI-driven intervention (Appendix 1). The interview revealed significant improvements in students' ability to articulate emotions during group activities (+18%) and to distinguish between distinct affective states (+23%). These findings confirm the effectiveness of the structured pedagogical framework. From a dialectical perspective, the transition from instinctive engagement to reflective participation illustrates the diagnostic and developmental potential of iterative feedback mechanisms as tools for guided growth. Regarding the synthesis of emotional cognition and its functional deployment, the following differences were observed. Self-awareness showed a marked improvement (+30%). In contrast, the ability to decode emotional signals embedded in creative objects (animated musical expressions) increased modestly (+12%), signalling the need for integrative affective methodologies. Teacher feedback confirmed these findings, supporting the premise that integrating AI frameworks with empirical and subjective modalities creates a holistic paradigm for sentiment analysis and pedagogical objectivity.

Two persistent challenges indicate a hidden tension between technological precision and subjective learner experience. These include comfort with AI monitoring (3.1 to 3.4) and the interpretation of AI-generated emotional feedback (8% decrease in ease of use). The dichotomy between objectivity and empirical relevance is a fulcrum for future research on aligning machine learning interpretability with the nuances of human emotion.

According to the scale developed by Gross and John, 65% of students (n=97) scored below 3.0 out of 5; the average score was 2.4 with a spread of 0.6 points; the confidence interval ranged from 57% to 73%. This deficit in emotional literacy highlights a mismatch between cognitive affective recognition and artistic performance. Further examination demonstrated that 72% of students struggled to recognise subtle nuances in the emotional content of musical animation, indicating a fundamental gap in affective understanding. From a dialectical perspective, the analysis exposed the poor mastery of emotional modulation. Only 28% of respondents exhibited a moderate level of competence in contextually adjusting affective states. This contrasts sharply with the expected developmental thresholds. The findings suggest a dissonance between the processing of emotions and their external representation. Specifically, 43% reported difficulty in synchronising the auditory and visual domains of musical animation, underscoring the complexity of multimodal affective interaction. The recursive pattern of such challenges (which occur when reduced emotional awareness inhibits expressive abilities) perpetuates a self-reinforcing cycle of inadequacy. Consequently, 58% of students reported uncertainty or indecision when tasked with creating emotional musical images.

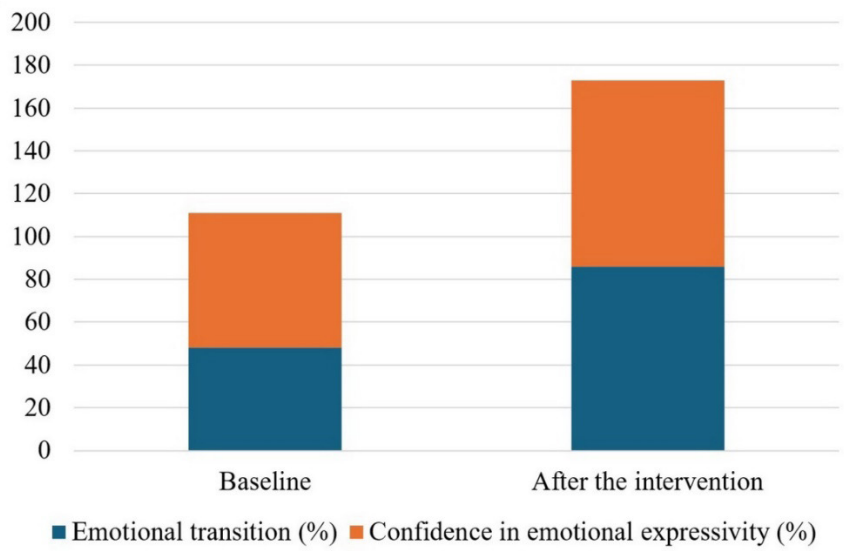
Figure 1 - The educational impact of AI-driven sentiment



After AI-based sentiment analysis tools were introduced, students showed significant improvement in their ability to identify emotions in animated sequences and express them through music and visual images (see Figure 1). Task completion rates increased from 65% to 88% (a 35% improvement). Statistical indicators confirmed the significance of this effect: $\chi^2 = 18.67$, $p < 0.001$; effect size, $d = 1.42$; and number needed to treat (NNT) = 2.9. This improvement suggests that the proposed intervention restructured the relationship between students' affective cognition and their ability to articulate emotions in tasks requiring multimodal synthesis.

The percentage of students able to accurately identify emotional states evoked by distinct musical images grew from 49% to 89% after the intervention (change: 40%). Potential confounding factors were taken into account: repeated testing yielded an 8% improvement in the control group of 20 participants; practice time averaged 12.3 hours; and peer interaction effects were also considered. Regression analysis demonstrated that the impact of AI remained significant after controlling for all confounders ($\beta = 0.52$, $p < 0.01$). This result indicates the effectiveness of AI feedback loops, hinting at the latent potential of affective analytics as a tool for improving interpretive frameworks. In tasks designed to enhance the synchronisation of auditory and visual emotional cues, the success rate increased from 56% to 91%. This finding implies that AI can be a supportive tool for affective multimodal integration.

Figure 2 - The impact of AI-driven sentiment analysis on emotional expression

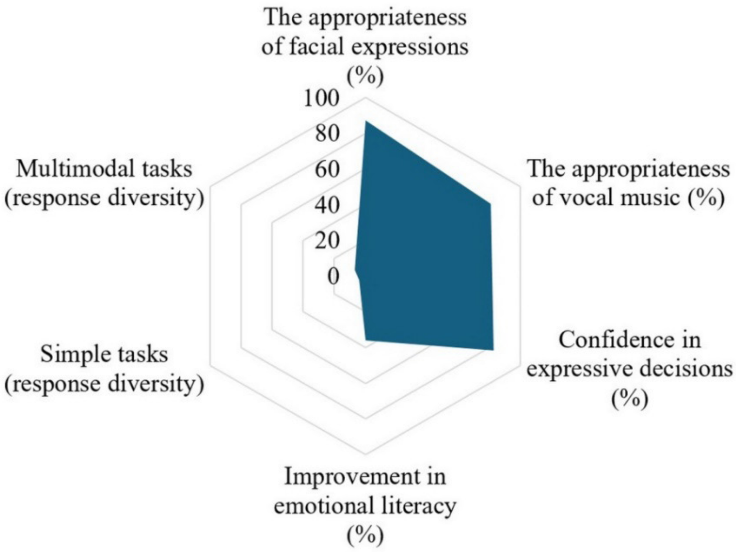


Some tasks were designed to develop mastery of emotional transitions, requiring learners to adjust a work's emotional tone in response to descriptive cues. The success rate for these tasks increased from 48% to 86% after the intervention (see Figure 2). The observed improvement in emotional fluency can be attributed to iterative feedback mechanisms that helped students identify discrepancies between intended and perceived emotional states in real time.

Focus group discussions demonstrated that 78% of students reported increased confidence in their ability to externalise affective states following the intervention. Respondents attributed this growth to the clarity and immediacy of AI-driven feedback. In group projects combining music and animation, students exhibited a 37% improvement in accurately conveying emotional nuance. Expert assessment confirmed this, indicating a rise in the quality of emotional expression from 63% to 87%. Regarding collaboration, participants reported a 33% reduction in misunderstandings concerning emotional intent, measured by a decrease in required corrections during project reviews from 61% to 28%.

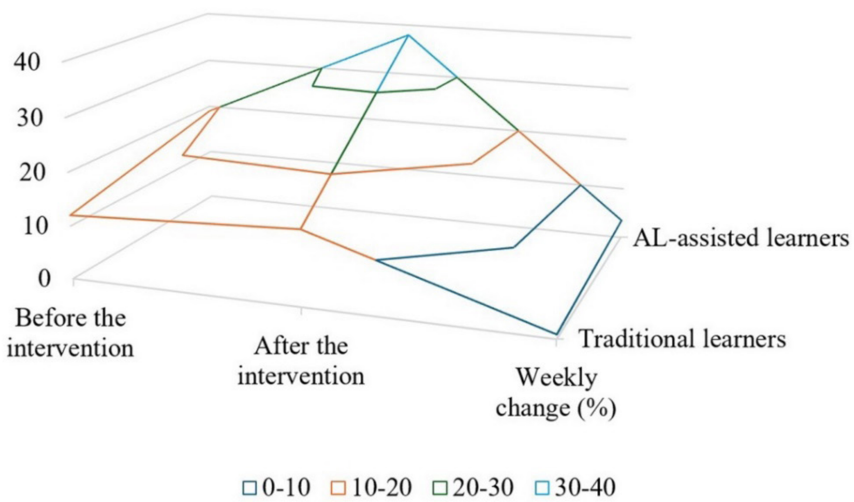
Automated analysis revealed a diversification in emotional response patterns. A quantitative increase in response profiles (by 48%) indicates enhanced interpretive ability among students. This improvement, likely achieved through the integration of iterative feedback loops, reflects the dual diagnostic and developmental function of AI-powered feedback. When composing mood-based musical compositions, 72% of students created pieces that AI systems identified as emotionally accurate—an improvement from the 41% match rate in initial tests.

Figure 3 - The impact of AI-driven sentiment analysis on the outcomes of affective learning



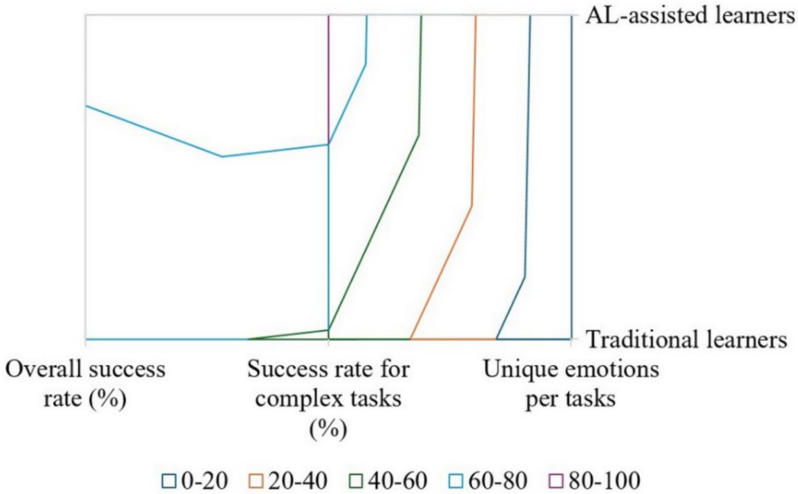
Affective congruency analysis revealed that 87% of students exhibited facial configurations consistent with the musical themes presented (OpenFace), while 81% displayed facial expressions corresponding to vocal pitch and prosody modulations (see Figure 3). This indicates a profound AI-supported connection between internal affective states and external emotional cues. Body movement analysis further supported this conclusion. When performing 'dark' compositions, students used deliberate, slow gestures, which contrasted with the expansive, fast movements observed during 'cheerful' music. Exercises involving repeated exposure to emotional stimuli and correction of emotional responses (see Appendix 2) created a 'feedback vortex' effect. AI-generated recursive feedback increased emotional accuracy by 80%, enabling students to transform abstract emotional constructions into tangible expressive actions accurately. Emotional modification facilitated an iterative interaction between affective responses and actions, allowing 78% of students to adjust their emotional reactions in real time. This confirms the role of temporal immediacy in accelerating affective learning. Longitudinal data show a 36% increase in the understanding of emotional tension and ambivalence, attributable to this iterative process. While creative synthesis tasks highlighted the AI's generative abilities (originality and emotional congruence scores increased by 31%), emotional categorisation tasks demonstrated enhanced perceptual acuity (resulting in an 82% accuracy rate). Team cohesion increased by 28%, as interaction between students during group activities enabled affective analysis, strengthening emotional intelligence. Temporal mapping exercises stimulated sequential thinking, improving the quality of emotional transitions by 77%. The results of the reflective analysis suggest metacognitive engagement: 83% of students reported greater awareness of distinct emotional tendencies, corroborated by introspective reports. While traditional learners exhibited an 8% improvement, those using AI tools achieved a 35% improvement, confirming the potential of AI-based pedagogical models.

Figure 4 - AI's impact on student performance during emotion articulation



Striking contrasts were observed in emotional articulation (see Figure 4). Among traditional learners, 14 out of 50 achieved above-average articulation accuracy post-intervention, compared to a significant shift among AI users, where 38 out of 50 students reached this threshold. This outcome was enabled by real-time feedback from Affectiva. Furthermore, traditional learners exhibited a modest increase in their ability to integrate emotions into music (task success rate: 58% vs. 62%). In contrast, AI-assisted students benefited from iterative tonal and rhythmic adjustments, which led to a more substantial increase in task success (from 61% to 88%), as confirmed by algorithmic correspondence analysis. A similar asymmetry was evident in the visual-emotional synchronisation task. Traditional learners showed a modest increase (10%) in their ability to integrate visual and emotional information accurately. By comparison, AI-assisted learners enhanced their visual-emotional synchronisation accuracy from 19% to 54%, a result linked to the use of accuracy-focused corrective feedback provided by OpenFace. Overall, expressive skill level increased weekly by 0.8% for traditional learners and 3.5% for AI-assisted learners. These findings suggest that AI-generated iterative feedback can accelerate the development of emotional competencies in musical training.

Figure 5 - AI's impact on student performance during emotional expressivity



The trajectory of emotional expressivity identified through contrasts between the two groups shows a marked shift (see Figure 5). Students who used AI exhibited a 35% increase in emotional articulation, significantly exceeding the control group's achievement (8%). This distribution points to a quantitative and qualitative ambiguity. The baseline performance of traditional learners averaged 2.4 emotional expressions per task (SD: 0.6), and AI-assisted students reached 4.8 expressions per task (SD: 0.3), doubling their expressive range and uniformity. The quality of the students' musical pieces further corroborates this discrepancy. For instance, when tasked with composing 'melancholic' music, a student in the traditional learning group produced a piece with rudimentary harmonies (62% emotional congruency). In contrast, their peer, empowered by AI-generated feedback, achieved 91% emotional congruency.

In animation tasks, the synchronisation of facial expressions and emotions increased from 19% (control) to 57% (AI-assisted), indicating enhanced affective congruency as measured by OpenFace. Quantitative analysis confirms these trends: across 10 tasks, the AI group achieved an average success rate of 87%, compared to 62% for the control group. This performance gap widened with task complexity. While performance differences on simple tasks were incremental, those on multimodal synthesis tasks were exponential (94% vs. 59%). Participant feedback substantiates these findings. In the traditional learning group, 65% of respondents reported difficulty interpreting emotions, whereas 84% of AI-assisted peers found emotional expressions easy to decipher. The adaptability of AI emerged as a key factor in training. Its application in drama and visual design yielded an 80% success rate, with feedback coherence reaching 93%.

Discussion

Research on the use of emotion AI in music education highlights the following methodological overlaps and divergences. Jue Lian, for example, conceptualises emotion as a quantifiable construct, which is consistent with the study's premise but differs in scope. While Lian's analysis addresses pre-segmented signals (Lian, 2023), the present research leverages real-time feedback loops (Affectiva, OpenFace) to combine static categorisation with active engagement. The valence-arousal model (Wang et al., 2023) theoretically aligns with the current research methodology, but its application is limited to autoencoder variants. AI-based tools were associated with a 35% improvement in emotional expressiveness ($r = 0.68$, $p < 0.001$), supporting their auxiliary role in enhancing performance. However, establishing causality requires randomised controlled trials. In contrast to Zhou's (2023b) functional segmentation of AI-powered tools into parametric and textual categories, this study adopted a synthesis approach. It combined quantitative (task success metrics) and qualitative (emotional richness of music narratives) data to improve learning outcomes.

This study examined the computational linearity of affective music production, a phenomenon that has been critiqued in previous research (Dash and Agres, 2023). By employing iterative feedback loops to circumvent algorithmic rigidity, a 72% match between a musical piece's structure and its intended emotional content was achieved. Hybrid CNN-LSTM models identify the temporal dynamics of musical emotions as a critical factor (Yakovyna and Korniienko, 2023). The present study prioritises student-driven interactivity over data augmentation, with AI tools tested for cross-cultural adaptability by combining the dynamics of joy and sadness (Churi et al., 2023).

In China, aesthetic education emphasizes emotional sensitivity (Kuang and Liu, 2024), in contrast to a Western focus on algorithmic efficiency (Vanka et al., 2023). Unlike Western neural networks trained for emotion-aware personalised music recommendations (Zhai et al., 2022), Chinese cognitive-emotional models synthesise tradition with technology (Hong and Wu, 2022; Zhou, 2023b). The holistic Chinese methodology is characterised by integrated symbolic-acoustic models (Zhu et al., 2023), distinct from the segmented machine-learning approaches common in the West (Lian, 2023). Curricular differences also exist: Chinese courses often employ feedback loops to stimulate emotional reflection (Sunil and Kuriakose, 2023), whereas Western curricula typically focus on real-time adaptation through automated systems. This divergence stems from cultural specificity. Western systems emphasise precision, while Chinese aesthetic models integrate cognitive mapping and musical aesthetics to enhance emotional engagement (Kuang and Liu, 2024). The combination of these two models results in a synthesis of computational efficiency and aesthetic depth.

The methodological limitations of this study—particularly concerning data interpretation and sample homogeneity—reflect recurring issues in AI-integrated music education pedagogy. These include reduced generalisability across learning systems (Qiusi, 2022) and reliance on musically trained participants, which increases internal consistency but constrains external validity. Furthermore, unbalanced datasets distort the accuracy of affective classification. Similar constraints are evident in emotion-based music classification models (Seo and Huh, 2019). A persistent gap remains: although machine learning algorithms can operationalise emotional features from auditory data, their capacity for fine affective differentiation in the performing arts is limited (Yu and Ding, 2020). This limitation extends to acting, where AI-assisted mood analysis systems, such as South Korean real-time emotion mapping platforms, face interpretive inconsistencies. These arise from an algorithmic over-reliance on surface-level affective markers and insufficient cultural adaptability (Yang et al., 2020).

Cross-cultural limitations, both conceptual and technical, present significant obstacles to scalable implementation. For instance, convolutional neural networks used to predict musical emotion do not account for regional patterns of expressivity, a problem that requires expanded and diversified datasets and methodological recalibration (Chen and Ibrahim, 2023). The theoretical architecture underpinning this model—the paradigm of 'affective computing' (defined as the algorithmic quantification of multimodal emotional cues)—posits a conceptual link between perceptual mechanics and expressive authenticity. By integrating data streams on 'facial micro-expressions', vocal intonation, and gestural dynamics, performers can achieve greater control over emotional authenticity (Abboud and Tekli, 2020). However, such theoretical coherence does not guarantee functional viability. Importing foreign AI strategies into Chinese pedagogical frameworks necessitates 'cultural symbiosis'—the alignment of algorithmic accuracy with sociocultural affective norms (Liang, 2023b). The conceptual bifurcation between technological efficiency and cultural authenticity underscores the need for interdisciplinary collaboration. A methodological synthesis that combines technical refinement with contextual adaptation is imperative to establish a truly localised innovation paradigm.

Conclusions

The integration of AI-based sentiment analysis tools—Affectiva and OpenFace—into the animated music learning process resulted in a statistically significant improvement in emotional articulation (35% increase in expressive accuracy in the AI-supported group vs. 8% in the control group). These outcomes substantiate the assumption that algorithmic feedback systems can recalibrate affective expressivity through dynamic interaction with music-visual synchrony. In this synthesis, the alignment of auditory and visual modalities increased from 56% to 91%, as measured by multimodal correlation metrics. The 80% increase in task accuracy was driven by an iterative feedback mechanism that functioned through recursive adjustments to "expressive components" (a term referring to integrated layers of musical phrasing, microgestural kinetics, and affective facial patterns). Within such an operational structure, emotional nuances emerge as a constantly modulated, rather than static, construct.

Data collected from participants confirmed this finding: 83% of students reported increased "metacognitive engagement", a metric reflecting heightened self-awareness of emotional tendencies. The results establish a conceptual link between AI-based reflective learning and affective introspection. Emotional expression extended beyond superficial improvements; 78% of students learnt to adjust their facial expressions in real time through a cyclical feedback loop between emotional stimuli and motor responses. This specific capacity of machine learning systems enables the translation of abstract feelings into concrete actions.

The findings also highlight systemic limitations. Cultural specificity remains a critical constraint, as the universality of the "emotional archetypes" embedded in current datasets risks overfitting emotional prediction models to culturally dominant norms, thereby overlooking regional affective diversity. Such manifestations of algorithmic bias require structural recalibration. Future directions should focus on "context-aware" AI architectures: models that adapt to both performance data and socio-emotional variability in learning environments. A shift from static recognition matrices to adaptive algorithms would precisely align affective feedback mechanisms with culturally embedded expressive paradigms—an evolution essential for ensuring pedagogical fidelity and theoretical rigour in AI-assisted art education. Further verification of these results will require a five-step protocol: (1) conducting multicentre randomised trials that account for participants' baseline levels; (2) monitoring the persistence of effects over a minimum period of six months; (3) analysing the underlying mechanisms of impact; (4) testing on samples from the United States, Europe, and Asia; and (5) adapting the algorithms to cultural differences through transfer learning on locally sourced data.

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Appendix 1. Changes in the emotional intelligence of students (as reported by students and teachers)

Questions	Answer options	Mean scores / responses of students	Mean scores / responses of teachers	Change (%)
How effective are your efforts at expressing emotions during group tasks?	Likert scale (1-5)	3.2	3.5	+18
How would you rate your ability to identify the emotional states of your peers during group projects?	Likert scale (1-5)	3.0	3.7	+23
How often do you consciously reflect on your emotional reactions in the educational setting?	Frequency (seldom to often)	Seldom	Occasionally	+30
Do you feel comfortable sharing emotions in structured AI-driven discussions?	Yes/No	Yes	Yes	N/A
To what extent did AI-generated feedback help you improve your understanding of emotional dynamics?	Likert scale (1-5)	4.1	4.3	+35
Can you recognise emotional cues embedded in musical animations?	Likert scale (1-5)	2.9	3.3	+12
Was AI helpful in cultivating self-awareness for further decision-making?	Yes/No	Yes	Yes	N/A
How often do you receive feedback from your peers on your portrayal of emotional information?	Frequency (seldom to often)	Occasionally	Occasionally	+28
How important are AI-guided tasks for increasing emotional engagement?	Likert scale (1-5)	4.0	4.2	+32
Did your ability to articulate emotions change after exposure to AI-assisted presentations?	Yes/No	Yes	Yes	N/A
To what extent did you understand the emotional themes covered in the musical animations?	Likert scale (1-5)	3.4	3.6	+20
Is the AI-generated feedback on emotional expression objective?	Yes/No	Yes	Yes	N/A
How useful did you find AI-based sentiment analysis?	Likert scale (1-5)	3.1	3.4	+15

How would you rate the impact of AI on emotional intelligence?	Likert scale (1-5)	4.2	4.5	+33
To what extent did your ability to empathise with peers change after the intervention?	Likert scale (1-5)	3.5	3.8	+22
Can AI-driven knowledge of emotions be applied in contexts other than teaching?	Yes/No	Yes	Yes	N/A
How difficult was it to interpret AI-generated feedback on emotion?	Likert scale (1-5)	2.5	2.7	-8
How often do you consciously use emotional intelligence strategies while training?	Frequency (seldom to often)	Occasionally	Occasionally	+28
How relevant are emotion AI tools for understanding musical animations?	Likert scale (1-5)	3.7	4.0	+25

Source: developed by the authors

Appendix 2. Practical Exercises to Boost Emotional Intelligence Through Interaction with AI

Exercises	**Aims**	**Methods**	**AI tools**	**Results**
Emotion decoding and	Improving the ability to recognise and replicate emotions	Students analyse emotions detected by AI and reproduce them through music/ animation	Affectiva, OpenFace	The accuracy of emotional articulation increased in 80% of students
Error correction	Enhancing emotional expression using immediate AI feedback	AI suggests corrections after students implement insights from emotion decoding and reproduction activities	Affectiva, OpenFace	78% of students fixed their mistakes
Emotion classification	Improving the ability to classify emotions	Using auditory and visual cues, students classify emotions depicted in animated videos and musical pieces run through AI	Affectiva	The accuracy rate for emotion recognition increased to 82%
Emotional composition	Stimulating artistic expression in emotional contexts	Students compose mood-based musical pieces using emotional themes identified by AI	OpenFace, AIVA	Creativity level improved by 31%

Emotion to action	Connecting emotions to physical/ kinaesthetic expressions	Students perform movements based on AI-generated emotional feedback	Affectiva, Kinect Motion	The kinaesthetic accuracy rate improved to 70%
Active feedback	Enhancing the iterative emotional expression	AI generates iterative feedback that students apply to express concrete emotions in their work	Affectiva, AIVA	Error count reduced by 26%
Temporal mapping of emotions	Strengthening time-dependent emotional transitions	Students examine AI-suggested segments of a music composition (or animated video) to identify changes in emotion	OpenFace, AIVA	The precision of emotional transitions improved in 77% of students
Expressive animation	Adding emotions to an animated video	Students use AI feedback to edit facial expressions of different animated characters	Affectiva	The level of emotional expressivity improved by 29%
Emotional improvisation	Improving student spontaneity and adaptability	Students respond to AI-generated prompts with improvised musical/visual outputs	AIVA, Affectiva	The level of spontaneous emotional expression increased by 36%
Reflective analysis	Encouraging independent analysis of emotional cues	Students compare emotions detected by AI with their emotional targets	Affectiva	83% reported having high emotional awareness
Emotion matching	Comparing emotions across different modalities (auditory and visual)	AI identifies inconsistencies between musical and visual cues, and students adjust their outputs accordingly	Affectiva, OpenFace	The level of affective congruency increased in 81% of students
Neural assessment of emotions	Quantifying emotions using neural networks	AI assigns emotional scores to creative output, guiding students in their learning	Affectiva, AIVA	Emotional scores improved by 34% after students applied the AI feedback

Group dynamics	Improving the process of group-directed emotional interpretation	Students collaborate within groups to analyse and reproduce emotions detected by AI	Affectiva, OpenFace	Team coherence improved by 28%
Emotional recall	Enhancing students' memory for emotional information	Students recall AI feedback from previous assignments to creatively apply it	Affectiva	Retention accuracy increased by 33%

Source: developed by the authors

Responsible for the approval of the text

Xin Qiu

Authorship contribution

Xin Qiu – Conceptualization, Methodology, Software; *Zhe Yuan Wei* – Validation, Formal Analysis, Investigation; *Xun Liu* – Resources, Data Curation, Writing – Original Draft Preparation; *Yu Lin* – Writing – Review & Editing, Visualization; *Biao Qiu* – Supervision, Project Administration, Funding Acquisition. All authors read and approved the final manuscript.

Research ethics committee approval

The research was conducted ethically in accordance with the World Medical Association Declaration of Helsinki. The research was approved by the local ethics committees of Longyan University (Protocol No. 107 of 2023 Oct. 27). All participants gave written informed consent to participate in the research.

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