A Pedagogical Interpretation of the AI Recursive Learning Method and Its Application in Vocal Music Learning

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Abstract

The “black-box” nature of the vocal organ renders the learning process highly dependent on the establishment of proprioception. Traditional vocal music teaching models often suffer from a lack of feedback during after-class practice, leading to inefficient repetition and cognitive discontinuity in skill acquisition. Focusing on the “Artificial Intelligence (AI) Recursive Learning Method” emerging against the backdrop of generative artificial intelligence technology, this paper systematically interprets its internal mechanism and application value from the perspective of learning science. Combining the theory of Productive Failure with the interactive, constructive, active, passive (ICAP) Framework for cognitive engagement, the study reveals that the AI Recursive Learning Method, through its cyclical mechanism of “task-driven practice, gap exposure, instant explanation, and revision and reconstruction”. It can transform learners’ failure experiences in individual practice into explicit cognitive resources, and promote the shift of learning engagement from shallow passive imitation to in-depth constructive reflection. The research demonstrates that as a dynamic “cognitive scaffold”, this method effectively bridges classroom teaching and individual practice, alleviating the structural contradiction between “teaching” and “practice” in vocal music education. Finally, this paper clarifies the boundaries of technological application, and proposes that a new human-machine collaborative ecosystem in vocal music education should be constructed on the premise of affirming the dominant role of teachers in aesthetic guidance.

Keywords

Artificial Intelligence recursive learning method, Vocal music learning, Productive failure, Cognitive scaffold, Music education

Introduction

Vocal music is widely regarded as one of the most intractable arts to teach in human society, primarily due to the inherent “black-box” property of the vocal instrument. Unlike external musical instruments such as the piano or violin, the vocal folds and resonance cavities of a singer are embedded within the body, invisible and intangible, making it impossible for learners to comprehend the sound production process through direct observation. As the vocal pedagogue William Vennard pointed out, vocal music learning relies to a large extent on the gradual establishment of “proprioception”, that is, the mastery of vocal techniques through the awareness and regulation of internal bodily sensations [1]. This characteristic of heavy dependence on internal physical perception has resulted in a typical pain point in vocal music teaching: Beginner learners often “fail to hear their authentic vocal performance” and struggle to quickly translate teachers’ abstract sensory instructions (e.g., “place the sound on the mask”) into specific muscular movements.

In the traditional master-apprentice teaching model, such “transmission of sensations” is highly contingent on the teacher’s on-site guidance and verbal cues. However, this model faces practical challenges in modern higher education and popular music education. First, it is the issue of feedback lag. The core of vocal music learning lies in the cycle of “practice-feedback-revision”. Nevertheless, during extensive after-class individual practice, once students are deprived of the teacher’s supervision, they are prone to fall into the predicament of “blindly repeating mistakes”, leading to the solidification of incorrect muscular memory [2,3]. Second, it is the subjectivity and uncertainty of evaluation. For inexperienced learners, relying solely on auditory feedback is often biased; they are in urgent need of an objective reference frame that transcends “subjective

auditory perception".

Against this backdrop, the integration of artificial intelligence technology has increasingly been regarded as a supplementary tool for vocal music teaching, rather than a replacement for teachers. Relevant studies have shown that AI-driven analysis and feedback systems can extend the feedback and self-regulation stages in the learning process through real-time error correction, personalized practice suggestions and reflective prompts, thereby enhancing learners' technical proficiency and metacognitive abilities [4,5]. These studies indicate that the educational value of AI does not lie in replacing the aesthetic judgment and experiential guidance of vocal music teachers, but in providing learners with a more continuous and reusable feedback environment, so as to mitigate the problem of "feedback discontinuity after class" in traditional teaching.

From the perspective of learning science, this learning process characterized by repeated trial and revision is inherently consistent with theories related to "learning through failure". Kapur proposed the concept of Productive Failure, emphasizing that learners' failed attempts in complex tasks are not inefficient behaviors, but rather critical stages for promoting deeper understanding by exposing cognitive gaps [6,7]. In terms of learning engagement, the ICAP Framework proposed by researchers points out that learning outcomes improve significantly as learners shift from passive reception to constructive and interactive engagement [8]. These theories provide an important pedagogical reference for understanding the recursive learning process of "trial-feedback-revision-retrial" supported by AI technology.

In recent years, in the practical discussions of AI-assisted learning, a learning approach known as the "AI Recursive Learning Method" has gradually attracted attention. Starting with specific tasks, this method allows learners to continuously identify problems in practice, and uses conversational AI tools to provide instant explanations and supplements for cognitive gaps in the learning process, thus forming a sustained cyclical learning process. It should be noted that the "AI Recursive Learning Method" is not a strictly original pedagogical theory, but a learning practice model formed under the technical conditions of artificial intelligence. It is therefore necessary to interpret its learning mechanism and educational value within the existing pedagogical theoretical framework.

Based on the above analysis, this paper attempts to systematically interpret the AI Recursive Learning Method from a pedagogical perspective, clarify its learning mechanism by combining theories such as Productive Failure and the ICAP Framework, and further explore the feasibility of applying this learning approach in the field of vocal music learning - a domain that heavily relies on physical perception and repetitive skill training. It is expected to provide theoretical reference for the integration of technology and teaching in music education.

The emergence and basic characteristics of the AI recursive learning method

Practical background and emergence of the AI recursive learning method

With the popularization of conversational artificial intelligence technology in learning scenarios, a learning approach characterized by task-driven practice, real-time feedback and iterative revision has gradually gained attention in practical applications. The "AI Recursive Learning Method" originated from practical explorations in the fields of computer science and engineering, and was summarized by artificial intelligence researcher Gabriel Petersson based on his self-learning and skill training experience. Its core idea does not center on the systematic teaching of knowledge systems, but emphasizes starting with specific tasks, continuously exposing problems in the process of practice, and using conversational AI tools to provide instant supplements for cognitive gaps, thus forming a cyclical learning process. As a new learning strategy emerging in the context of generative artificial intelligence technology, it has fundamentally transformed the linear path of knowledge acquisition.

It should be emphasized that the AI Recursive Learning Method is not an educational theory directly derived from academic research, but a methodological approach gradually formed and summarized in learning practice. Its proposal is more based on empirical observations of the learning process rather than rigorous theoretical modeling. Therefore, this paper defines the method as follows: a dynamic learning model driven by high-order complex tasks that utilizes AI as an instant cognitive scaffold. By continuously identifying and repairing

cognitive gaps, this model realizes the recursion from specific problem-solving to abstract knowledge construction. In this sense, this paper discusses the AI Recursive Learning Method as an object of learning practice rather than a theoretical system.

Basic connotations of the AI recursive learning method

From the operational perspective, the key to the AI Recursive Learning Method lies not in the complexity of artificial intelligence technology itself, but in the structure of the learning process it supports. Different from the traditional learning model dominated by linear knowledge transmission, the AI Recursive Learning Method exhibits obvious nonlinear characteristics: Learning usually starts with specific tasks or practical goals. In the process of task execution, learners inevitably encounter failures, confusion or uncertainties, which constitute the "cognitive gaps" in the learning process. Subsequently, learners use artificial intelligence tools to conduct instant inquiries and analysis of the problems, and obtain targeted explanations or suggestions. Finally, learners apply the feedback obtained to task practice, and further expose higher-level problems in new attempts. The above process does not proceed linearly, but unfolds in a cyclical and progressive manner.

Therefore, the AI Recursive Learning Method does not negate systematic knowledge learning. Instead, through a "point-to-area" strategy, it leverages the high-frequency interactive features of artificial intelligence to lower the learning threshold of complex tasks, enabling learners to gradually complete the meaningful construction of knowledge and skills in the process of "learning by doing". This characteristic is structurally isomorphic with the learning mode of "revision through experience" emphasized in vocal music learning, laying a methodological foundation for its application in vocal music education.

Pedagogical interpretation of the AI recursive learning method

Interpretation of learning mechanism based on productive failure

In the field of learning science, research on the role of "failure" in the learning process provides an important reference for understanding the pedagogical implications of the AI Recursive Learning Method. The theory of Productive Failure proposed by Manu Kapur posits that learners' failed attempts at complex tasks are not inefficient or avoidable processes, but rather critical opportunities to facilitate the construction of understanding by exposing cognitive gaps and activating in-depth thinking. Unlike the traditional teaching approach characterized by "explanation first, practice later", this theory emphasizes that learners engage in problem-solving directly without first mastering a complete knowledge structure. Its value lies not in immediate accuracy rates, but in the subsequent improvement of conceptual understanding and transfer ability.

From this perspective, the learning process of "repeated trial and revision in tasks" emphasized by the AI Recursive Learning Method is highly consistent with the learning mechanism described by Productive Failure. In the AI Recursive Learning Method, learning does not begin with comprehensive mastery of systematic knowledge, but with direct engagement in specific tasks. During practice, learners inevitably encounter failures, confusion, or uncertainties - experiences that are not simply regarded as signs of insufficient ability, but as key nodes in the learning process. It is at these nodes that learners gradually recognize deficiencies in their understanding or skills by perceiving the gap between task goals and their current performance, thereby forming clear learning needs.

This learning demand triggered by failure is not only cognitively significant, but also involves the activation mechanism of learning motivation. Goal-setting theory indicates that when learners face clear goals and receive feedback related to their current performance, their perception of the "goal-status gap" will significantly affect subsequent levels of engagement [9,10]. In the AI Recursive Learning Method, specific tasks themselves constitute a relatively clear goal framework, while the real-time feedback provided by conversational artificial intelligence continuously strengthens learners' awareness of this gap. Instead of simply inducing frustration, this gap perception is transformed into intrinsic motivation for sustained trial and adjustment with the support of actionable feedback.

Compared with classic Productive Failure teaching scenarios, the AI Recursive Learning Method presents

new characteristics in the "support method after failure". In traditional instructional design, the interpretation and integration of failure experiences typically occur centrally in subsequent teacher-led explanation sessions. In contrast, the AI Recursive Learning Method advances and embeds this interpretation process into learners' practice. At the moment a failure occurs, learners can use conversational AI tools to conduct instant inquiries and clarifications on specific problems, so that failure experiences no longer exist in a fragmented and emotional form, but are quickly converted into analyzable and revisable cognitive objects.

This recursive cycle of "failure-interpretation-retrial" does not weaken the cognitive conflict and conceptual restructuring emphasized by Productive Failure. On the contrary, it reduces the emotional cost for learners when facing failure to a certain extent, making it easier for them to maintain sustained engagement in complex tasks. This is particularly crucial for skill-based learning. Without waiting for classroom feedback or centralized explanations, learners can continuously calibrate their understanding of tasks and operational methods during practice, thereby gradually forming more robust cognitive structures and operational strategies.

Therefore, from the perspective of Productive Failure, the AI Recursive Learning Method is not a negation or replacement of the concept of "learning through failure", but a practical extension of this concept under the conditions of artificial intelligence technology. In this process, artificial intelligence does not assume the role of "directly providing correct answers", but serves as a cognitive tool that supports learners to reflect on failure experiences, perceive goal gaps, and maintain learning engagement, enabling failures to be transformed into effective learning resources more frequently and with lower risks.

Analysis of learning engagement based on the ICAP Framework

In the pedagogical interpretation of the AI Recursive Learning Method, the perspective of "how failure is converted into learning resources" alone is insufficient to fully explain its learning effects. To further understand how this learning approach promotes learners' sustained engagement and in-depth understanding, it is necessary to introduce an analytical perspective on the "quality of engagement" in the learning process. So, the ICAP Framework for learning engagement provides an important theoretical tool for distinguishing different levels of learning activities and their corresponding cognitive effects.

The ICAP Framework categorizes learning activities into four levels: interactive, constructive, active and passive. It points out that learning outcomes do not improve linearly with the "surface-level activity" of tasks, but are significantly enhanced as the depth of learners' cognitive processing increases. Within this framework, passive reception of information involves only the lowest level of cognitive engagement. In contrast, learning enters the constructive or interactive level when learners can generate new understandings beyond existing information, or continuously revise and deepen their understanding through interaction.

From the perspective of the ICAP Framework, the impact of the AI Recursive Learning Method on the vocal music learning process is mainly reflected in its structural reshaping of learning engagement levels. In traditional vocal music teaching, learners often remain in a passive or limitedly active learning state in classroom settings. For example, listening to teachers' demonstrations, imitating vocalization methods, or conducting repetitive practice according to instructions. Such activities are necessary in the initial stage of skill acquisition, but without further reflection and interpretation, learners tend to stay at the level of superficial imitation, making it difficult to form stable and transferable understanding. In contrast, the AI Recursive Learning Method provides more sustained conditions for learners to enter a Constructive learning state by embedding "inquiry - interpretation - revision" into the practice process. During practice, learners do not merely repeat vocalization movements. Instead, when encountering failures or confusion, they take the initiative to identify problems, pose specific questions to AI, and compare the explanations obtained with their own bodily sensations. This process requires learners to generate new expressions of understanding, such as reorganizing their vocalization state, physical perception, or practice strategies, thus transcending the simple reproduction of existing instructions. According to the definition of the ICAP Framework, such activities exhibit the typical characteristics of constructive learning.

When the AI Recursive Learning Method is implemented

in a conversational form, the learning process may also present the characteristics of Interactive learning under certain conditions. Although AI is not a human learning partner, in the process of high-frequency question-and-answer interactions, learners need to respond to, revise, or further inquire about AI's feedback. This continuous cognitive exchange is functionally similar to the "co-construction of meaning" emphasized by Interactive learning; its core role is to promote learners' repeated testing and adjustment of their own understanding, rather than simple information reception.

From the perspective of vocal music learning, this high-level learning engagement supported by the AI Recursive Learning Method has special significance. Vocal music skills are highly dependent on physical experience and internal perception, and such experiences are often difficult to fully master through a single demonstration or imitation. Through repeated inquiry and interpretation, learners can transform vague bodily sensations into relatively clear cognitive expressions, thereby gradually developing self-monitoring and self-regulation abilities during practice. This shift from "following instructions" to "understanding-based practice" is exactly the learning engagement upgrade path emphasized by the ICAP Framework.

Furthermore, in some learning scenarios, during the continuous process of interpretation and revision, learners begin to reflect on their existing understanding assumptions and practice strategies - such as their inherent perceptions of vocal placement, force application methods, or technical instructions. This learning process, which extends from behavioral revision to the adjustment of understanding frameworks, is structurally similar to the double-loop learning mechanism proposed by Argyris and Schön, involving the reflection and reconstruction of goals, rules, and the assumptions behind them [11]. The high-frequency feedback and sustained inquiry environment provided by the AI Recursive Learning Method lowers the threshold for learners to engage in this in-depth reflection process to a certain extent, enabling them to not only revise "how to do it", but also gradually reflect on "why to do it this way".

Therefore, from the perspective of the ICAP Framework, the educational value of the AI Recursive Learning Method is not mainly reflected in the increase of practice frequency or the acceleration of feedback speed, but in its restructuring of the structure of learning activities. By promoting learners to enter Constructive and even Interactive engagement, and triggering reflection on understanding frameworks under certain conditions, this learning method lays a more solid cognitive foundation for the stable acquisition and transfer of vocal music skills. Based on the above pedagogical analysis, the core learning mechanism of the AI Recursive Learning Method can be summarized as a recursive process, as shown in Figure 1.

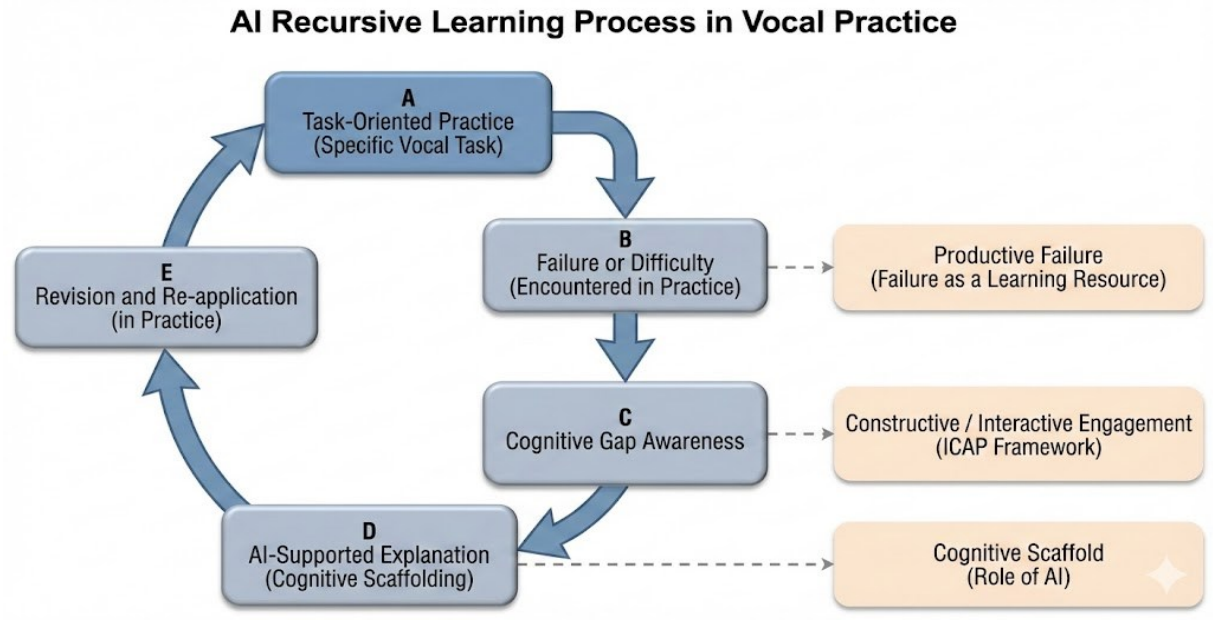

Figure 1. Recursive mechanism of the AI recursive learning method in vocal practice: from task-oriented practice to cognitive framework adjustment.

Moreover, in blended learning contexts - where classroom guidance and after-class AI-supported practice complement each other - evaluating the depth of learners' cognitive engagement becomes crucial. Li and others proposed a multi-dimensional evaluation system for deep learning ability in blended learning, including critical thinking, knowledge transfer, and self-regulation, which provides a feasible tool for measuring the effectiveness of the AI Recursive Learning Method in promoting in-depth learning. Their research also emphasizes that technical tools in blended learning should not only optimize feedback efficiency but also align with the improvement paths of deep learning ability, such as strengthening metacognitive reflection and collaborative knowledge construction [12]

Application paths of the AI recursive learning method in vocal music learning

Application paths in individual vocal music practice

In vocal music learning, besides technical issues such as intonation, breath control, and vocal register transition, expressivity-related problems also constitute core challenges for learners during individual practice. The so-called expressivity issues do not merely refer to "whether emotions are properly conveyed", but involve how learners physically embody musical imagery, emotional trajectories, and aesthetic intentions through sound. In contrast to technical problems, such issues often lack explicit external criteria and rely more heavily on learners' insight into the relationship between vocal variations and internal sensations.

In traditional individual practice, when confronted with expressivity problems, learners often fall into two extreme states due to the absence of real-time feedback: One is over-reliance on emotional imagination while neglecting vocal control. The other is regression to purely technical repetitive practice out of uncertainty about the effectiveness of their expression. The former may lead to vocal imbalance, while the latter tends to reduce musical expression to technical execution. Both are detrimental to the steady development of expressive competence.

At this level, the role of the AI Recursive Learning Method does not lie in making judgments on emotional or aesthetic values, but in supporting learners to repeatedly analyze the relationship between "vocal variation-physical sensation-expressive intention". During individual practice, learners can pose specific questions to AI regarding their expressive difficulties. For instance, they may inquire about why a certain musical phrase sounds technically stable yet lacks emotional tension, or how different timbre choices influence expressive outcomes. The feedback provided by AI is more oriented toward potential adjustments to vocal parameters, physical coordination methods, or practice approaches, rather than evaluating the merits of the expression, thereby offering learners an intermediary perspective for analyzing expressivity-related issues.

Through this approach, expressivity issues are re-integrated into the recursive learning structure of "trial-interpretation-retrial". By repeatedly comparing the sensory differences brought about by different vocal states, learners gradually develop the ability to self-judge expressive effects, instead of relying on one-time success or external evaluations. This process helps learners transform abstract musical imagery into perceptible and adjustable vocal experiences, ensuring that expression is no longer confined to subjective imagination but grounded in an understanding of vocal control and physical sensations.

From a learning mechanism perspective, this practice mode helps avoid the separation of "expression" and "technique". Expressivity issues are no longer regarded as an additional layer after technical mastery. Instead, through AI-supported recursive reflection, they form an integral part of vocal music learning alongside technical practice. As a result, learners gradually develop a practice orientation that balances vocal control and musical expression during individual practice, laying the foundation for higher-level artistic presentation.

Auxiliary application in vocal music teaching scenarios

In vocal music teaching scenarios, there has long been a structural disconnect between teacher guidance and individual practice. On the one hand, vocal music classes are highly real-time and targeted, allowing teachers to provide refined feedback based on students' current vocal conditions. On the other hand, classroom time is limited, and students often struggle to fully replicate teachers' judgment logic and correction paths during after-class practice. This contrast between "feedback-intensive classroom settings" and "feedback-scarce

individual practice" often leads to the weakening or even disappearance of the technical awareness and practice strategies developed in class during after-class sessions.

Against this backdrop, the AI Recursive Learning Method can be regarded as an intermediary mechanism connecting classroom teaching and individual practice. Its core function is not to intervene in direct teacher-student interaction, but to extend the implicit teaching logic from the classroom to after-class practice scenarios, enabling learners to maintain a problem-oriented and reflection-oriented practice approach even in the absence of teachers.

From a teaching structure perspective, the introduction of the AI Recursive Learning Method helps transform the one-way feedback model of "demonstration - imitation - correction" prevalent in traditional vocal music classes. In classroom settings, teachers often need to focus on identifying problems and providing correction suggestions within limited time, leaving students in a predominantly passive role of receiving instructions and imitating immediately. Without further interpretation and internalization, such feedback is likely to be perceived by students as localized technical directives rather than transferable practice principles. By integrating AI-supported recursive inquiry and interpretation into after-class practice, students can reactivate knowledge acquired in class in recurring problem situations, re-interpreting and reconstructing teachers' instructions.

In practical application, the AI Recursive Learning Method does not require teachers to alter their existing teaching methods; instead, it supports students in independently internalizing classroom content by establishing clear connection paths between teaching objectives and practice tasks. For example, the adjustment directions proposed by teachers for a specific vocal problem during class can be transformed into concrete questions by students in after-class practice. Through interaction with AI, students can continuously clarify the applicable conditions of such adjustments across different pitches, volumes, or musical contexts. In this way, classroom feedback is no longer a one-time correction but is converted into reusable and verifiable practice resources.

From the perspective of learning engagement, this application approach helps enhance students' cognitive participation outside teaching scenarios. In traditional vocal music teaching, students often lack clear problem awareness during after-class practice, leading to a regression to mechanical repetition. The AI Recursive Learning Method sustains students' constructive engagement in after-class practice by continuously guiding them to pose questions, interpret problems, and verify understandings, thereby creating a more coherent learning experience throughout the entire learning process.

Meanwhile, in terms of the teacher-student relationship, the AI Recursive Learning Method does not diminish the central role of teachers in vocal music teaching. On the contrary, it serves to reduce students' reliance on teachers for "real-time error correction", allowing classroom time to be allocated more to advanced technical judgment, musical expression, and aesthetic guidance. Within this structure, teachers still assume the roles of technical framework constructors and aesthetic guides, while AI functions as an auxiliary tool to support students in maintaining a consistent reflection path in after-class practice aligned with classroom learning.

Overall, in vocal music teaching scenarios, the application value of the AI Recursive Learning Method is mainly reflected in its supplementary and extensional role in teaching structures. By bridging classroom feedback and individual practice, this learning approach helps mitigate the problem of "disconnection between teaching and practice" in traditional vocal music education, enabling learners to maintain continuous cognitive engagement and a reflective orientation across different learning scenarios, thereby providing more stable support for the long-term development of vocal music skills.

Limitations and ethical discussions

Although the AI Recursive Learning Method demonstrates potential in supporting reflection, extending feedback, and optimizing practice structures in vocal music learning, its application is subject to various constraints. It is worth noting that AI technology exhibits diverse application forms and target orientations in different educational scenarios. Deng constructed a BP neural network-enhanced system to support college students' employment and mental health, which reflects the flexibility of AI in addressing different educational needs but also highlights the importance of matching technical characteristics with specific educational

scenarios [13]. A systematic discussion of these limitations and ethical issues not only helps clarify the applicable boundaries of this learning approach but also prevents misuse or over-reliance in the process of technological application.

Artificial intelligence cannot replace auditory aesthetic judgment in vocal music

The core of vocal music learning lies not only in the executability of techniques but also in the development of auditory aesthetic judgment and artistic style awareness. Judgments regarding timbre selection, emotional tension control, and the understanding of musical work styles and cultural contexts all exceed the scope of rule-based or parameterized description. Current artificial intelligence systems exhibit strong capabilities in acoustic analysis and language generation, but their feedback is essentially based on existing data patterns and probabilistic inference, making it impossible for them to form genuine aesthetic judgments.

In the AI Recursive Learning Method, the role of artificial intelligence is primarily to support learners in identifying problems and understanding potential technical or perceptual causes, rather than evaluating the artistic value of vocal performance outcomes. Therefore, this learning approach does not constitute a substitute for vocal teachers' aesthetic judgment, but should be regarded as a tool providing assistance at technical and cognitive levels. Treating AI outputs as aesthetic standards may instead lead learners to develop a mechanistic orientation toward expression, undermining the artistic diversity inherent in vocal music learning.

Potential risks of misleading feedback and learning misguidance

The AI Recursive Learning Method relies heavily on continuous interaction between learners and artificial intelligence, and its effectiveness is largely determined by the accuracy and appropriateness of feedback content. However, in the highly contextualized field of vocal music learning characterized by significant individual differences, the explanatory feedback provided by artificial intelligence carries inherent risks of misguidance. For example, suggestions based on general vocal principles may not be suitable for specific learners' physiological conditions or current technical stages.

Furthermore, learners often lack the ability to independently judge the quality of feedback during individual practice. Over-reliance on AI suggestions may lead to the repeated reinforcement of incorrect practice strategies. Therefore, the effective application of the AI Recursive Learning Method depends on learners maintaining a critical attitude toward feedback, treating it as a reference interpretation rather than an authoritative conclusion. This risk indicates that the application of artificial intelligence in vocal music learning must still take teacher guidance and learners' self-perception as the ultimate calibration mechanisms.

The irreplaceability of teachers and the boundaries of teaching responsibility

From an educational ethics perspective, the introduction of the AI Recursive Learning Method does not weaken the central position of teachers in vocal music teaching. On the contrary, it highlights the critical role of teachers in technological applications. Vocal music teachers are not only responsible for technical guidance and aesthetic instruction but also play irreplaceable roles in learning path planning, learning pace regulation, and emotional support.

Within this structure, artificial intelligence is more appropriately understood as a cognitive support tool, whose function is to extend classroom feedback and reflection processes rather than replacing teachers' judgments and responsibilities. Entrusting individual practice entirely to AI management may lead to the blurring of teaching responsibilities and even trigger ethical disputes regarding the attribution of learning outcomes. Therefore, in practical application, it is necessary to clarify the auxiliary nature of AI and ensure teachers' leading position in the learning process through instructional design and usage norms.

Conclusion

In the field of vocal music learning, which is highly dependent on physical perception and experiential insight, traditional teaching models have long been confronted with practical predicaments such as delayed feedback, disordered individual practice, and insufficient self-regulation capabilities of learners. With the popularization of artificial intelligence technology in learning scenarios, how to introduce technical means to optimize the structure of the learning process without undermining teachers' professional judgment and artistic aesthetics has become an urgent issue to be addressed in

music education research.

Taking the "AI Recursive Learning Method" as the research object, this paper systematically analyzes its learning mechanism and application paths from a pedagogical perspective. The study argues that the AI Recursive Learning Method is not a brand-new educational theory, but an emerging learning practice model under the conditions of generative artificial intelligence technology. Its core feature lies in starting with specific tasks, and supporting learners to continuously expose and repair cognitive gaps in practice through the recursive process of "trial-feedback-revision-retrial". Interpreting this learning approach within the theoretical frameworks of learning science such as Productive Failure and the ICAP Framework helps to reveal its pedagogical rationality in promoting learning engagement, activating reflective processes, and supporting the acquisition of complex skills.

The research further indicates that in the context of vocal music learning, the application value of the AI Recursive Learning Method is not reflected in improving practice efficiency or providing standardized answers, but in restructuring the structure of the learning process. By embedding interpretation and reflection into the individual practice process, this learning approach helps drive learners to shift from mechanical repetition to constructive and interactive engagement. Under certain conditions, it further encourages them to reflect on their existing understanding frameworks and practice strategies. This process not only facilitates the correction of technical problems, but also provides support for the insight into expressivity issues and the development of self-regulation capabilities.

At the teaching level, the AI Recursive Learning Method can serve as an intermediary mechanism between classroom teaching and after-class practice, extending the scope of teachers' feedback and alleviating the structural problem of "disconnection between teaching and practice" in traditional vocal music teaching. Its functional positioning is more appropriately understood as a "recursive cognitive scaffold". Through high-frequency, low-risk feedback and inquiry support, it helps learners maintain a problem-oriented and reflective orientation across different learning scenarios, rather than replacing teachers' core role in technical judgment and aesthetic guidance.

Nevertheless, the involvement of technology has not changed the human-centric essential attribute of vocal music art. As emphasized in the discussion of this paper, the boundary of the AI Recursive Learning Method clearly stops at technical analysis and cognitive assistance. It cannot replace the central position of vocal music teachers in aesthetic judgment, style shaping, and the transmission of artistic emotions. Looking forward to the future vocal music education ecosystem, the ideal vision should be a "dual-core driven" human-machine collaborative model: Teachers, as instructional designers and aesthetic authorities, focus on controlling the artistic direction and spiritual connotation; while artificial intelligence, as an all-weather cognitive partner, undertakes the polishing of basic techniques and practice feedback in the extensive after-class time and space. This collaborative mechanism is not only expected to fundamentally alleviate the structural contradiction of "disconnection between teaching and practice" in traditional vocal music teaching, but also reminds us that in the era of artificial intelligence, the innovation of art education should go beyond the level of tool efficiency, and further explore how technology can reshape cognitive processes, thereby more fully unleashing the unique value of human subjects in artistic creation.

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Conflict of Interest

The authors declare no conflict of interest.

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