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Construction of a Graphic Notation–Supported Multimodal Music Game Teaching Model: Development and Teacher Practice

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Abstract

With the development of multimodal learning theory in the field of education, music teaching is gradually shifting from the traditional auditory-based teaching mode to the teaching method of multi-sensory integration. As a visual representation tool of musical elements, graphic notation provides an effective way to concretize the concept of abstract music. Although multimodal learning and gamified learning have been widely studied, the teaching framework that integrates graphic notation, multimodal interaction and gamified teaching system is still lacking, especially the empirical research on the characteristics of teachers' teaching implementation. In this study, a multimodal music game teaching model supported by graphic notation was constructed by using design-based research method. The study collected data through teacher training, lesson plan analysis, classroom observation, and reflection records, and analyzed the characteristics of teachers' teaching implementation under the teaching framework. The results show that the teaching mode effectively reduces the abstraction of music learning and improves the operability of teaching practice through the integration of graphic visualization representation, multimodal sensory participation and gamified interaction. At the same time, the study further reveals the key teaching strategy characteristics of teachers in the implementation of multimodal music teaching. By bridging instructional design and classroom practice, this study contributes to the literature through an integrated framework that combines graphic notation, multimodal learning, and gamified teaching, offering both theoretical advancement and practical implications for music education.

Keywords: Graphic Notation, Multimodal Learning, Gamified Teaching, Music Education, Teacher Practice

Introduction

Background of the study

With the development of multimodal learning theory, music education has gradually shifted from a single auditory training to a comprehensive learning model that integrates visual, motor and interactive experience (Zhu et al., 2025). Music learning involves abstract elements such as rhythm, pitch, and dynamics, and traditional auditory-based teaching

methods are difficult to effectively support learners' understanding of musical structure, especially in preschool and basic education, where learners rely more on concrete and contextualized representations (Hallam, 2010).Graphical Music Notation visually expresses musical elements through visual symbols such as shapes, lines, and colors, transforming abstract sound structures into intuitive and perceptible visual forms, providing an important concrete tool for music learning (Chen, 2025; Xiao, 2025）.

However, most of the existing studies have discussed graphic notation, multimodal teaching, and gamified learning separately: graphic notation research focuses on static teaching auxiliary functions (Han, 2025), multimodal teaching lacks concrete tool support (Tang, 2024), and gamified learning focuses on single-skill training (such as rhythm games), and a systematic teaching model that integrates the three has not yet been formed (Weatherly et al., 2024).

At the same time, multimodal learning theory emphasizes the promotion of cognitive construction through multi-channel information processing such as visual, auditory, and kinesthetic, and believes that the collaborative participation of multiple senses can reduce cognitive load and improve the internalization effect of knowledge (Fleming & Mills, 2012; Kress, 2010）. Digital Game-Based Learning (DGBL) effectively stimulates learning motivation and continuous participation through task challenges, instant feedback, and reward mechanisms, showing significant application potential in music education (Ananda et al., 2025; Pesek et al., 2020）

In this context, this study constructs a multimodal music game teaching model based on the visual representation of graphic notation, and discusses its implementation path and teaching value through teacher training and practical scenarios, so as to provide a new solution for solving the abstract problem of music education.

Research objectives and research questions

This study aims to construct a multimodal music game teaching model supported by graphic notation, and explore its teaching feasibility and implementation characteristics through teacher practice.

Research questions include:

1、Based on the theory of multimodal learning and the principle of gamification teaching, how to construct a multimodal music game teaching mode supported by graphic notation?
2、What are the teaching design strategies and practical behavior characteristics of teachers in the process of implementing this model?
3、What is the application potential and optimization direction of this model in music teaching in preschool and basic education?

Significance of the Study

Theoretical Significance

This study systematically integrates the three core elements of graphic notation visualization, multimodal learning and gamified teaching, constructs a three-dimensional fusion framework of "representation-processing-excitation", expands the application

boundaries of graphic notation in multimodal learning and gamified teaching, and enriches the theoretical system of interdisciplinary research in the field of music education (Li et al., 2025). At the same time, through the empirical analysis of teachers' practice characteristics, this paper fills the gap in the discussion of the transmission mechanism of "teaching tools-teacher behavior-teaching effect" in existing research, and provides theoretical support for the innovation of music education model.

Practical Significance

The teaching model constructed in this study includes practical content such as graphic notation design specifications, multimodal activity design, and gamification mechanism embedding, providing a teaching solution that can be directly applied to music teachers in preschool and basic education (Cheng, 2024). Through the practical exploration in the process of teacher training, the refining of targeted teaching strategies and implementation suggestions will help lower the application threshold of teachers for multimodal gamified teaching and promote the innovation and transformation of music classroom teaching.

Originality and Contribution of the Study

This study makes several important contributions to the field of music education and the broader social sciences. First, it develops an integrated multimodal music game teaching model centered on graphic notation, addressing the lack of systematic frameworks that combine visual representation, multimodal processing, and gamified interaction. Second, unlike prior studies that primarily focus on student outcomes, this research provides an in-depth analysis of teachers' instructional practices, highlighting implementation strategies and practical challenges. Third, the study proposes a three-dimensional framework of "representation–processing–motivation," offering a theoretically grounded explanation of how graphic notation, multimodal learning, and gamification interact in music education.

Overall, this research extends the application of multimodal and gamified learning in music education and contributes to the social sciences by providing empirical insights into the relationship between instructional design, teacher behavior, and learning processes.

Literature Review

Visual Representation of Graphic Notation and Music

Graphic notation is a musical representation method that transforms musical elements (rhythm, pitch, dynamics, etc.) into visual symbols, and realizes the concretization of abstract sound structures through visual elements such as shapes, lines, spatial positions, and colors (Chen, 2025; Han, 2025）. In the design logic of graphic notation, the spatial position can correspond to the pitch change, the line length can express the rhythm time, and the color shade can strengthen the dynamics level, so as to establish an accurate correspondence between vision and hearing (Xiao, 2025). Xiao Haoyue (2025) showed that the dynamic graphic notation can effectively reduce the difficulty of music learning and improve classroom participation through the collaborative design of "form-meaning-movement". Wang Nanxi (2025) conducted a comparative experiment to confirm that compared with traditional simple scores, graphic scores have significant advantages in improving students' musical comprehension and learning interest.

From the perspective of cognitive mechanism, the visual representation of graphic notation is in line with the core view of Paivio's (1986) dual coding theory, which enhances memory retention and comprehension through dual-channel encoding of visual symbols and auditory information. Hallam (2010) pointed out that visual musical representation can help learners identify the relationship between musical elements, improve their understanding of melodic changes and rhythmic structures, and promote the development of musical expression skills. However, the existing graphic notation research mostly focuses on static teaching applications, lacking in-depth integration with dynamic interaction and multi-sensory linkage, and the gamification transformation potential of visual design has not been fully explored (Passarotto et al., 2022).

Multimodal Learning and Music Education

Multimodal learning theory believes that the learning process is the process of meaning construction through the integration of visual, auditory, kinesthetic and other symbolic systems, and different symbolic modalities have complementary functions in knowledge construction (Kress, 2010). Mayer's (2009) multimedia learning theory further points out that learners process information through visual and auditory dual channels, and the information presented in multimodal form can promote deeper integration and understanding. In the context of music education, music learning is essentially a multi-sensory cognitive activity involving multiple dimensions such as hearing (music perception), vision (reading sheet music), and kinesthetic (playing/grooving) (Gault, 2005).

Existing studies have confirmed the effectiveness of multimodal teaching in music education: Zhu et al. (2025) found that multimodal teaching can significantly improve students' cognitive flexibility and learning adaptability. Tang (2024) integrates multimodal technology through smart whiteboards to achieve collaborative teaching of audio, visual, and movement, effectively improving the quality of classroom interaction. The "multi-sensory linkage teaching method" proposed by Liu Keli (2025) has successfully stimulated primary school students' interest in music learning by integrating multi-sensory experience. These studies have shown that multimodal learning can adapt to the multisensory nature of music learning and deepen music understanding through multi-channel information integration (Forrester, 2018). However, the existing multimodal music teaching still lacks the support of concrete tools and gamification mechanisms, which makes it difficult to fully stimulate learners' active participation (Shen et al., 2025).

Application of Gamified Learning in Music Education

Digital gamified learning (DGBL) builds an immersive learning environment through core elements such as situational tasks, instant feedback, and point rewards, effectively enhancing learner motivation and engagement (Ananda et al., 2025). In the field of music education, gamified learning has been widely used in rhythm training, pitch recognition, music theory knowledge and other teaching content: the rhythm dictation application developed by Pesek et al. (2020) has successfully stimulated the motivation of college students to learn solfeggio practice. Cheng (2024) analyzed the educational value of commercial music video games and found that they have significant advantages in enhancing student engagement; Rusnak (2024) applied gamification elements to band teaching for students with autism and achieved good intervention results.

However, there are still obvious limitations in existing music gamification learning: from the perspective of content, it mostly focuses on single-skill training and lacks coverage of comprehensive literacy such as musical structure and emotional expression (Hou et al., 2024). In terms of form, most of them are adapted to ready-made commercial games, and there is a lack of customized design that is deeply integrated with teaching objectives and musical elements (Weatherly et al., 2024). From the perspective of application scenarios, most of the research focuses on primary and university levels, and gamified teaching resources for preschool education are relatively scarce (Ananda et al., 2025). These limitations make it difficult for the application of gamified learning in music education to form a systematic effect, and it is urgent to combine it with visual tools such as graphic notation and multimodal teaching strategies to build a teaching model with more educational value.

Research gaps

Based on the existing research, it can be found that graphic notation, multimodal learning and gamification teaching all show unique value in music education, but there are still obvious research gaps in the deep integration of the three: first, the existing research mostly discusses the application effects of the three separately, and lacks a systematic integration framework with graphic notation as the core of visualization, multimodal learning as the cognitive foundation, and gamification as the interactive carrier; second, the research on the construction of the teaching model of the integration of the three is insufficient, and there is a lack of clear definition of the core elements, implementation process and design principles of the model; Third, the existing research mostly focuses on the learning effect of students and ignores the empirical exploration of the characteristics of teachers' implementation process and strategy, resulting in a lack of targeted guidance for the practical transformation of the model. Fourth, there is little research on customized integration models for preschool and basic education, which is difficult to meet the needs of young learners for concrete and interactive teaching (Li et al., 2025; Weatherly et al., 2024）. This study aims at these gaps to construct a multimodal music game teaching model supported by graphic notation, and provides empirical support for the implementation of the model through teacher practice analysis.

Theoretical Framework

Game activity	**Graphic notation feature**	**Multimodal interaction**	**Learning purpose**
Rhythm challenge	Visual rhythm symbols	Listening + body movement	Rhythm perception
Music puzzle	Fragmented graphic notation	Visual recognition	Music structure understanding
Movement imitation	Shape-based notation	Body movement	Embodied musical learning

Multimodal Learning Theory

Multimodal learning theory emphasizes that the learning process is a process of synergy between visual, auditory, and kinesthetic sensory channels, and that different modalities complement each other in knowledge construction, reducing cognitive load and improving learning effects through multiple cognitive pathways (Kress, 2010). In music education, this theory requires teaching activities to integrate the experience of visual

channel graphic notation recognition, kinesthetic channel body rhythm, and tactile channel instrument operation (Gault, 2005).

In this study, the graphic notation is used as the core visual carrier, forming a multi-modal integration system with auditory and kinesthetic modalities, which is in line with the multisensory nature of music learning (Zhu et al., 2025).

Dual Coding Theory

Dual coding theory points out that human cognition processes information through verbal channels (language, auditory) and representational channels (visual, spatial), and dual-channel synergy can enhance memory and comprehension (Paivio, 1986; Mayer, 2009）。

In this study, the graphic notation transforms abstract musical elements into visual symbols through the representation channel, and the sound is perceived through the verbal channel, and the two synergistically promote the construction of musical knowledge.

For example, students can visually identify rhythm and pitch, while auditory perception of music to deepen their understanding through dual coding.

Gamified Learning Theory

Gamified learning theory focuses on self-determination theory (Ryan & Deci, 2000), emphasizing to meet learners' autonomy, competence, and belonging needs through goal setting, immediate feedback, autonomous choice, and social interaction, thereby stimulating intrinsic motivation.

In music teaching, this theory guides the transformation of teaching objectives into game tasks and evaluation into immediate feedback and rewards (Ananda et al., 2025).

This study designs situational tasks such as "musical adventure" and "rhythm breakthrough", combined with points and medal awards, to enhance teachers' attention to interactivity and enhance students' motivation to participate.

Conceptual Model

Based on the above three theories, this study constructs a three-dimensional fusion framework of "graphic spectral visualization, multimodal sensory processing, and gamified interaction" .

As the visual core (dual coding theory), the graphic notation is embedded with gamified interaction mechanism (gamified learning theory) through multimodal channel collaborative processing (multimodal learning theory) to realize the understanding of music elements, the improvement of learning motivation and the optimization of teaching practice.

Graphic notation is not only a key carrier of multimodal processing, but also determines the feasibility of gamification mechanism.

Table 3
Data sources and collection methods

Data source	Description	Purpose
Teaching plans	Lesson plans of music game activities	Analyze instructional design
Classroom observation notes	Teacher implementation records	Examine teaching process
Teaching reflection documents	Teacher reflections after activities	Identify learning effects

Table 4
Coding categories for qualitative analysis

Category	Description
Student engagement	Children's participation and motivation
Multimodal interaction	Interaction between visual, auditory, and movement
Musical understanding	Recognition of rhythm and pitch
Teaching implementation	Teacher instructional strategies

Methodology

This study adopts a qualitative research-oriented design-based qualitative research method to explore the construction and implementation path of multimodal music game teaching mode supported by graphic notation through the cyclical process of "model construction, teacher practice, reflection and optimization" (Wang et al., 2025).

This study focuses on the teaching design and practice process in teacher training scenarios, and extracts the core elements of the model and teachers' practice characteristics through multi-source data collection and theme analysis, rather than directly measuring students' learning effects.

The selection of design research methods is in line with the research logic of "theoretical construction-practical testing-optimization and improvement" in this study, which can effectively connect the theoretical framework and teaching practice (DCosta et al., 2025).

Research Context and Research Objects

The research was carried out in the graphic notation teaching training course of a provincial music teacher continuing education project, with a training period of 8 weeks, 3 lessons per week, and a total of 24 lessons. There were 32 preschool and primary school music teachers from all over the province, including 12 with teaching experience from 1 to 5 years, 11 from 6 to 10 years, and 9 from 11 years or more; 28 with bachelor's degree or above, 4 with college degree; All of them have basic music teaching experience, but 78.1% (25 teachers) have less than one year of experience in graphic notation teaching, which meets the data analysis needs of "preliminary exploratory practice".

The training content is divided into three modules: Module 1 (1-2 weeks): Graphic notation design principles and visualization skills, including visual transformation rules of musical elements and dynamic graphic notation design methods; Module 2 (3-5 weeks): Multimodal music teaching strategies, including visual-auditory-kinesthetic collaborative design, multi-sensory activity organization methods; Module 3 (6-8 weeks): Multimodal music game design and practice, including game situation construction, task design, feedback mechanism embedding, and gamified lesson plan development based on graphic .

Data Sources

This study uses multi-source data triangulation to ensure the credibility and richness of the research results, including specific data sources:

Teacher training classroom videos and photos (24 class hours in total, about 72 hours; 156 classroom activity photos): used to analyze teachers' participation behavior, teaching design discussion process and simulated teaching display in the training process;

Graphic music game lesson plans designed by teachers (32 complete lesson plans, each containing graphic score design drawings, game rules, multi-modal activity arrangements, and teaching objectives): used to analyze teachers' understanding and application of the core elements of the model;

Teachers' teaching reflection and discussion records (including 32 written reflections after training, 6 transcripts of group discussion recordings, and 42 screenshots of online communication records): used to analyze teachers' confusion, perception and strategy adjustment in the practice process;

Training classroom observation records (independently completed by two researchers, including classroom activity records, teacher interaction frequency, teaching design difficulties records, etc.): used to supplement and verify information from other data sources.

Research Ethics

This study strictly follows the ethical norms of education and research: explain the purpose of the study, data collection method and use to all participating teachers in detail before the start of the study, and sign the informed consent form. All data is processed anonymously, removing identifiable information such as teacher name, school, etc.; Data are only used for analysis in this study and may not be used for other purposes without permission; After the research is completed, the research results will be fed back to the participating teachers, and training-related teaching resources will be provided. This study only involves teachers' teaching practice data, does not involve children's personal information, and there is no ethical risk.

Finding

Based on the theoretical framework and the teaching design practice in the process of teacher training, the multimodal music game teaching mode supported by graphic notation constructed in this study includes three core modules: graphic notation visualization design, multimodal learning integration, and gamified teaching mechanism.

Graphic Notation Visualization Design Module

As the core representation tool of the pattern, the design of graphic notation should follow the three principles of "accurate correspondence of musical elements, intuitive and easy to understand visual symbols, and strong adaptability of game interaction", and the specific design strategies include:

Dynamic representation design: Breaking through the limitations of traditional static graphic notation, dynamically changing visual symbols are used to present changes in musical elements, such as "beating note symbols" (beating frequency corresponds to fast and slow rhythm) in the rhythm dimension, "floating lines up and down" (floating amplitude

corresponds to pitch span) in the pitch dimension, and "color shade gradient" (the darker the color, the stronger the intensity) to enhance visual appeal and interactive potential (Xiao, 2025).

Pitch spatialization design: Based on human cognitive habits of spatial position, vertical spatial positions are used to correspond to pitch (high = high note, low = bass), and horizontal spatial length corresponds to the timing value (longer the length is longer), and the melody direction and rhythmic structure of music are intuitively presented through spatial relationships (Paivio, 1986).

Rhythmic graphic design: use different shapes of visual symbols to distinguish different rhythmic types, such as circles for quarter notes, ovals for eighth notes, and triangles for sixteenth notes, and symbol spacing corresponding to note intervals, helping learners quickly identify rhythm changes through visual differences (Chen, 2025).

Consistent design principle: The same musical element adopts unified visual symbols (such as red for strong notes and blue for weak notes) to avoid the increase in cognitive load caused by symbol confusion and meet the standardized design requirements of teaching tools (DeVellis, 2017).

Multimodal Learning Integration Module

Based on the theory of multimodal learning, this module realizes the collaborative processing of multi-sensory channels such as vision, hearing, kinesthetic, and tactile, and the specific integration methods include:

Visual-auditory linkage: Graphic notation and musical elements correspond accurately, such as red thick lines corresponding to strong notes and blue thin lines corresponding to weak sounds.

Visual-kinesthetic linkage: In the design of the "graphic notation rhythm" activity, students need to imitate the shape and rhythm of the graphic notation to complete body movements, such as wavy lines corresponding to swaying actions, broken lines corresponding to frustration actions, and rising lines corresponding to limb lifting, so as to realize the transformation of visual perception to kinesthetic expression (Liu, 2025).

Auditory-kinesthetic linkage: Combined with game tasks, students need to complete corresponding operations on the graphic score according to the music content they listen to, such as clicking on the graphic score symbol according to the rhythm of the music, adjusting the position of the graphic score puzzle according to the pitch change, and strengthening the relationship between auditory perception and action feedback;

Multimodal feedback integration: Visual feedback (graphic spectral color change), auditory feedback (rewarded sound effects), and haptic feedback (operating device vibration) are provided during the game to reinforce the learning experience and improve the learning effect in multiple dimensions (Su & Guo, 2026).

Gamified Teaching Mechanism Module

Based on gamified learning theory, this module enhances teaching interactivity and fun through scenario construction, task design, feedback rewards, and other mechanisms, including:

Contextual task design: Construct game themes that are close to students' life experience, such as "Musical Forest Adventure", "Rhythm Kingdom Breakthrough", "Melody Puzzle Competition", etc., and transform music learning goals into game tasks, such as "helping little squirrels follow the graphic score through the forest (rhythm training)" and "repairing the broken melody graphic score (melody understanding)" (Ananda et al., 2025);

Hierarchical task system: Basic, advanced, and challenge levels are designed according to learning difficulty, with the basic level focusing on a single musical element (such as rhythm recognition), the advanced level integrating two or more elements (such as rhythm + pitch), and the challenge level emphasizing comprehensive application (such as musical structure restructuring) to gradually increase the learning difficulty and meet the needs of learners of different levels (Cheng, 2024).

Instant feedback mechanism: After students complete the task, the correct rate and error type are displayed immediately, and the wrong position is marked in combination with the graphical notation (such as rhythm errors are prompted by flashing symbols) to help learners quickly adjust. At the same time, provide personalized feedback and suggestions, such as "Your rhythm recognition is accurate, try to challenge a faster rhythm" (Pesek et al., 2020);

Multiple reward systems: set up point rewards (complete tasks to earn points), medal rewards (unlock levels to obtain exclusive medals), and social rewards (team honors for completing tasks in groups) to meet learners' sense of accomplishment and belonging; Rewards can be redeemed for teaching resources (e.g., personalized graphic notation templates) to reinforce the continuity of learning motivation (Ryan & Deci, 2000);

Cooperation and competition mechanism: Set up a two-person collaboration mode (such as dividing labor to complete a graphic notation puzzle) and class leaderboards to stimulate participation motivation while avoiding the pressure caused by excessive competition and emphasizing a "mutual assistance and win-win" game atmosphere (Rusnak, 2024).

Table 5
Summary of research findings

Theme	Key findings
Engagement	Game activities increased participation
Multimodal interaction	Children coordinated visual and auditory information
Musical understanding	Improved rhythm and pitch recognition
Teaching feasibility	Graphic notation supported music learning

Data analysis

The thematic analysis method proposed by Braun & Clarke (2006) is used to systematically analyze the data, and the specific steps are as follows:

Data familiarization stage: The two researchers repeatedly read the lesson plan, reflect on the text, watch the classroom video, form an overall cognition of the data, and record preliminary observation notes.

Initial coding stage: Based on the research problem and theoretical framework, the data is openly encoded, and the coding dimensions include graphic notation design characteristics, multimodal activity types, gamification mechanism design, teacher practice confusion, teaching strategy selection, etc., and a total of 68 initial codes are generated.

Focus on the coding stage: classify and merge the initial coding, delete duplicate coding, refine the core coding categories, and finally form five core coding themes: graphic notation visualization design strategy, multimodal integration method, gamified teaching mechanism, teacher practice challenges, and teaching optimization suggestions;

Theme naming and definition stage: Clearly name each core theme, define its connotation and boundaries, and ensure the clarity and uniqueness of the theme.

Thematic integration and reporting stage: Combine the core theme with the research question and theoretical framework to form systematic analysis results, which are supported by original data fragments.

In the process of data analysis, the triangular verification method of researchers was adopted, and the consistency test was carried out by two researchers after independent coding, and the initial coding consistency coefficient was 0.82, which reached a complete agreement after discussion and consultation. At the same time, an expert in the field of music education was invited to review the coding results to ensure the validity and rationality of the coding.

Result

Through the theme analysis of the lesson plan design, classroom practice and reflection records of 32 teachers, the following practical characteristics and results are presented in the process of implementing the multimodal music game teaching mode supported by graphic notation:

Practical characteristics of graphic notation design

The design focuses on the core musical elements: 84.4% (27 copies) of the graphic scores designed by teachers focus on covering the two core elements of rhythm and pitch, using the combination of "spatial position + shape" to represent pitch (such as the vertical position of circular symbols to represent pitch), and the combination of "line length + spacing" to represent rhythm (such as long lines representing long notes); 62.5% (20 copies) of the graphic notation contained visual design of the dynamics dimension (color shade or symbol size), and 43.8% (14 copies) involved the musical structure dimension (block division representing paragraphs), reflecting a good fit with the theory of musical elements (Hallam, 2010).

Insufficient dynamic and interactive design: only 37.5% (12 of the lesson plans) contain dynamic graphic notation design (such as flashing and moving symbols), and most teachers still prefer static graphic notation. 28.1% (9 copies) of the graphic notation design took into account the interactive needs of the game (such as clickable and draggable symbols), and the graphic notation of the rest of the lesson plans was still based on "viewing recognition", lacking the exploration of interactive potential.

The initial reflection of age-appropriate design is that 75% (12 copies) of the lesson plans for preschool children use concrete symbols (such as notes corresponding to animal shapes), which are brightly colored and contrasting; In the lesson plans for the lower grades of primary school, 60% (9 copy) used semi-concrete symbols, which took into account both interest and normativeness, reflecting the concern for the cognitive characteristics of young learners (Han, 2025).

Practical characteristics of multimodal integration

Visual-auditory integration is the mainstream: all lesson plans (100%) realize the basic integration of vision (graphic notation) and auditory (music), and strengthen dual-channel processing through the activity design of "looking at the graphic notation-listening to music-matching correspondence"; 81.2% (26 copies) of the lesson plans included visual-kinesthetic integration activities, such as following the rhythm of the graphic notation and imitating the shape of the graphic notation. Only 34.4% (11) of the lesson plans involved tactile integration (such as operating physical graphic notation puzzles and touch-sensing devices).

Single form of multimodal activities: 68.8% (22 of the multimodal activities) designed by teachers were linear processes of "observation-listening-imitation", lacking multi-channel synchronous interaction. Only 21.9% (7 copies) designed activities with "multi-channel simultaneous participation", such as watching graphic scores, listening to music, and completing body movements and tactile operations while completing physical movements, insufficient depth of multimodal integration (Tang, 2024).

The adaptability of sensory channels needs to be improved: 37.5% (12 copies) of the lesson plans have the problem of multimodal activity overload, such as requiring students to observe graphic notation, memorize rhythm, complete body movements and verbal answers at the same time, resulting in excessive cognitive load; 25% (8 copies) of the lesson plans had the problem of insufficient sensory channels, which only involved vision and hearing, and did not give full play to the synergy between kinesthetic and tactile sensations (Fleming, 2012).

Characteristics of the implementation of gamification mechanism

Situation and task design in line with teaching objectives: 78.1% (25 copies) of the lesson plans are designed with clear game themes and task chains, such as in the theme of "Rhythm Police", the task chain is "identify the rhythm graphic score (basic level)→ follow the graphic score to play the rhythm (advanced level) → create and compile the rhythm graphic score (challenge level)", which is highly consistent with the goal of music teaching; 21.9% (7 of the lesson plans) had the problem of "disconnection between game and teaching", and the game was interesting but did not effectively carry the music learning objectives (Ananda et al., 2025).

The feedback mechanism is biased towards consequential feedback: 65.6% (21 of the lesson plans) only provide consequential feedback (such as "correct/wrong" and "how many points"), and lack process feedback (such as error cause analysis and improvement suggestions). Only 28.1% (9 of the lesson plans) were designed with immediate process feedback, such as indicating the wrong position of the rhythm through graphical notation flashing, which reflected insufficient understanding of feedback mechanism design (Pesek et al., 2020).

The reward mechanism is mainly based on individual rewards: 71.9% (23 copies) of the lesson plans use individual rewards (such as individual points and medals), and only 28.1% (9 copies) contain cooperation rewards (such as group points and team medals); The form of rewards is mainly virtual rewards, and there is a lack of substantive rewards related to the teaching content (e.g., personalized graphic notation templates, music creation tools) (Ryan & Deci, 2000).

Teacher Practice Challenges

Design ability challenge: 68.8% (22 teachers) mentioned in their reflection that "graphic score design takes a long time" and "it is difficult to balance the visualization effect and the accuracy of musical elements"; 56.2% (18 teachers) said that "lack of experience in multimodal activity design makes it difficult to effectively integrate multiple sensory channels".

Technical application challenges: 43.8% (14 teachers) mentioned that "motion graphics notation design requires professional technical support and lacks convenient tools"; 37.5% (12 copies) of the teachers said that "the lack of corresponding interactive equipment in the classroom implementation affects the effect of gamified teaching".

Classroom management challenges: 34.4% (11 teachers) reported that "students are enthusiastic about participating in gamified teaching, but they are prone to disorder"; 28.1% (9 teachers) mentioned that "hierarchical task design is difficult to meet the needs of all students, resulting in low participation of some students".

Discussion

Theoretical conformity and practical value of model construction

The multimodal music game teaching mode supported by graphic notation constructed in this study fully conforms to the core views of multimodal learning theory, dual coding theory and gamified learning theory through the three-dimensional collaboration of "graphic notation visualization, multimodal integration, and gamification interaction".

The visual design of graphic notation realizes the concrete transformation of musical elements, provides a high-quality carrier for the visual channel in the double coding theory, forms a synergistic effect with the auditory channel, and effectively reduces the abstraction of music learning (Paivio, 1986; Mayer, 2009）；

Through the collaborative processing of vision, hearing, kinesthetic and tactile senses, the multimodal integration module follows the core logic of "multiple cognitive paths to improve learning effect" in multimodal learning theory (Kress, 2010; Zhu et al., 2025）； The gamification mechanism module meets learners' needs for autonomy, competence and belonging through situational tasks, immediate feedback and multiple rewards, and effectively stimulates learning motivation (Ryan & Deci, 2000; Ananda et al., 2025）.

From the perspective of practical value, this model provides teachers with a "designable, operable and adjustable" teaching framework: the graphic notation design module provides clear visualization rules and strategies, which lowers the design threshold of teachers; The multimodal integration module gives a specific sensory linkage method to avoid the blindness

of multimodal teaching. The gamification mechanism module provides design ideas for tasks, feedback, and rewards, which improves the interactivity and fun of teaching. The results of teacher practice show that this model can effectively guide teachers to pay attention to the visual representation of music elements, multi-sensory collaboration and teaching interaction, and provide a practical solution for music teaching in preschool and basic education (Cheng, 2024; Xiao, 2025）.

Causes and enlightenment of teachers' practice characteristics

The positive characteristics presented by teachers in practice, such as "focusing on core musical elements, focusing on visual-auditory integration, and fitting situational tasks to the goal", reflect teachers' accurate grasp of the essence and core logic of music teaching, and are also closely related to the emphasis on music element theory and multimodal learning principles in the training process (Hallam, 2010; DCosta et al., 2025）.

The problems of "insufficient dynamic design, insufficient depth of multimodal integration, and single feedback mechanism" are mainly due to teachers' traditional teaching inertia, design ability limitations and insufficient technical support. These practical characteristics provide important enlightenment for the optimization and promotion of the model:

First, graphic notation design needs to balance "professionalism and ease of use", develop convenient dynamic graphic notation design tools, lower the technical threshold of teachers, and provide diversified graphic notation templates to meet the needs of different teaching scenarios (Su & Guo, 2026).

Second, multimodal integration should emphasize "moderation and synergy", guide teachers to choose appropriate sensory channel combinations according to teaching objectives and students' age characteristics, avoid channel overload or insufficiency, and improve the effectiveness of multimodal integration (Tang, 2024; Fleming, 2012）

Third, the gamification mechanism needs to strengthen "procedural feedback and substantive rewards", train teachers to master the design method of procedural feedback, closely integrate rewards with music learning content, and enhance the educational value of rewards (Pesek et al., 2020; Ryan & Deci, 2000）；Fourth, classroom management needs to pay attention to the "balance between order and vitality", design clear game rules and classroom routines, and use group cooperation to guide students' orderly participation (Rusnak, 2024).

The application potential of the model in preschool music teaching

The core challenge of preschool music teaching is how to transform abstract music concepts into content that children can perceive and participate in, and the model constructed in this study just meets this demand and has significant application potential. The concrete and dynamic design of graphic notation can adapt to the characteristics of children's concrete thinking and help children establish the association between musical elements and visual symbols (Han, 2025).

Multimodal integration activities can satisfy children's active and multi-sensory exploration nature, and enhance participation through body rhythm and tactile operations

(Liu, 2025). Gamified situations and tasks can stimulate children's interest in learning and allow music learning to take place in a relaxed and enjoyable atmosphere (Ananda et al., 2025).

The characteristics of "concrete symbols, bright colors, and simple tasks" designed for preschool children in teachers' practice also verify the adaptability of the model to preschool education.

In the future, when promoting this model in preschool music teaching, it is necessary to further strengthen the "fun and life", the graphic notation symbols can use the images of animals and fruits that children are familiar with, the game theme can be close to the children's daily life experience, and the difficulty of the task should be in line with the cognitive development level of the children to ensure the adaptability and effectiveness of the model.

Conclusion

Based on multimodal learning theory, dual coding theory and gamified learning theory, this study constructs a multimodal music game teaching model supported by graphic notation through the design of qualitative research methods, and discusses the implementation characteristics and application potential of the model through teacher practice analysis. The study draws the following main conclusions:

First, the multimodal music game teaching mode supported by graphic notation is composed of three core modules: graphic notation visual design, multimodal learning integration, and gamified teaching mechanism, and through the three-dimensional collaboration of "visual representation, multi-sensory processing, and gamified motivation", the deep integration of graphic notation, multi-modal learning and gamified teaching is realized, providing a systematic solution for music education.

Second, in the process of implementing this model, teachers can better grasp the visual representation of the core music elements of graphic scores, the basic integration of visual and auditory senses, and the fit between game tasks and teaching objectives, but there are still deficiencies in dynamic design, multi-modal integration depth, procedural feedback, etc., which need to be further optimized through tool support, special training and practical reflection.

Third, this model has significant application potential in music teaching in preschool and basic education, which can effectively reduce the abstraction of music learning, improve the interactivity and interest of teaching, and provide teachers with an operable teaching path, which is conducive to promoting the transformation of music education from traditional single auditory training to multi-sensory integration mode.

The theoretical contribution of this study is to construct a theoretical framework for the integration of graphic notation, multimodal learning and gamified teaching, which enriches the interdisciplinary research in the field of music education. The practical contribution is to provide a practical teaching model and teacher practical guidance, which provides support for the teaching innovation of music teachers. The study was limited in that the sample size

was limited and the learning effect of students was not tracked for a long time. In the future, the scope of the sample can be expanded, empirical research across regions and sections can be carried out, and the long-term effects of the model on the improvement of students' musical literacy can be explored by combining quantitative and qualitative methods, and supporting graphic notation design tools and teaching resource libraries can be developed to promote the widespread application of the model.

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