

Investigating the effects of game-based learning on cognitive development and motivation in classical music appreciation among university students in Hebei



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ABSTRACT

This study investigated the effects of game-based learning on cognitive development and motivation in classical music appreciation among university students in Hebei Province, China. Using a quantitative research design and structural equation modeling, the study examined data collected from 368 undergraduate students across five universities, including students majoring in art-related fields and those taking music appreciation as an elective course. The research explored how game-based learning influences cognitive development and intrinsic motivation, with particular attention to the mediating role of social support. The results demonstrated that game-based learning significantly enhances cognitive development and intrinsic motivation through both direct and indirect pathways. The study revealed that social support plays a crucial mediating role in translating cognitive development into enhanced motivation. Additionally, the research revealed distinct patterns between art-related majors and students from other disciplines in their responses to game-based learning approaches. These findings contribute to the understanding of educational technology in music education and provide practical insights for implementing game-based learning in classical music appreciation courses. The study's comprehensive theoretical framework offers valuable guidance for educators and researchers in designing effective learning environments that integrate technological innovation with traditional music education.

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1. Introduction

Classical music appreciation is a classical domain of education that is rigid and structured and enhances students' cognitive skills, emotional intelligence, and multicultural awareness. Some studies indicate that music education, particularly classical music appreciation, promotes cognitive skills such as language acquisition and performance in executive tasks (Tanja et al., 2021). According to Campayo-Muñoz and Cabedo-Mas (2017), music serves to reinforce empathy and emotional regulation, as it allows for the expression and comprehension of emotions. Additionally, by increasing students' cultural literacy and aesthetic perception, appreciation of music is fostered, and

elements of traditional music are integrated, which contributes to the building of a set of ethical values and a broader perspective. Nevertheless, university students find it increasingly difficult to participate in classical music education due to digital distractions and modern technologies. In the same spirit, Chawke (2022) noted that even though conventional teaching approaches such as lectures are effective ways of delivering knowledge to students, they are not entirely recommendable ways of motivating people, especially in the context of classical music.

Over the past few years, educational research has sought to incorporate novel approaches to learning, such as game-based learning (GBL), into both practice and theory. Game-based learning implements the mechanics and aesthetics intrinsic in games to achieve success in enhancing learning outcomes in a fun, interactive, and engaging way. This approach was found to be effective in education, from mathematics and science to languages and history. Its potential to foster motivation, focus, and mental growth proves to be useful for revolutionizing classical music education, specifically in the context of younger students who would

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otherwise find normal music appreciation courses boring.

Recent research has highlighted and accepted the concept that GBL can improve problem-solving ability, memory, and critical thinking as three key characteristics of a person's mind. In addition, GBL has been proven to increase student motivation, retention, and engagement, which are features that tend to be common in traditional educational institutions and methods (Nadeem et al., 2023). By employing a game-based perspective, students are likely to understand the subject better, incorporate abstract ideas more, and enjoy the process of learning.

This study evaluates the influences that the gamified learning approach has on the motivation levels and cognitive capability of music students in the development of their critical analysis competencies alongside instrument understanding, specifically in relation to classical music in Chinese students. For the purpose of conducting an in-depth evaluation of the research problem, the study aims to determine the relationships between a student's motivation and consideration of cognitive development via instruments leveraging gamified activities. The study analysis provides support material for the already developed academic work regarding the problem of engaging students in music classes. Additionally, this research highlights the specifics that educators want to assist in the cognitive development of students enrolled in music education programs.

2. Literature review

2.1. Introduction to game-based learning

In a GBL scenario, educators combine educational objectives with the use of video games, which ensures that students find them engaging and enjoyable, as argued by Xie et al. (2021). One of the key features that gives video games the maximum appeal is immersion, which enables students to retain the core content more effectively than traditional methods do. This approach makes use of elements to create dynamics and mechanics through different aesthetic aspects of a game, which turn learning into something more purposeful and interesting than ever was (Xie et al., 2021). These dynamics also change the learning process, as students take on a more active role instead of being passive recipients of the content and its core ideas (Choosang et al., 2023).

GBL is seen as a contemporary approach to education that aids in the achievement of certain defined goals. GBL incorporates educational components with aspects of games that are stimulating, captivating, and student-centered. This impeccable blend makes the teaching and learning process very interesting and improves upon the areas that are usually weak when the conventional approach is used; for example, the learner's motivation to be a part of the process is often

dampened. Accordingly, GBL is gaining increasing popularity because of its ability to stimulate learners, particularly within the scope of learning areas that might be challenging to teach using more traditional approaches, for example, in disciplines that call for adequate learner involvement and concentration extending over a period of time (Choosang et al., 2023).

There are numerous studies that document the effectiveness of GBL in assisting educators in improving school student engagement levels and overall learning outcomes. While the use of GBL has been well valued in science, language, and mathematics, it has also served to be beneficial in assisting students in retaining concepts better, excelling academically, and even fostering student satisfaction (del Moral Pérez et al., 2018). With GBL, learners are guaranteed active participation in their learning, which helps foster retention of information while constructing an understanding of concepts owing to its stimulating interactivity (Xie et al., 2021).

In addition, the capacity of GBL to have elements of motivation has received much attention from researchers in the field of education. As noted above, GBL incorporates the aspects of fun, challenge, and competition, which makes learning more appealing or interesting so that students love participation. Such motivational characteristics are vital, especially in classical music education, as learners' interest is likely to diminish, especially when the content is too deep for them or when the content is unrelated to the students' lives. It can be concluded that game-based learning is effective at addressing this problem and encourages educators to find a new balance that encourages students to become fully engaged in lessons when they are quiet and passive during learning (del Moral Pérez et al., 2018).

2.2. Cognitive development and motivational aspects in music education

Motivation and cognitive development in music education work together in many dimensions that are beneficial to learning and student engagement. In music education, cognitive development is exhibited through language development, executive functions, memory, and problem-solving. Researchers have documented the effectiveness of musical groups' lessons on the development of language skills, including phonological awareness and vocabulary (Tanja et al., 2021). Furthermore, Kraus et al. (2014) noted that music training benefits children's language by enhancing their ability to process speech sounds while they are reading.

Executive functions are another broad cognitive area that music education claims to impact. According to Shen et al. (2019), music training is said to facilitate the enhancement of working memory, whereas activities such as recognizing rhythm and melody involve more than one cognitive system, prompting the training of cognitive flexibility and attentional control (Sachs et al., 2017). Such

enhancement remains not only at the level of being suprasmusical performers but also at the level of general cognitive ability. Moreover, other studies have reported that the retention of verbal information and selective attention are improved through extensive training in music, which in turn enhances learning and recall ability. According to [Chaiakaraphong et al. \(2021\)](#), the practice of music in classrooms is said to improve selective attention, which, as we all know, is important in academic attainment.

Problem-solving abilities are further developed through the expansion of creative ideas, which is one of the core skills of music education. Composing, improvising, and arranging are activities that highly depend on advanced problem-solving and analytic skills ([Barbaroux et al., 2019](#)). Such activities harness not only cognitive flexibility but also concentration and visuomotor precision ([Chaiakaraphong et al., 2021](#)).

In music education, the motivational parts are also essential. However, one of the most significant components of this area of education is intrinsic motivation. Intrinsic motivation is characterized by wanting to learn because of one's interests and curiosity, which effectively results in deeper immersion in the task and improved learning outcomes. It has been reported that students in music education have high levels of intrinsic motivation rooted in the pleasure of the pursuit of music and its mastery ([Ting and Lina, 2023](#)). This intrinsic motivation enhances the sense of independence as well as perseverance in the face of difficult learning scenarios ([Kusurkar et al., 2011](#)).

Extrinsic motivation, while different in nature, also contributes to musical learning through external rewards and recognition. While extrinsic motivations may be useful at times for performing certain tasks, especially over a short period of time, evidence suggests that extrinsic motivations are more effective when supportive of one's intrinsic motivation rather than being a stand-alone motivator ([Ting and Lina, 2023](#)). The recognition of teachers, peers, and family members can motivate students to pursue further exposure to music and help improve their self-image ([Evans and Liu, 2019](#)).

The involvement of the students in the music programs is associated with achievement and engagement with the material. According to [Costa et al. \(2023\)](#), cocurricular musical activities result in greater behavioral engagement in the school. Music education addresses fundamental psychosocial needs, autonomy, competence, and relatedness, which are intrinsic motivators ([Evans and Liu, 2019](#)). Teacher support is beneficial in the accomplishment of both motivational types, which involves expert teachers who are also enthusiastic about creating favorable learning conditions.

Furthermore, this combination greatly increases motivation in music subjects. Additionally, self-efficacy affects both motivation and engagement not only in [Chen \(2024\)](#) but also in music education, where it has been shown that students with high

music self-efficacy are also more motivated and achieve higher academic results.

2.3. Relationship between game-based learning and cognitive development

GBL is resourceful in enhancing the cognitive development of an individual by controlling the cognitive load set out in a task. There is a theory of cognitive load that states that an individual who is learning has limitations on the amount of information that they can process, and if the limit is exceeded, too much cognitive load will negatively affect learning. GBL reduces extrinsic cognitive load, which is the resources that are wasted on putting in an effort that is not required, but enhances the germane cognitive load that is useful and aimed at realizing goals ([Chang et al., 2017](#)). By creating an appropriate amount of cognitive load, GBL optimizes the learning process, which enables the students to internalize the key messages, thus leading to better understanding. This balance encourages students to think critically about the information presented to them.

In addition, game-based learning has been shown to be useful in advancing the ability of students to employ mnemonic techniques, which are strategies that are critically important in the storage and easy retrieval of information. The work of [Shen et al. \(2011\)](#) on students showed that when game attachments are added to models, there is a notable increase in students' use of mnemonic strategies during recall of previously taught information, resulting in GBL assisting in the retention of the information better. In addition to these memory improvements, GBL also helps students develop metacognitive skills, which refer to learners' ability to monitor and control their own thinking processes. These abilities are very important for performance at school, and they are acquired in a number of game-based learning contexts because of the highly interactive and challenging nature of the achievement limbs of the game.

The achievement of the flow state is also one more area where GBL helps address students in addition to their cognitive deficits. Flow, where students have their full concentration on the task at hand, has been associated with better cognitive engagement and better learning results ([Lai et al., 2013](#)). Games tend to be very useful in getting people into flow states because of their ability to provide feedback on a learner's performance instantly, their ability to readjust the difficulty level of the game to what the learner can cope with, and the use of endorsements to attract the interest of learners. The intrinsic and enhancing aspects of GBL assist in creating this flow state, leading to improvements in both learning and cognitive development.

The influence of GBL on development is not only cognitive; rather, the underlying mechanisms are much more extensive. GBL is said to positively influence emotions by providing a context of

learning through games where good feelings, such as being excited and a sense of achievement, increase learner motivation, as well as the outcomes of that learning context (Tu et al., 2015). The very exposure to positive engagement offered by the games transforms students into more self-directed learners, motivating them to persist and tirelessly work on a given learning task. The fun that comes from the success obtained from working on the challenges of the game itself reinforces the learning, with this feeling being both rewarding and intellectually stimulating.

At an additional level, learning with the use of a game-based approach is characterized by the inclusion of collaborative learning strategies. In these games, solving problems or completing goals is often done by groups of students, which enhances both the cognitive and social aspects. The practice of CBT together with GBL enhances not only critical thinking but also shared decision-making, problem-solving, and even reflection, which are necessary for cognitive development (Katual et al., 2023). As students work with their peers in the learning activity, they are taken through various angles of the same issue and many ways of solving it, which, at the end of the day, facilitates better understanding of the topic.

The literature has made prominent arguments and presented data that establish the effectiveness of GBL in nurturing cognitive growth. The evidence gathered from many studies suggests that GBL is far superior to traditional learning methods, as the former approaches foster better cognitive load balancing, learning engagement, and overall cognitive results (Chang et al., 2017). Compared with their contemporaries, children with GBL in their formative years tend to have well-rounded cognitive, social, and emotional growth, as evidenced through meta-analyses and systematic reviews tailored towards studying the impact of GBL on young children (Alotaibi, 2024). Empirical research, such as that of Dong et al. (2024), which aims to portray GBL material that is based on VR, reveals how interactive room features have the ability to attract students' attention while also increasing their engagement in the material presented to them, further strengthening their understanding of their cognitive skills.

The literature presented above provides a rather optimistic and positive picture of the impact that GBL has on cognitive growth; however, challenges still remain in pessimistically envisioning this impact. (Dong et al., 2024). Shen et al. (2011) presented a rather worrisome outlook, suggesting that students tend to learn better only to a certain degree, clustering the educational portions of GBL alongside game features; if the portion covering game elements overshadows the educational content, then students and teachers alike will be disappointed in the outcome. GBL has the potential to have a positive long-term impact, but studies need to be conducted to explore the long-term impact in

greater detail. Therefore, the following hypothesis is proposed:

H1: Game-based learning positively impacts students' cognitive development in classical music appreciation.

2.4. Relationship between game-based learning and motivation

Sanchez et al. (2022) claimed that students who utilized game-based training exhibited significantly greater intrinsic motivation and more active engagement than those who were enrolled in a computer-based program. As a result, GBL is capable of decreasing extrinsic motivation via engagement and enhancing the intrinsic motivation of a child. Furthermore, GBL offers immersive games that facilitate higher levels of intrinsic motivation than conventional methods of education do. It has been established that GBL allows for hands-on approaches that provide instant feedback from the materials and aids the students in grasping the concepts from an interactive viewpoint, therefore generating SPICE: Students' Personal Intrinsic Contentual Engagement.

Motivational processing and outcome processing play significant roles in sustaining motivation in digital game-based learning (DGBL). According to Huang et al. (2010), the integrative theory of motivation, volition, and performance (MVP) highlights the importance of both motivational processing (e.g., attention, relevance, and confidence) and outcome processing (e.g., satisfaction) in maintaining motivation. In the context of GBL, games that capture learners' attention and provide meaningful outcomes lead to a cycle of motivation that supports continued engagement and performance improvement. The design of games that focus not only on the immediate appeal of gameplay but also on providing satisfactory outcomes is essential in sustaining motivation over time.

The motivational facets of self-efficacy and goal setting are active within GBL settings. The level of motivation can also increase due to the feedback and goal-designing tools incorporated for students' self-efficacy. Oskar et al. (2010) integrated the negotiation mechanism within game-based learning to assist students in goal setting. More importantly, for learners who were less assured of their competencies, being able to set goals increased self-efficacy. This, in addition to other evidence discussed, proved that GBL engagement can function as a framework for capability development and motivate students to endure through the great process of learning.

In contrast to GBL, where fully developed games are used for educational purposes, gamification may be viewed as a set of elements added to the learning activity. Zhang and Yu (2022) reported that in lower learning contexts, gamification can propel learning and motivation more than serious games can.

Since customizability is at the essence of educational games, the teachings of gamification can be customized to the individual student's requirements by using point systems, badges, sorting tables, and other elements of motivation. Compared with the framework outlined by serious games, which is more rigid, the ability to adapt gamification to focus on some of the elements proves its vigor in education.

Moreover, a steady rise in adoption rates of GBL has contributed to better academic results, which consequently adds to students' internal drive and motivation. As per [Eltahir et al. \(2021\)](#), students were able to display considerable improvement in their academic performance in the Arabic language grammar course after adopting GBL tools in a higher education scenario.

On the basis of these findings, the following hypothesis is proposed:

H2: Game-based learning enhances students' intrinsic motivation to engage in classical music appreciation.

2.5. Interrelationships between cognitive development and motivation in music education

Through music education, children learn advanced skills that increase confidence and self-efficacy, ultimately leading them to be further motivated to learn more, as the cycle repeats itself. This, in turn, improves their overall commitment and mastery of the required musical skills ([Chen, 2024](#)).

Music education, which involves cognitive challenges for students as well as high motivation and incentives, is particularly beneficial. These programs are geared toward facilitating the construction of both systems, one being intellectual and the other motivational, which leads to higher academic and musical results ([Portowitz et al., 2009](#)). Finally, these integrated programs focus not only on the motivation and needs of the child but also encourage and aid in cognitive development.

In addition to cognitive and motivational components, emotions and social dynamics are also profoundly important in influencing the connection between the two. Emotional intelligence, together with social interaction and support from peers and educators, is essential for both cognitive processes and motivation. For example, in a music ensemble context, students' emotional intelligence and self-regulation skills help them work well with others, control emotions, and increase their motivation ([Picado et al., 2023](#)). Intrinsic motivation, according to empathy and prosocial behavior researchers, helps develop social support networks ([Oh and Roh, 2022](#)); this allows for the bidirectionality of spending motivation to engage. In addition, evidence indicates that social support provides the necessary link between motivation and engagement in developmental processes ([Trudeau et al., 2021](#)), indicating its importance in explaining how motivation is achieved. These emotional and social

aspects enhance the quality of interaction, thus positively influencing the cognitive process and increasing the students' willingness and eagerness to realize their goals in music.

This is the case for a broad array of programs aimed at fostering cognitive growth, as the involvement of social factors has been shown to enhance and ease the application of learned skills. On the other hand, [Hallam et al. \(2016\)](#) stressed the significance of these factors by pointing out that emotions and social settings in a learning context are crucial when there are changes in the motivation of a student who is gaining experience.

On the basis of this literature, the following hypothesis is proposed:

H3: There is a positive correlation between cognitive development and intrinsic motivation in classical music education.

H4: Social support mediates the relationship between cognitive development and intrinsic motivation in classical music education.

In addition, [Fig. 1](#) presents the conceptual framework of this study, illustrating the hypothesized relationships among the variables. These findings support both direct effects (H1 and H2), correlations (H3), and the mediating role of social support (H4) in the learning process.

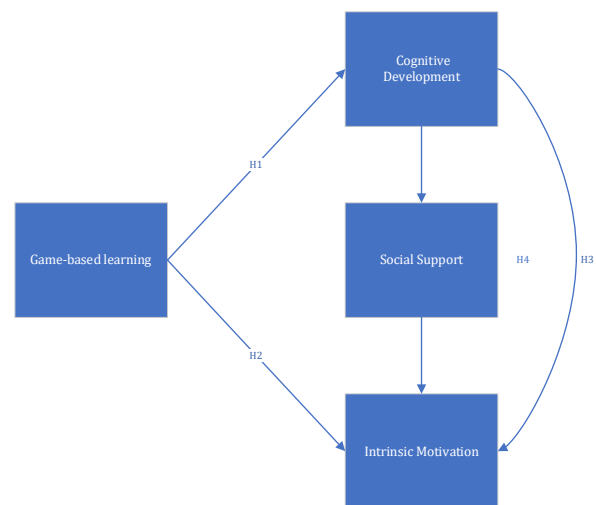


Fig. 1: Conceptual framework

3. Methodology

3.1. Research design

The study followed a quantitative research model utilizing a structured questionnaire survey approach to determine if any relationships exist between game-based learning, cognitive development, intrinsic motivation, and social support in classical music evaluation. This specific research design was selected to ensure that adequate data were collected from a large population sample, and then statistical analyses were used to test the proposed relationships between the variables of the study. To determine the use of game-based learning among

students while studying classical music, a self-administered questionnaire was used that focused on the students' experiences and perceptions. This method is beneficial because it allows the incorporation of several variables at once; in this instance, the different variables are game-based learning as the independent variable, cognitive development and intrinsic motivation as the dependent variables, and social support as the mediating variable. This particular design allows for the testing of both direct relationships (H1, H2, H3) and the mediating effect relationships (H4) described from the theoretical perspective.

3.2. Participants and sampling

A purposive sampling strategy was used rather than a random one for this study; students selected from universities in Hebei Province, China, constituted the target population, and these were undergraduate students enrolled in classical music courses during the academic period of 2023-2024. The rationale for selecting game-based learning participants was the inclusion of individuals who were knowledgeable about the subject matter, which in this case was based on learning experiences within a classical music setting.

The minimum required sample size was determined to be 200, based on statistical requirements and precedent in comparable game-based learning research. In accordance with Kline's (2023) recommendations, 200 respondents are sufficient for structural equation modeling, while Fritz and MacKinnon (2007) suggested at least 50 for mediation analysis. Previous comparable studies in educational technology (Chang et al., 2017; Eltahir et al., 2021) used sample sizes of 100–300 participants. To account for incomplete or invalid responses (typically 10–15% of survey studies), the initial recruitment target was set at 230. Data collection was conducted over four weeks across five universities in Hebei Province, ultimately yielding 368 valid completed responses—substantially exceeding the initial target. This larger-than-anticipated sample resulted from broad instructor participation across multiple departments and reflects strong student interest in the topic. The final sample of 368 far exceeds the recommended minima for both SEM and mediation analysis, thereby strengthening the statistical power and reliability of all findings.

Participants were obtained from the music departments in the institution after seeking relevant formal approvals from heads of departments and course facilitators. The inclusion criteria were as follows: (1) were currently enrolled as full-time undergraduates, (2) were taking or had taken at least one course on classical music appreciation, and (3) had used game-based learning applications in music studies. The students who did not meet the criteria were not allowed to participate in the study.

All participants were adequately briefed about the objectives for which data were being collected,

the fact that their participation was voluntary, and the steps taken to maintain the confidentiality of the information they provided. The students were provided with a written form and signed the form after ensuring that they understood that they may withdraw from the study at any time without any consequences.

3.3. Research instruments

The study utilized a structured questionnaire comprising four main sections to measure the key variables: game-based learning, cognitive development, social support, and intrinsic motivation. All the items were measured via a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

As shown in Table 1, the game-based learning scale was adapted from previous studies (Fredricks et al., 2004) and consists of five items measuring students' engagement, participation, enjoyment, retention, and confidence in game-based learning activities. These items were selected because they capture core engagement and motivational constructs consistently applied in educational technology research (Eltahir et al., 2021), and their suitability for higher education music contexts is supported by prior work (Choosang et al., 2023). The cognitive development scale, adapted from Wouters et al. (2013), includes three items assessing students' problem-solving abilities, task completion, and critical thinking skills. These items have been applied in prior GBL studies in arts and learning contexts (Chang et al., 2017; Dong et al., 2024), supporting their validity in the present setting. To measure social support, three items were adapted from Cohen and Wills (1985) and Lakey and Cohen (2000), focusing on emotional support, practical assistance, and guidance. The intrinsic motivation scale, based on Ryan and Deci's (2000) self-determination theory, comprises three items evaluating students' enjoyment, sense of accomplishment, and interest in learning. All adapted scales were reviewed by two music education experts prior to data collection to verify content validity and contextual relevance for the classical music appreciation setting. Minor linguistic adjustments were made to ensure clarity for the target population.

3.4. Data collection procedures

For the purposes of this research, data were collected via an online platform (wjx.cn), which is widely utilized in academic research throughout China for surveys. This contemporaneous method was preferred to assist with data collection and archiving.

University course instructors from Hebei Province who participated in the study were contacted and informed of the study purpose and procedures. These instructors acted as important links and provided the digital questionnaire link to

the students enrolled in classical music appreciation classes. Each instructor was provided with detailed information about the study and instructions on how to properly provide their students with the questionnaire.

The online questionnaire started with an information sheet explaining the rationale of the study, the voluntary nature of participation, and the considerations of confidentiality. Consent from the participants was obtained electronically prior to the commencement of the survey. To enhance data collection, the platform has built-in features that interlink and ensure that only complete responses are submitted, thereby reducing missing data.

For each returned questionnaire, a unique identifier was assigned by the system. This was done while safeguarding the confidentiality of the respondents. The settings of the platform were configured such that multiple entries from the same participant were discarded. The survey was also designed to include attention check questions that would help screen out invalid responses.

The commencement of data collection coincided with the start of a new term, which enabled a range of diverse class schedules, so the duration covered for data collection was four weeks.

3.5. Data analysis methods

Data analysis was performed via SmartPLS 4.0, following a two-step approach to structural equation modeling. The measurement model evaluation assessed reliability and validity through factor loadings (threshold > 0.7), Cronbach's alpha and composite reliability (CR > 0.7), and average variance extracted (AVE > 0.5). Discriminant validity was confirmed via the Fornell–Larcker criterion and the Heterotrait–Monotrait ratio (HTMT < 0.85).

The structural model was tested by bootstrapping with 5,000 resamples to examine path coefficients and hypothesized relationships. Model quality was evaluated through R^2 values, effect sizes (f^2), and predictive relevance (Q^2). The mediating effect of social support was assessed via specific indirect effects analysis. Model fit was assessed using the SRMR (< 0.08) and NFI (> 0.90) indices. It should be noted that CFI and RMSEA, while conventional in CB-SEM, are not directly applicable to PLS-SEM; the SRMR serves as the recommended equivalent fit criterion for PLS-based models (Hair et al., 2019). Descriptive comparisons were noted between art-related majors and students from other disciplines to explore potential differences in response patterns.

Table 1: Measurement items

Variable	Measurement items	Source
Game-based learning	GBL1: I feel motivated to engage in learning activities in the game.	Fredricks et al. (2004)
	GBL2: I actively participate in the game to understand the content.	
	GBL3: I enjoy the learning experience when playing the game.	
	GBL4: The game helped me remember the concepts I learned.	
Cognitive development	GBL5: I feel confident in my ability to complete tasks in the game.	Wouters et al. (2013)
	CD1: I can apply what I learned from this game to solve problems.	
	CD2: The game helped me improve my ability to solve complex tasks.	
	CD3: I think critically about the concepts I learned while playing.	
Social support	SS1: I feel that I have people I can rely on for emotional support.	Cohen and Wills (1985) and Lakey and Cohen (2000)
	SS2: When I need help with practical tasks, I can rely on others.	
	SS3: I receive helpful advice and guidance from others when needed.	
Intrinsic motivation	IM1: I enjoy engaging in this activity for its own sake.	Ryan and Deci (2000)
	IM2: I feel a sense of accomplishment when I complete this activity.	
	IM3: I am curious and interested in learning more about this activity.	

4. Results

The study collected data from 368 undergraduate students across five universities in Hebei Province. The sample comprised 202 male students (54.9%) and 166 female students (45.1%), representing a relatively balanced gender distribution. Among the participants, 298 students (81.0%) were enrolled in art-related majors, while 70 students (19.0%) were from other academic disciplines and had chosen classical music appreciation as an elective course on the basis of personal interest. This composition of participants ensured a comprehensive representation of both specialized arts students and those pursuing music appreciation from diverse academic backgrounds.

As shown in Table 2, all the constructs showed strong internal consistency reliability, with Cronbach's alpha values ranging from 0.829 to 0.869, comfortably exceeding the 0.70 threshold. Composite reliability measures (both ρ_a and ρ_c) further confirmed the construct reliability, with values ranging from 0.842 to 0.909. Convergent

validity, assessed through average variance extracted (AVE), was satisfactory for all the constructs. The AVE values ranged from 0.579–0.707, surpassing the critical threshold of 0.50. Social support (0.707) and intrinsic motivation (0.704) showed particularly strong convergent validity, whereas game-based learning (0.579) and cognitive development (0.648) maintained acceptable levels. These results indicate a robust measurement model suitable for structural analysis.

As shown in Table 3, the path analysis results reveal significant relationships among the study variables. Game-based learning exhibited a strong direct effect on cognitive development ($\beta = 0.591$), indicating that gamified learning approaches substantially enhance students' cognitive development in classical music appreciation. The relationship between cognitive development and learning outcomes involves two pathways. First, cognitive development had a moderate direct effect on intrinsic motivation ($\beta = 0.374$). Second, cognitive development had a strong influence on social support ($\beta = 0.693$), which in turn had a moderate

effect on intrinsic motivation ($\beta = 0.358$). These findings suggest that social support plays an important mediating role in the relationship between cognitive development and motivation. Game-based learning also had a direct, albeit weaker, effect on intrinsic motivation ($\beta = 0.152$), suggesting that while gamification directly influences student

motivation, its primary impact occurs through enhanced cognitive development and social support mechanisms.

These findings collectively support the theoretical framework suggesting that game-based learning enhances both cognitive development and motivation through direct and mediated pathways.

Table 2: Construct reliability and validity

Variables	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Cognitive development	0.829	0.880	0.842	0.648
Game-based learning	0.863	0.901	0.869	0.579
Intrinsic motivation	0.869	0.897	0.875	0.704
Social support	0.866	0.909	0.876	0.707

As shown in Table 4, the indirect path from game-based learning to intrinsic motivation through both cognitive development and social support was statistically significant ($\beta = 0.146$, $t = 3.470$, $p = 0.001$), indicating a strong mediating effect through this dual pathway. The indirect effect of game-based learning on intrinsic motivation through cognitive development alone was also significant ($\beta = 0.220$, $t = 2.684$, $p = 0.007$), as was its effect on social support through cognitive development ($\beta = 0.408$, $t = 5.440$, $p < 0.001$). Additionally, cognitive development had a significant indirect effect on intrinsic motivation through social support ($\beta = 0.248$, $t = 3.167$, $p = 0.002$).

Table 3: Path coefficients

Path	Path coefficients
Cognitive development -> intrinsic motivation	0.374
Cognitive development -> social support	0.693
Game-based learning -> cognitive development	0.591
Game-based learning -> intrinsic motivation	0.152
Social support -> intrinsic motivation	0.358

These findings provide robust evidence for the mediating roles of both cognitive development and social support in translating the benefits of game-based learning into enhanced intrinsic motivation. The consistently low p-values (all < 0.01) and strong t-statistics underscore the statistical reliability of these mediation pathways.

Table 4: Indirect effects

Path	Standard deviation (STDEV)	T-statistics (O/STDEV)	P-values
Game-based learning -> cognitive development -> social support -> intrinsic motivation	0.042	3.470	0.001
Game-based learning -> cognitive development -> intrinsic motivation	0.082	2.684	0.007
Game-based learning -> cognitive development -> social support	0.075	5.440	0.000
Cognitive development -> social support -> intrinsic motivation	0.078	3.167	0.002

As shown in Table 5, the SRMR values for both the saturated (0.030) and estimated (0.070) models were well below the 0.080 threshold, indicating a strong fit. The NFI values were robust for both the saturated (0.948) and estimated (0.934) models, exceeding the 0.900 benchmark. While the d_ULS, d_G, and chi-square values showed expected increases from the saturated model to the estimated model, they remained within acceptable ranges. These results collectively confirm the model's strong empirical validity and theoretical soundness.

Table 5: Model fit

Fit index	Saturated model	Estimated model
SRMR	0.030	0.070
d_ULS	0.092	0.510
d_G	0.092	0.124
Chi-square	180.478	228.735
NFI	0.948	0.934

Additionally, Fig. 2 presents the structural equation modeling results illustrating the relationships among the variables. The path coefficients and factor loadings demonstrate the strength and significance of these relationships. Game-based learning, measured through five indicators (GL1–GL5), has a strong direct effect on cognitive development ($\beta = 0.591$) and a moderate indirect effect on intrinsic motivation through social support. The model reveals that cognitive

development, assessed by three indicators (CD1–CD3), significantly influences both social support ($\beta = 0.693$) and intrinsic motivation ($\beta = 0.374$). Social support, measured by three indicators (SS1–SS3), serves as a mediating variable, demonstrating a substantial effect on intrinsic motivation ($\beta = 0.358$). The factor loadings for all measurement items exceed the recommended threshold of 0.60, indicating strong construct validity.

5. Discussion

The strong positive effect of game-based learning on cognitive development ($\beta = 0.591$, $p < 0.001$) aligns with Chang et al. (2017), who demonstrated that GBL optimizes cognitive load and improves learning outcomes. In the specific context of classical music appreciation, this finding carries particular significance. Classical music presents inherent cognitive challenges for students lacking prior musical training, including demands of aural discrimination, structural analysis, and historical contextualization. GBL addresses these challenges by scaffolding complex content through interactive mechanics—such as pattern recognition tasks, composer identification games, and listening-based reward systems—which reduce extraneous cognitive load while directing germane load toward

musical schema formation (Chang et al., 2017; Dong et al., 2024). This is in harmony with current theories on the positive influence of interactive teaching techniques on students' cognitive development.

Importantly, social support significantly mediated the relationship between cognitive development and intrinsic motivation (indirect effect = 0.248, $t = 3.167$, $p = 0.002$). This result supports Katual et al.'s (2023) research in the area of

collaborative learning in game-based environments, this time in a reverse way, by suggesting that better cognitive abilities promote better negotiation interactions and social support. The prominent path coefficient describing the relationship from social support to cognitive development ($\beta = 0.693$) also helps confirm the empirical evidence provided by Picado et al. (2023), who developed a theoretical framework linking the progression of cognition to social involvement in music learning contexts.

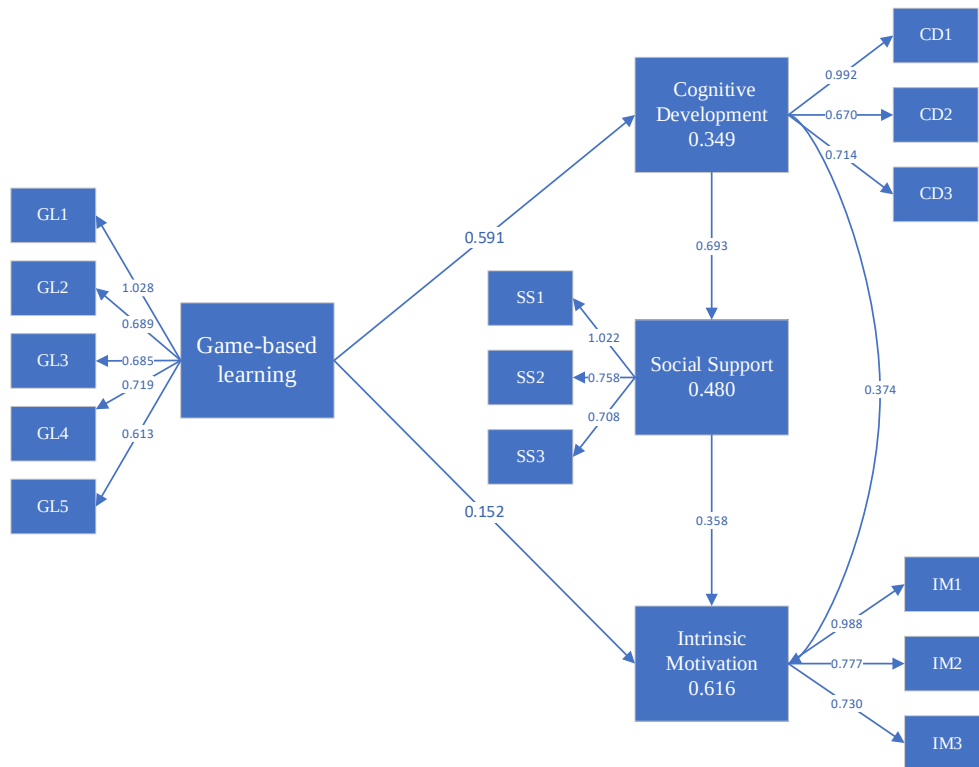


Fig. 2: Path analysis model

The other dimension of the study assesses the effects of game-based learning on learners' intrinsic motivation via different approaches, in this case, direct effects ($\beta = 0.152$) and indirect effects via cognitive development and social support. This multipath influence enhances Sanchez et al.'s (2022) conclusions regarding the motivational effects of gamified training on learners, with a clearer understanding of the role of different strategies in enhancing students' motivation. The high factor loading of measures of intrinsic motivation supports and expands Ting and Lina's (2023) study in showing the link between the strategies used in teaching and the motivation of students in music education.

The impact of the results on educational practice and theory is profound. Educators and institutions benefit from the findings, as the inclusion of gamified learning in a classical music appreciation class can improve the learning experience of students, assuming that teaching uses gamified design principles that promote students' interactions among themselves. The descriptive fit indices of our model (NFI = 0.934, SRMR = 0.070) suggest the correctness of our assumption and complement the

understanding of previous works that analyzed these determinants separately.

An additional observation worth noting concerns the descriptive patterns between art-related majors and students from other disciplines. Based on the sample composition and response tendencies, art-related students appeared to exhibit relatively higher baseline cognitive engagement with classical music content, likely reflecting prior domain exposure and familiarity. In contrast, non-art majors appeared to show greater relative gains in intrinsic motivation following GBL intervention, suggesting that game-based approaches may be particularly effective in cultivating initial interest among students without a musical background. However, these observations are based on descriptive comparisons rather than formal multigroup statistical testing, and should therefore be interpreted with caution. Future research employing PLS-based multigroup analysis is needed to systematically examine whether these differential patterns are statistically significant. Nevertheless, these preliminary patterns highlight the potential need for adaptive GBL design that accounts for students' prior knowledge and disciplinary

orientation, with implications for music curriculum design in Chinese higher education.

Although this study confirms the efficacy of game-based learning for music education, future studies should focus on the retention of learning outcomes over longer periods to incorporate trends in the effectiveness of various types of game-based activities on distinct components of cognition. Hence, a holistic model contributes to the understanding of the interconnectedness of cognitive development, social factors, and motivation in game-based learning systems for advanced music education practice and research.

6. Limitations

Despite the valuable insights offered by this study, several limitations must be acknowledged. First, the use of purposive sampling from five universities in Hebei Province limits the generalizability of the findings to broader Chinese or international contexts. Future research should employ random sampling across a wider range of institutions to enhance external validity. Second, reliance on self-reported questionnaire data introduces the possibility of social desirability bias and common method variance; future studies would benefit from incorporating objective performance measures alongside survey instruments. Third, the cross-sectional design precludes causal inference, and longitudinal studies are needed to determine whether the positive effects of GBL persist over time. Fourth, the measurement scales were not subjected to a formal pilot study in the music education context, and future research should include context-specific validation prior to data collection. Fifth, while descriptive differences between art-related majors and non-art majors were observed, a formal multigroup analysis was not conducted in this study; future research should employ such techniques to rigorously test whether the structural relationships differ significantly across student groups.

7. Conclusion

The findings from this study validate the proposed hypotheses and advance our understanding of game-based learning in classical music education. Hypothesis 1, which proposed that game-based learning positively impacts students' cognitive development in classical music appreciation, was strongly supported. The analysis demonstrated that game-based learning significantly enhances students' ability to understand, analyze, and appreciate classical music concepts.

Hypothesis 2, which suggests that game-based learning enhances students' intrinsic motivation to engage in classical music appreciation, was also confirmed. The results revealed that game-based approaches increase student motivation through both direct effects and indirect pathways, making the learning process more engaging and personally rewarding for students.

The study found strong support for Hypothesis 3, which predicted a positive correlation between cognitive development and intrinsic motivation in classical music education. This relationship proved to be robust, indicating that as students develop stronger cognitive abilities in music appreciation, their intrinsic motivation to engage with the subject matter increases correspondingly.

Hypothesis 4, which proposes that social support mediates the relationship between cognitive development and intrinsic motivation, was conclusively supported. The analysis revealed that social support plays a crucial role in translating enhanced cognitive abilities into increased motivation, highlighting the importance of collaborative learning environments in music education.

These findings collectively demonstrate the effectiveness of game-based learning in classical music appreciation education. This research provides valuable insights for educators and institutions seeking to enhance their music education programs through technological innovation.

List of abbreviations

AVE	Average variance extracted
CB-SEM	Covariance-based structural equation modeling
CBT	Computer-based training
CFI	Comparative fit index
CR	Composite reliability
d _G	Geodesic distance
d _{ULS}	Squared Euclidean distance
DGBL	Digital game-based learning
GBL	Game-based learning
HTMT	Heterotrait–Monotrait ratio
MVP	Motivation, volition, and performance
NFI	Normed fit index
PLS-SEM	Partial least squares structural equation modeling
RMSEA	Root mean square error of approximation
SEM	Structural equation modeling
SPICE	Students' personal intrinsic contentual engagement
SRMR	Standardized root mean square residual
STDEV	Standard deviation
VR	Virtual reality

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Compliance with ethical standards

Ethical considerations

All participants provided written informed consent prior to participation and were advised of their right to withdraw at any time. Data were anonymized and stored securely. No personal

identifying information was collected. The study posed minimal risk to participants, as it involved only a self-administered questionnaire on learning experiences and perceptions.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

- Alotaibi MS (2024). Game-based learning in early childhood education: A systematic review and meta-analysis. *Frontiers in Psychology*, 15: 1307881. <https://doi.org/10.3389/fpsyg.2024.1307881> PMID:38629045 PMCID:PMC11018941
- Barbaroux M, Dittinger E, and Besson M (2019). Music training with Démos program positively influences cognitive functions in children from low socio-economic backgrounds. *PLOS ONE*, 14(5): e0216874. <https://doi.org/10.1371/journal.pone.0216874> PMID:31095606 PMCID:PMC6522123
- Campayo-Muñoz EÁ and Cabedo-Mas A (2017). The role of emotional skills in music education. *British Journal of Music Education*, 34(3): 243-258. <https://doi.org/10.1017/S0265051717000067>
- Chaiakapong N, Pichayakul T, Klangphahol K, and Chinnapong P (2021). Development of musical experiential model to enhance executive functions of early childhood. *Kasetsart Journal of Social Sciences*, 42(3): 564-570. <https://doi.org/10.34044/j.kjss.2021.42.3.17>
- Chang CC, Liang C, Chou PN, and Lin GY (2017). Is game-based learning better in flow experience and various types of cognitive load than non-game-based learning? Perspective from multimedia and media richness. *Computers in Human Behavior*, 71: 218-227. <https://doi.org/10.1016/j.chb.2017.01.031>
- Chawke A (2022). An exploration of the impact of formal and non-formal teaching and learning approaches on piano students' musical knowledge, skills, engagement and motivation: A longitudinal action research study. PhD dissertation, Mary Immaculate College, Limerick, Ireland.
- Chen L (2024). Delving into the role of self-efficacy in predicting motivation and engagement among music learners. *Learning and Motivation*, 86: 101961. <https://doi.org/10.1016/j.lmot.2024.101961>
- Choosang S, Chai-ngam N, and Pongkiatchai R (2023). Instructional design: Under the concept of game based learning for nursing education. *Journal of Food Health and Bioenvironmental Science*, 16(1): 60-70.
- Cohen S and Wills TA (1985). Stress, social support, and the buffering hypothesis. *Psychological Bulletin*, 98(2): 310-357. <https://doi.org/10.1037/0033-2909.98.2.310> PMID:3901065 PMCID:PMC11341294
- Costa M, Cruz I, Martins F, Veríssimo L, and Castro I (2023). Extracurricular music activities in school and school engagement: Students' and teachers' perspectives. *Qualitative Research in Education*, 12(1): 52-80. <https://doi.org/10.17583/qre.11206>
- del Moral Pérez ME, Guzmán Duque AP, and Fernández García LC (2018). Game-based learning: Increasing the logical-mathematical, naturalistic, and linguistic learning levels of primary school students. *Journal of New Approaches in Educational Research*, 7: 31-39. <https://doi.org/10.7821/naer.2018.1.248>
- Dong X, Liang H, Ding X, and Zhang Y (2024). Enhancing children's cognitive skills: An experimental study on virtual reality-based gamified educational practices. *Education and Information Technologies*, 29: 7569-7594. <https://doi.org/10.1007/s10639-023-12075-y>
- Eltahir ME, Alsalihi NR, Al-Qatawneh S, AlQudah HA, and Jaradat M (2021). The impact of game-based learning (GBL) on students' motivation, engagement and academic performance on an Arabic language grammar course in higher education. *Education and Information Technologies*, 26: 3251-3278. <https://doi.org/10.1007/s10639-020-10396-w>
- Evans P and Liu MY (2019). Psychological needs and motivational outcomes in a high school orchestra program. *Journal of Research in Music Education*, 67(1): 83-105. <https://doi.org/10.1177/0022429418812769>
- Fredricks JA, Blumenfeld PC, and Paris AH (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, 74(1): 59-109. <https://doi.org/10.3102/00346543074001059> PMCID:PMC9053798
- Fritz MS and MacKinnon DP (2007). Required sample size to detect the mediated effect. *Psychological Science*, 18(3): 233-239. <https://doi.org/10.1111/j.1467-9280.2007.01882.x> PMID:17444920
- Hair JF, Risher JJ, Sarstedt M, and Ringle CM (2019). When to use and how to report the results of PLS-SEM. *European Business Review*, 31(1): 2-24. <https://doi.org/10.1108/EBR-11-2018-0203>
- Hallam S, Creech A, Papageorgi I, Gomes T, Rinta T, Varvarigou M, and Lanipekun J (2016). Changes in motivation as expertise develops: Relationships with musical aspirations. *Musicae Scientiae*, 20(4): 528-550. <https://doi.org/10.1177/1029864916634420>
- Huang WH, Huang WY, and Tschopp J (2010). Sustaining iterative game playing processes in DGBL: The relationship between motivational processing and outcome processing. *Computers & Education*, 55(2): 789-797. <https://doi.org/10.1016/j.compedu.2010.03.011>
- Katual D, Drevin L, and Goede R (2023). Game-based learning to improve critical thinking and knowledge sharing: Literature review. *Journal of the International Society for the Systems Sciences*, 67: 1-28.
- Kline RB (2023). Principles and practice of structural equation modeling. 5th Edition, Guilford Publications, New York, USA.
- Kraus N, Slater J, Thompson EC, Hornickel J, Strait DL, Nicol T, and White-Schwoch T (2014). Music enrichment programs improve the neural encoding of speech in at-risk children. *The Journal of Neuroscience*, 34(36): 11913-11918. <https://doi.org/10.1523/JNEUROSCI.1881-14.2014> PMID:25186739
- Kusurkar RA, Croiset G, and Ten Cate OTJ (2011). Twelve tips to stimulate intrinsic motivation in students through autonomy-supportive classroom teaching derived from self-determination theory. *Medical Teacher*, 33(12): 978-982. <https://doi.org/10.3109/0142159X.2011.599896> PMID:22225435
- Lai CH, Chu CM, Liu HH, Yang SB, and Chen WH (2013). An examination of game-based learning from theories of flow experience and cognitive load. *International Journal of Distance Education Technologies*, 11(4): 17-29. <https://doi.org/10.4018/ijdet.2013100102>
- Lakey B and Cohen S (2000). Social support theory and measurement. In: Cohen S, Underwood LG, and Gottlieb BH (Eds.), *Social support measurement and intervention: A guide for health and social scientists*: 29-52. Oxford University Press, New York, USA. <https://doi.org/10.1093/med:psych/9780195126709.003.0002>

- Nadeem M, Oroszlanyova M, and Farag W (2023). Effect of digital game-based learning on student engagement and motivation. *Computers*, 12(9): 177.
<https://doi.org/10.3390/computers12090177>
- Oh S and Roh SC (2022). Intrinsic motivation for work activities is associated with empathy: Investigating the indirect relationship between intrinsic motivation for work activities and social support through empathy and prosocial behavior. *Personality and Individual Differences*, 189: 111487.
<https://doi.org/10.1016/j.paid.2021.111487>
- Oskar YM, Willson LIN, and Tak-Wai CHAN (2010). Designing a negotiation mechanism to engage students in learning mathematics. In the Proceedings of the 18th International Conference on Computers in Education, Asia-Pacific Society for Computers in Education, Putrajaya, Malaysia: 563-567.
- Picado M, Pereira C, and Castilho LC (2023). Emotional intelligence and self-regulation in the teaching and learning process of music ensemble with singing. In: Raposo D, Neves J, Silva R, Correia Castilho L, and Dias R (Eds.), *Advances in design, music and arts II*: 712–732. Springer, Cham, Switzerland. https://doi.org/10.1007/978-3-031-09659-4_50
- Portowitz A, Lichtenstein O, Egorova L, and Brand E (2009). Underlying mechanisms linking music education and cognitive modifiability. *Research Studies in Music Education*, 31(2): 107-128.
<https://doi.org/10.1177/1321103X09344378>
- Ryan RM and Deci EL (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, 55(1): 68–78.
<https://doi.org/10.1037/0003-066X.55.1.68>
PMid:11392867
- Sachs M, Kaplan J, Der Sarkissian A, and Habibi A (2017). Increased engagement of the cognitive control network associated with music training in children during an fMRI Stroop task. *PLOS ONE*, 12(10): e0187254.
<https://doi.org/10.1371/journal.pone.0187254>
PMid:29084283 PMcid:PMC5662181
- Sanchez DR, Nelson T, Kraiger K, Weiner E, Lu Y, and Schnall J (2022). Defining motivation in video game-based training: Exploring the differences between measures of motivation. *International Journal of Training and Development*, 26(1): 1-28. <https://doi.org/10.1111/ijtd.12233>
- Shen CY, Chen MP, Chen NS, Chuang TY, and Huang YC (2011). The effectiveness of game-based learning on students' mnemonic techniques and perceptions. In the Proceedings of the 5th European Conference on Games Based Learning, Athens, Greece: 553-561.
- Shen Y, Lin Y, Liu S, Fang L, and Liu G (2019). Sustained effect of music training on the enhancement of executive function in preschool children. *Frontiers in Psychology*, 10: 1910.
<https://doi.org/10.3389/fpsyg.2019.01910>
PMid:31507486 PMcid:PMC6714059
- Tanja L, Adriana SG, and Mari T (2021). Perspectives on the potential benefits of children's group-based music education. *Music & Science*, 4: 20592043211033578.
<https://doi.org/10.1177/20592043211033578>
- Ting Z and Lina J (2023). Motivation and guidance of teaching strategies on folk music education of music majors in colleges and universities. *Educational Administration: Theory and Practice*, 29(2): 185-202.
- Trudeau S, Boudrias JS, and Cournoyer A (2021). Behavioral integration of individual psychological assessment feedback: Assessor and social support. *The Spanish Journal of Psychology*, 24: e37.
<https://doi.org/10.1017/SJP.2021.34> **PMid:34120671**
- Tu CH, Sujo-Montes LE, and Yen CJ (2015). Gamification for learning. In: Papa R (Ed.), *Media rich instruction: Connecting curriculum to all learners*: 203–217. Springer, Cham, Switzerland.
https://doi.org/10.1007/978-3-319-00152-4_13
PMid:26368913
- Wouters P, van Nimwegen C, van Oostendorp H, and van der Spek ED (2013). A meta-analysis of the cognitive and motivational effects of serious games. *Journal of Educational Psychology*, 105(2): 249–265. <https://doi.org/10.1037/a0031311>
- Xie Y, Wang J, and Zheng Y (2021). Research context and trends of educational games: A systematic review of CSSCI articles. In the Proceedings of the 13th International Conference on Education Technology and Computers, ACM, Wuhan, China: 69-76. <https://doi.org/10.1145/3498765.3498776>
- Zhang Q and Yu Z (2022). Investigating and comparing the effects on learning achievement and motivation for gamification and game-based learning: A quantitative study employing Kahoot. *Education Research International*, 2022: 9855328.
<https://doi.org/10.1155/2022/9855328>