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Research on the construction of intelligent teaching system for music education in the context of digitalization

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SUMMARY: *Digital development is changing the organization of music education, but there are still widespread problems in existing teaching such as resource dispersion, feedback lag and insufficient process support. Around this practical demand, this paper, supported by computer technology, studies the construction path of music education intelligent teaching system under the background of digital, and designs the system from two aspects of music education network course design and teaching resources comprehensive management. On the course side, an intelligent teaching process covering goal decomposition, task arrangement, audio collection, process evaluation and feedback correction was constructed. At the management end, an integrated management system is designed, which integrates resource storage, label modeling, authority control and intelligent matching. The experimental results show that the average evaluation of network course design experts reaches 4.71, the accuracy of resource recognition is 95.4%, and the average response time of the system is 8.7 s under the scale of 5000 resources. Research shows that the system can improve the organizational efficiency, resource invocation ability and personalized support level of music teaching, and provide technical reference for the continuous optimization of digital music education.*

KEYWORDS: *Digital music education; Intelligent tutoring system; Web-based course design; Teaching Resources Management*

1 Introduction

For a long time, although music education continues to absorb the technical achievements of multimedia and network platforms, the classroom operation mode still relies more on the traditional chain of teachers 'on-site demonstration, students 'imitation practice and dispersed review after class. In terms of core teaching links such as vocal music, instrumental music, solfegchoric training and music theory, teaching effects are often limited by time, venue, equipment conditions and teachers 'individual experience. Students 'learning differences in rhythm grasp, pitch identification, timbre control and work understanding are also difficult to continuously record and accurately identify in time. After entering the stage of digital development, music education is not only faced with the problem of "moving courses online", but also how to reconstruct the teaching organization, resource circulation, learning feedback and evaluation mechanism with the help of computer technology, so that the teaching system can shift from single-point tool use to data-driven overall collaboration [1, 2].

Compared with general subjects, the object of music teaching has stronger timing, perception and expression. A student's singing, keyboard playing or improvisation task

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contains not only the beat, speed, strength and frequency spectrum characteristics at the audio signal level, but also the practice frequency, error type, pause position and correction path at the behavior level. It is difficult to stably extract such fine-grained information only by teacher observation in class. With the development of speech recognition, audio signal processing, pattern recognition, deep learning and learning analysis technology, computers have been able to complete tasks such as melody contour capture, rhythm deviation detection, performance similarity comparison, exercise behavior modeling and personalized content recommendation within a certain range. This makes the music teaching system have a realistic foundation from "displaying resources" to "understanding learning process" [3, 4]. Especially in the context of digital audio acquisition, MIDI data analysis and cloud course platform continues to mature, students 'learning trajectories can be continuously stored, dynamically analyzed and fed back into subsequent teaching decisions.

Previous studies have shown that after digital technology is involved in music education, it not only changes the way of resource presentation, but also has a significant impact on teachers' decision-making, curriculum implementation and students' creative learning [5, 6]. Mobile learning, blended teaching, virtual reality practice environment, intelligent interactive piano, flipped classroom and other forms have proved that technology is not an accessory device of music teaching, but to some extent reshapes the teaching relationship and learning scene [7, 8]. However, many practices at this stage still stay at the tool overlay level. One kind of platform focuses on video playing and assignment uploading, and lacks the structured processing of music learning process data. Another kind of system emphasizes technical novelty, but ignores curriculum logic, resource organization and evaluation closed loop, resulting in the common phenomenon of "having a platform but not intelligent" and "having data but difficult to use" [9, 10]. Especially in music education in colleges and universities, curriculum resources are often scattered in different terminals and platforms, and there is a lack of unified metadata description and calling rules between music examples, audio, video, case explanations and students 'exercise records. It is difficult for teachers to form continuous teaching portraits, and it is difficult for students to obtain learning support matching their personal abilities.

Based on this, the construction of intelligent teaching system for music education under the background of digital should not be understood as the introduction of a number of software tools, but should be regarded as a system engineering covering curriculum design, resource management, process collection, intelligent analysis and result feedback. Its core is not to replace teachers, but to integrate and calculate multi-source data in the teaching process with the help of computers, so as to transform the original implicit learning state into identifiable, traceable, and intervenable information objects, so as to improve the fineness of teaching organization and the timeliness of feedback. Because of this, the music education intelligent teaching system should not only consider the structure arrangement of network courses, learning task release and interaction mechanism, but also consider the tag management, recommendation strategy, authority control and operation evaluation of the resource library, so as to form a closed-loop system involving the teaching end, learning end and management end.

This paper focuses on this problem, based on the actual needs of digital music education, discusses the construction ideas and implementation paths of intelligent tutoring system. Starting from the practical significance of the construction of music education intelligent teaching system, this paper further designs the music education network course and intelligent teaching process, and on this basis, puts forward the integrated management system scheme of teaching resources, and then analyzes its application performance in the course implementation effect and resource management efficiency combined with the experimental results. It is hoped that this research can provide an operational technical framework for the optimization of music education teaching mode under digital conditions, and also provide new ideas for music curriculum to move from experience-driven to data-aided decision-making.

2 Related Research

In recent years, the research of digital music education has changed from "tool access" to "system construction". On the one hand, the existing literature focuses on how digital technologies enter the classroom, and on the other hand, it has begun to discuss the synergistic relationship between teaching platforms, resource organization, and intelligent analytics. Merchan Sanchz-Jara et al. [11] made a comprehensive review of AI-assisted music education, pointing out that intelligent recognition, automatic feedback and learning support have become important development directions in this field, but the application of technology still faces problems such as insufficient teaching adaptability and inconsistent evaluation standards. Lam[12] and Zhang et al. [13] respectively, from the perspective of creativity cultivation and blended teaching effect, believe that digital platform can expand the time and space boundary of music learning, but without task stratification and data recording mechanism in curriculum process, platform advantages are difficult to stably translate into learning results.

Focusing on the research of classroom implementation level, most of the results emphasize the role of technology in the reorganization of teaching activities. Shin and Jung[14] and Cheng et al. [15] analyzed the issues of technology acceptance and digital competence in music classroom from the perspective of teachers, and found that teachers generally held a positive attitude toward digital resources and online tools, but there were still obvious shortcomings in platform scheduling, data interpretation and teaching decision support. Chen[16], Liu and Shao[17] introduced mobile learning into music course design, and pointed out that mobile terminals, online homework and exercise records could enhance students' continuous learning ability. However, such studies focused more on the course activities themselves, and the in-depth analysis of learning trajectories was still limited. Lv[18] 's research on AI flipped classroom shows that the task push and feedback mechanism supported by the algorithm can improve student engagement, but the system-level resource linkage and management strategy has not yet been carried out.

From the perspective of computer implementation, some researches have begun to touch the core technology of music education intelligent system. Chen[19] developed music teaching software based on neural network algorithm and user analysis, and explained that audio feature extraction, behavior data modeling and personalized recommendation can enter the teaching system design process. Lu[20] proposed the idea of intelligent interactive piano teaching, indicating that sensor acquisition, signal recognition and real-time feedback can improve the pertinence of skill training. Sai[21] and Yang[22] respectively introduced digital multimedia and virtual reality tools into online music learning and psychological support scenarios, expanding the interaction boundaries of intelligent systems for music education. However, on the whole, the existing research is still mostly around a single course, a single tool or a local function, and the overall research on the design of online courses, teaching resources governance, learning process mining and management platform linkage is still insufficient.

Table 1 summarizes the representative content of the existing studies. It can be seen that the current achievements have provided an important basis for the digital transformation of music education, but there are still two prominent shortcomings. First, most of the research focuses on application display and ignores the system architecture, lacking a complete closed loop from data collection, resource organization to feedback decision-making. Second, the attention to the integrated management of teaching resources is significantly weaker than the classroom application research, and the intelligent resource management mechanism adapted to the music education scene has not yet been formed. Based on this, this paper intends to further build an intelligent teaching system for music education from two levels of network course design and integrated management of teaching resources, so as to enhance the implementability and continuous operation ability of the system.In addition, the current literature still lacks sufficient discussion on the scalability and interoperability of music education systems. Many existing studies verify the usefulness of a certain digital tool in a specific teaching activity, but relatively few explain how different functional modules can be connected into a unified platform architecture under real teaching conditions. In practical music education, course planning, assignment release, performance submission, resource retrieval, evaluation generation, and teaching management are not isolated tasks. They rely on continuous data circulation among multiple modules. If the system lacks interface coordination and common data standards, the information generated in one teaching link cannot effectively support the next link, and the platform will easily fall into fragmented operation. Therefore, beyond the discussion of teaching effect itself, it is also necessary to examine whether the music education intelligent teaching system has stable data structure, process continuity, and adaptive expansion ability. This issue is precisely the aspect that needs to be further strengthened in existing research and also constitutes an important entry point of this paper.

Table 1: Summary of existing related studies

Reference No.	Research Focus	Main Technologies or Methods	Main Conclusions	Limitations
[1]	Review of artificial intelligence-assisted music education	Literature review, review of AI applications in education	Clarified the application prospects of intelligent feedback and learning support	Focuses mainly on review studies and lacks a systematic implementation path
[5]	Study on music teachers' digital competence	Questionnaire survey, competence analysis	Teachers' digital literacy has become an important prerequisite for system implementation	Insufficient discussion of teaching platform architecture
[11]	Design and effectiveness of online piano courses	Mobile learning, online course design	Digital courses can improve learning convenience and continuity	Lacks resource management and intelligent diagnosis mechanisms
[10]	Development of music teaching software	Neural networks, user analysis	Can provide personalized teaching support and functional expansion	Places more emphasis on software functions, with insufficient system coordination
[19]	Intelligent interactive piano teaching	Sensor recognition, real-time feedback	Real-time feedback helps improve the efficiency of performance training	Application scenarios are relatively narrow and difficult to extend to comprehensive teaching needs
[12]	Virtualized online music learning	Digital multimedia, virtual reality	Improved immersion and interactivity	Insufficient research on long-term teaching effectiveness and platform governance

3 Construction scheme of music education intelligent teaching system under the background of digital

3.1 The significance of constructing intelligent tutoring system for music education

Music education is different from general knowledge-based courses, and its teaching effectiveness is often based on continuous demonstration, immediate correction, repeated training and individual differences recognition. Traditional classroom can complete face-to-face instruction, but it is difficult to continuously record students' subtle changes in pitch, rhythm, strength, coherence and practice behavior. After entering the digital stage, the computer is no longer just an auxiliary terminal for playing audio or displaying courseware, but begins to undertake more core tasks such as data acquisition, feature extraction, learning diagnosis and resource scheduling. With the help of audio signal processing, speech recognition, MIDI event analysis, learning behavior log analysis and cloud database management, the "audible and visible" process information in music teaching is gradually transformed into "quantifiable, comparable and feedback" process information, which makes the construction of intelligent teaching system a practical necessity.

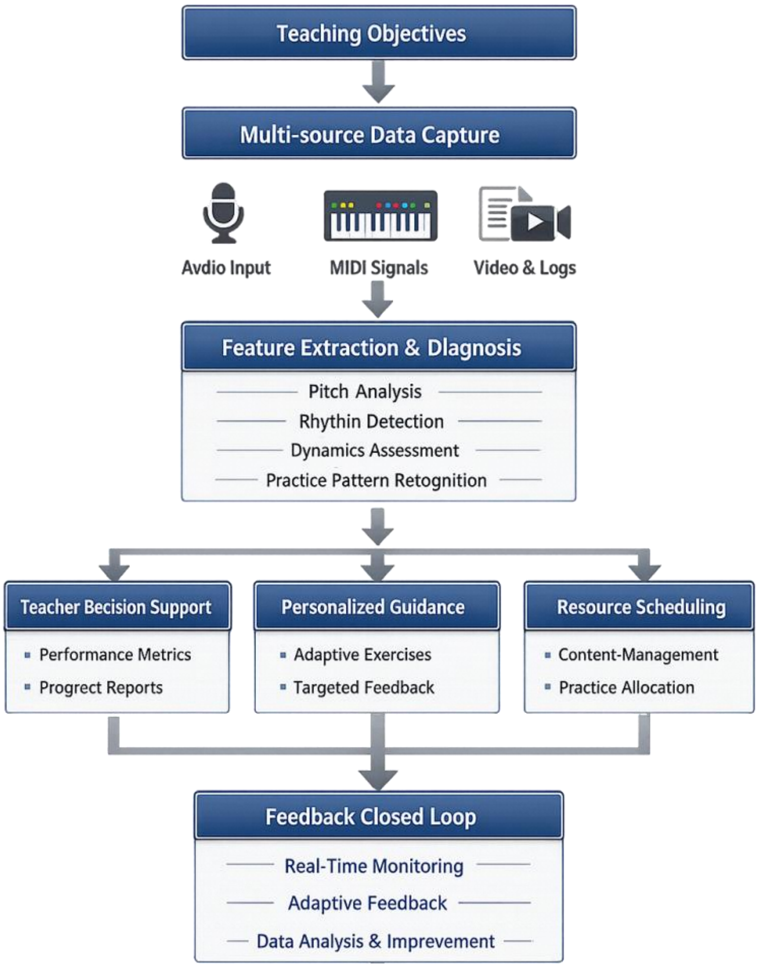

Figure 1: Action path diagram of intelligent teaching system for music education

As shown in Figure 1, the significance of intelligent teaching system for music education is not limited to improving classroom efficiency, but more importantly, reconstructing the teaching operation mode. The teacher can obtain the beat offset, pitch error, repeated error point and practice time distribution of students in the process of singing or playing through the system, so as to reduce the subjective fluctuations caused by only empirical judgment. On the student side, targeted feedback could be obtained in the continuous link of pre-class preview, in-class interaction and after-class training, avoiding the problem of "repetition but inefficiency" in the practice process. The management end can uniformly archive curriculum resources, learning records and evaluation results, providing data basis for subsequent curriculum optimization and teaching evaluation. In other words, the value of system construction is not only reflected in the "digital presentation", but in the use of computational models to organize teaching activities into a closed-loop structure that can be cyclically optimized. In order to measure the support degree of intelligent tutoring system for music teaching, this paper constructs a comprehensive support efficiency index

$$E = \alpha D + \beta P + \gamma R + \delta F \tag{1}$$

Among them, D represents the accuracy of teaching diagnosis, P represents the level of personalized resource matching, R represents the efficiency of resource calling, F represents the timeliness of feedback, $\alpha,\beta,\gamma,\delta$ are weight coefficients, and meet $\alpha+\beta+\gamma+\delta=1$. The index is not simply to evaluate the performance of software, but to describe the comprehensive role of the system in teaching decision support. When the value of E increases, it means that the system is better able to play a role in identifying learning states, allocating resources, and shortening feedback links.

From the perspective of teaching reform, the significance of intelligent tutoring system is to promote music education from "unified teaching" to "hierarchical support". Different students have great differences in the basic aspects of solfegchorge training, piano accompaniment, harmony analysis and work performance. If the same rhythm and same task intensity are still used in teaching, there will often be a situation that students with strong ability lack challenges and those with weak foundation are difficult to follow up. The computer system can group the students according to their historical performance and the current task results, and automatically match the music examples, demonstration audio, error correction video and extension training content in the resource library, so as to make the teaching arrangement more targeted. Table 2 summarizes the main meanings.

Table 2: The main significance of the construction of intelligent teaching system for music education

Dimension	Specific Manifestation	Corresponding Computer Support
Teaching diagnosis	Identification of pitch accuracy, rhythm, dynamics, and concentrated error-prone areas	Audio analysis, pattern recognition, error detection
Personalized teaching	Pushing hierarchical tasks and practice resources according to students’ ability levels	Learner profiling, recommendation algorithms, rule matching
Resource governance	Unified management of scores, audio/video materials, cases, and training records	Database management, tag indexing, cloud storage
Teaching evaluation	Incorporating process performance into evaluation rather than focusing only on results	Log mining, process modeling, visual analytics
Teaching management	Providing support for course optimization and teacher decision-making	Data statistics, report generation, access control

Therefore, the construction of music education intelligent teaching system under the background of digital is essentially to establish a new organizational relationship between teaching, resources and data. It not only responds to the long-term needs of music courses for immediate feedback and individual guidance, but also lays the technical foundation for subsequent network course design and resource integrated management system construction. If this system can operate stably, music education will no longer be just an experience-driven classroom activity, but will gradually form a new form of teaching characterized by data perception, intelligent analysis and continuous improvement.

3.2 Music Education Network Course and intelligent teaching process design

The key to the design of music education network course is not to upload the original classroom materials to the platform, but to organize the "teaching content-learning behavior-intelligent feedback-resource reconfiguration" into a circular digital link. Music courses are characterized by strong timing and expressiveness, and it is often not possible to judge whether a student has truly mastered rhythm, pitch, syntactic breathing, harmony hearing or performance control based on a single assignment submission. Based on this characteristic, the web-based course is designed as a closed-loop process consisting of learning environment recognition, course goal generation, task arrangement, intelligent training, process evaluation and feedback correction. The computer not only participates in resource presentation, but also participates in state recognition and teaching scheduling.

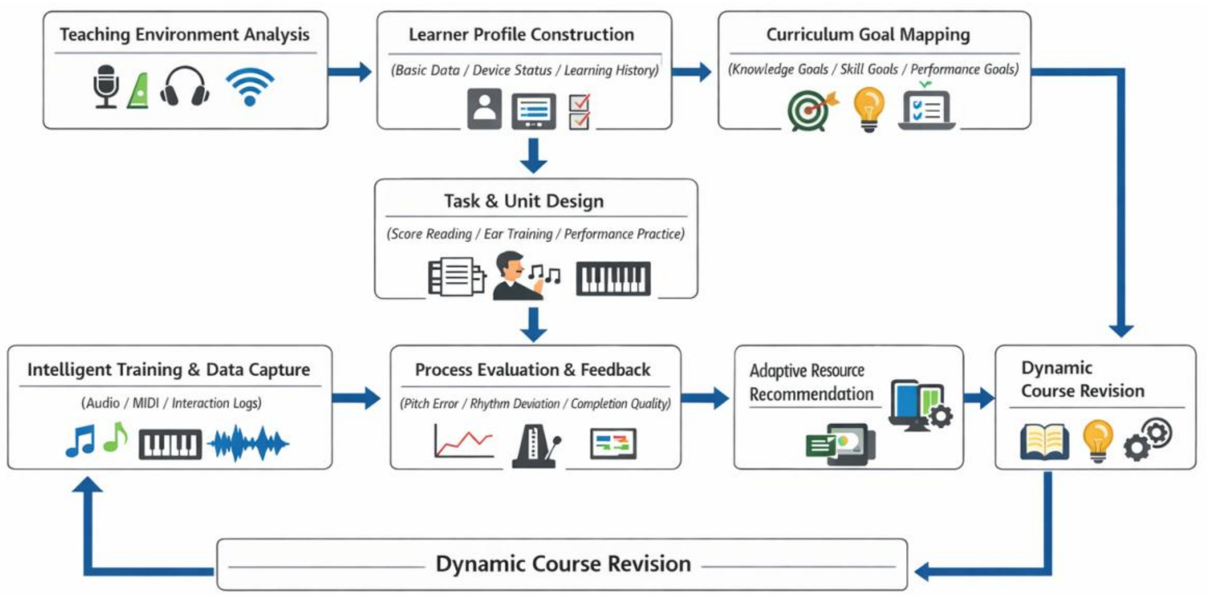

Figure 2: Music education network course and intelligent teaching process model

As shown in Figure 2, the starting point of the system operation is the digital identification of the teaching environment and the learning basis. The platform collects students' basic files, past course scores, practice habits, equipment access capabilities and audio sampling quality before the course begins, and establishes a teaching constraint set combined with the course outline. For music courses, this step is especially important, because the effect of network teaching is not only affected by the ability of students, but also by the terminal equipment, headphone delay, microphone quality and network stability constraints. If the front-end environment recognition is not sufficient, subsequent audio analysis and intelligent evaluation may be distorted. Based on this, the system represents the learning states as vectors

$$x_i = [p_i, r_i, e_i, l_i, m_i] \tag{2}$$

Here, p_i represents pitch performance features, r_i represents rhythm stability features, e_i represents music expression related features, l_i represents learning log intensity, and m_i represents medium access conditions. This vector not only describes the current ability of students, but also provides input for subsequent course push.

After learning environment identification, the system enters the stage of mapping course objectives and content. The goal of online course is no longer only written as "mastering the work" or "improving ability", but broken down into calculable and monitorable task units, such as interval identification accuracy, rhythm imitation deviation, solfegsong completion, passage proficiency of the work and continuity of practice after class. Let the set of course units be $C = \{c_1, c_2, \dots, c_n\}$, the student state is x_i, then the course matching value can be expressed as

$$M_{ij} = \alpha\,\text{sim}(x_i, r_j) + \beta q_j + \gamma h_i \tag{3}$$

Here, r_j is the ability demand vector of course unit c_j, q_j is the content difficulty coefficient, h_i is the quality of student history completion, $\alpha+\beta+\gamma=1$. When M_{ij} is higher, it means that the unit is more matching with the current learning state of students, and the system completes the hierarchical push and path sorting.

In terms of the specific teaching process design, this paper divides the network course into three continuous scenes of "introduction before class - training in class - consolidation after class". In the pre-class stage, the platform pushed music examples, demonstration audio, rhythm breakdown video and guidance tips to help students form preparatory auditory representations. In the middle stage, the system completed automatic analysis according to the real-time uploaded singing, playing or listening results, and gave the rhythm error position, pitch offset interval and repeated error segments. In the AFTER-class stage, the homework content was reconstructed according to the training performance of the session, so as to avoid all students facing the same set of mechanical exercises. This design uses computers to transform the details that are difficult to retain in the traditional classroom into traceable data, so that the network course has the ability of continuous feedback, rather than one-time task distribution mechanism.

Considering that the core problems in music learning often focus on the two basic dimensions of pitch and rhythm, the system performs feature decomposition on the audio signals submitted by students. Let the standard melody sequence be $Y = \{y_1, y_2, \dots, y_T\}$, the student actually sings or plays the sequence $\hat{Y} = \{\hat{y}_1, \hat{y}_2, \dots, \hat{y}_T\}$, then the pitch error can be defined as

$$E_p = \frac{1}{T}\sum_{t=1}^{T} |\, y_t - \hat{y}_t| \tag{4}$$

The rhythm deviation can be expressed as

$$E_r = \frac{1}{T}\sum_{t=1}^{T} |\, d_t - \hat{d}_t| \tag{5}$$

Here, d_t and $\hat{d}_t$ are the standard time value and the actual time value of students, respectively. In order to comprehensively reflect students' online course completion quality, this paper further constructs learning performance scores:

$$S = \lambda_1(1 - E_p) + \lambda_2(1 - E_r) + \lambda_3 I + \lambda_4 U \quad (6)$$

Here, I represents the interaction engagement, U represents the unit completion rate, and $\lambda_1 + \lambda_2 + \lambda_3 + \lambda_4 = 1$. This score can be used both for formative evaluation and as an important basis for the next round of resource recommendation.

In addition to the learning task arrangement, the platform design also places special emphasis on the interaction structure. If there is no interaction in music teaching, students are easy to gradually lose their judgment standards in isolated practice. To this end, in addition to teacher-student interaction, the system adds three kinds of interaction channels: student-student, student-resource and student-system. The teacher end can view the common problems and individual abnormal points of the class, the student end can carry out peer evaluation, segment training and online collaboration, and the system end provides continuous tips through the recommendation model and error pattern library. The joint participation of different interactive channels can make up for the lack of on-site companionship in online music teaching to a certain extent.

After the course runs, the system will also summarize and analyze the process data, and write the results back to the course design module. If a unit generally has a concentration of rhythm errors, an abnormal increase in the number of repeated submissions, or a high dropout rate, the platform determines that there is room for optimization in the content difficulty, explanation method, or training form of the unit. Thus, the music education online course is no longer a static course package, but a dynamic system that can continuously iterate according to the performance of the student population. Such intelligent teaching process makes the digital music education from the simple online transmission to the fine organization of the learning process, and also provides a clear data entry and logical foundation for the subsequent construction of the comprehensive resource management system.

3.3 Music education teaching resources integrated management System design

Whether the intelligent tutoring system for music education can be really implemented depends to a large extent on whether the resource management is stable, clear and computable. Compared with general courses, music teaching resources are more heterogeneous: the same knowledge point often corresponds to music score images, audio samples, demonstration videos, MIDI event streams, classroom explanation texts, homework records and students' singing and performance clips. If these contents are still scattered in different terminals according to teachers' personal habits, the platform can upload and play, but it is difficult to support subsequent intelligent retrieval, personality recommendation and process analysis. Based on this, this paper designs the integrated management system of music education teaching resources as an integrated structure of "unified storage, label modeling, permission verification, intelligent call, feedback and writeback", so that the resources are no longer a static collection of materials, but a teaching object that can be identified, calculated and reorganized.

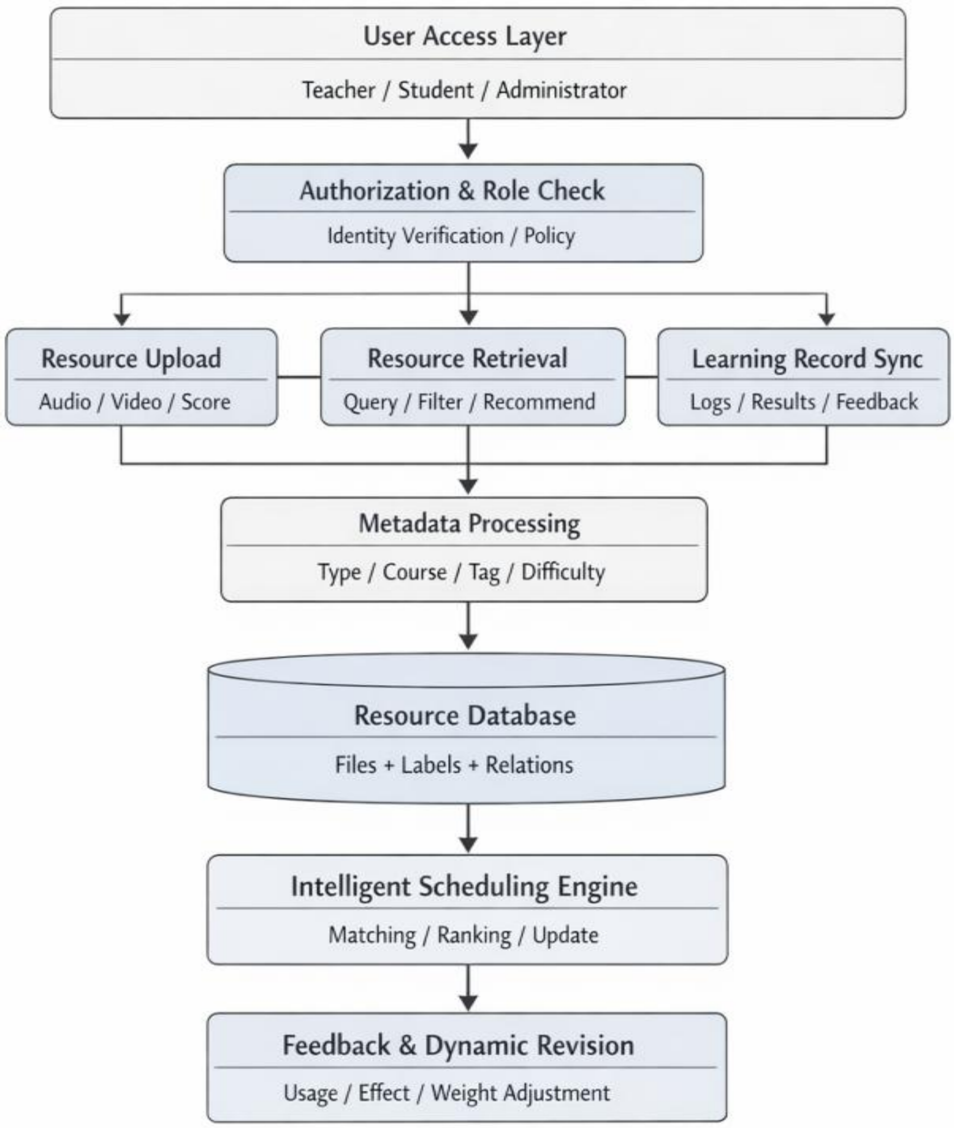

Figure 3: Music education teaching resources integrated management system structure

As shown in Figure 3, the system adopts a hierarchical resource storage mechanism at the bottom. The original resource layer is responsible for receiving spectral files, demonstration audio, teaching video, accompaniment track, exercise library and student works. The metadata layer structured the description of resource type, course attribution, difficulty level, applicable object, knowledge point association, upload time and use frequency. The service layer provides query, download, recommendation, review and statistics functions for teachers, students and management ends. This design avoids the common problem of "file, no structure" with music assets. Taking the basic piano course as an example, the same etude can be labeled as "scale training", "two-handed coordination" and "intermediate difficulty", and can be further associated with the demonstration speed, common error points and the corresponding error correction video. This results in a traceable network of connections between resources, rather than just isolated attachments.

To improve the accuracy of resource calling, a single teaching resource is represented as a feature vector in this paper

$$R_i = (t_i, c_i, d_i, k_i, f_i, u_i) \tag{7}$$

Here, t_i represents the resource type, c_i represents the course category, d_i represents the difficulty level, k_i represents the knowledge point label, f_i represents the resource format characteristics, and u_i represents the historical usage intensity. The current learning status of the student is denoted as

$$S_j = (a_j, b_j, e_j, h_j) \tag{8}$$

where a_j is the ability level, b_j is the current task type, e_j is the error feature, and h_j is the historical learning trajectory. Then the resource matching score can be defined as

$$P_{ij} = \alpha \cdot \mathrm{sim}(R_i, S_j) + \beta d_i + \gamma u_i - \lambda \Delta_{ij} \tag{9}$$

where, $\mathrm{sim}(R_i, S_j)$ represents the similarity between resource features and learning status, Δ_{ij} represents the offset between resource difficulty and student's current ability, $\alpha+\beta+\gamma+\lambda=1$. When Pij is high, the system preferentially pushes this resource to the corresponding student. In this way, the resource call no longer depends on the teacher's manual rumination, but is dynamically scheduled by the platform according to the learning portrait.

In addition to resource organization, access control is also a key link in system design. There are not only public course materials, but also teachers' self-built cases, class internal practice records and students' personal audio and video works in music education resources. If there is no clear authority mechanism, it will not only affect the safety of resources, but also go against the management of teaching order. Therefore, the system performs identity verification after the user logs in, and then judges the access range according to the role table and the permission table. Let the user identity be U, the resource security level be L, and the role permission matrix be A, then the access decision function can be written as

$$Q(U, R) = \begin{cases} 1, & A(U) \geq L(R) \\ 0, & A(U) < L(R) \end{cases} \tag{10}$$

When Q(U,R)=1, the user can perform view, edit or download operations. When Q(U,R)=0, the system only returns restricted information or denies access directly. In this way, the independence of teacher resource construction is guaranteed, and the privacy boundary of student training data is also protected.

In the database logic, the system sets users, courses, resources, labels, learning records and evaluation results as core entities, and establishes mappings through foreign key relationships. The resource entity and the course entity are one-to-many relationship, the label entity and the resource entity are many-to-many relationship, the learning record is connected with the student entity and the course entity, and the evaluation result acts on the resource calling module in reverse. The database not only assumes the storage function, but also constitutes the logical basis of front-end call and back-end analysis. If a certain type of resource has a high long-term click rate and completion rate, and the error correction effect is obvious, the system will increase its recommendation weight. If some video resources have a large number of visits but limited learning effectiveness improvement, the platform prompts teachers to re-examine their explanation structure or applicable objects. Resource values are thus no longer fixed, but are re-evaluated in continuous use.

In order to describe this dynamic update process, this paper further gives the resource weight correction formula:

$$w_i^{(n+1)} = w_i^{(n)} + \eta(r_i - \hat{r}_i) \tag{11}$$

where $w_i^{(n)}$ is the weight after the NTH round of resource recommendation, r_i represents the feedback value of the actual teaching effect of resources, $\hat{r}_i$ represents the predicted value of the system, and η is the update rate. The formula reflects that the resource management system is not simply saving materials, but constantly revising the resource sorting strategy according to the teaching results, so that the platform gradually has the ability of self-adaptive optimization.

It should be pointed out that the value of music education resource management system does not stop at "saving" and "finding". More importantly, it integrates the originally scattered samples, audio, video, assignment and evaluation records into the same computing framework, which makes the resource construction, course operation and learning analysis form a continuous connection. Teachers can call appropriate materials at a lower cost, students can obtain training content corresponding to their own problems in a shorter time, and managers can also grasp the weak links in the construction of curriculum resources through statistical results. The integrated management system constructed in this way can truly provide a stable resource base for the intelligent teaching system of music education under the digital background.

4 Result analysis and discussion

4.1 Effect analysis of Digital music Network Course design

After completing the construction of the digital music network course design model, in order to test its implementability and teaching suitability, this paper selects two courses of solfegchorge Training and Piano Foundation of a university's music education major for small-scale trial operation, and invites 5 experts to participate in the evaluation, including 2 music education experts, 2 educational technology experts, and 1 digital course platform developer. The evaluation adopted a five-point Likert scale from six dimensions: clarity of course objectives, rationality of task organization, effectiveness of interaction design, timeliness of intelligent feedback, matching degree of resource call and overall operability. Descriptive statistics were performed after the evaluation data were entered into SPSS 27.0. As shown in Table 3, the overall mean value of the network course design model is 4.71, and the standard deviation is 0.31, which is at a high level, indicating that the model has strong usability and realistic adaptability in the digital implementation of music courses.

Table 3: Evaluation results of digital music network course design effect

Evaluation Dimension	Mean	Standard Deviation
Clarity of course objectives	4.78	0.24
Rationality of task organization	4.69	0.33
Effectiveness of interaction design	4.66	0.37
Timeliness of intelligent feedback	4.74	0.29
Matching degree of resource access	4.73	0.30
Overall operability	4.68	0.32
Overall result	4.71	0.31

From the breakdown results, Table 2 shows that the mean clarity of course objectives reaches 4.78, indicating that experts generally believe that it is reasonable to separate knowledge objectives, skill objectives and performance objectives into computable task units in this study, which can avoid the problem of empty generalization of music online course objectives. The average rationality of task organization is 4.69, which indicates that the chain design of introduction before class, training in class and consolidation after class is more in line with the formation law of music skills. The average effectiveness of interaction design is 4.66, which is slightly lower than other indicators. Experts pointed out that the main reason is that the peer collaboration module and real-time ensemble scene are sensitive to terminal equipment and network delay, but the overall implementation still has a good prospect. The average timeliness of intelligent feedback is 4.74, which shows that the design of generating instant feedback based on pitch error, rhythm deviation and completion rate can better respond to the requirements of instant correction in music teaching. The mean matching degree of resource call was 4.73, indicating that a relatively stable linkage relationship had been formed between the course process and resource recommendation.

During the trial operation, the platform also synchronously recorded the learning behavior data of students. The results showed that the average completion rate of students 'unit tasks in the experimental course reached 91.6%, which was significantly improved compared with the passive viewing mode common in traditional online courses. The call rate of personalized exercise package generated by the system was 87.4%, indicating that students had a high acceptance of targeted training resources. Combined with the expert evaluation results and platform log analysis, it can be seen that the digital music network course designed by this study does not stay at the level of resource display, but realizes the continuous connection of task-driven, process collection and feedback correction under the support of computer, which lays the foundation for the further verification of subsequent comprehensive resource management system.

4.2 Experimental analysis of Intelligent Design of Music Education Resources Integrated Management System

In order to test the intelligent operation effect of the integrated management system of music education resources constructed in this paper, the system experiment is carried out in the simulation teaching platform environment. The experimental Server was configured with Intel Xeon 2×2.6 GHz CPU, 32 GB memory, MySQL 8.0 as the background database, Ubuntu Server 22.04 as the application service, and Windows 10 as the client operating system. Chrome 120 or above was used as the browser, and JMeter 5.6 was used as the stress test tool. A total of 5280 music teaching resources were imported into the resource library, including seven types of data: music score images, demonstration audio, teaching videos, MIDI files, exercise texts, student practice clips and evaluation records. Considering the heterogeneous format and complex retrieval path of music education resources, the system added three processing steps of label classification, permission verification and demand matching before resource call, and used three-layer feed-forward neural network to complete the training of resource demand recognition. The number of iterations was set to 200, the initial learning rate was set to 0.01, and the batch size was set to 32.

The core objectives of the experiment are two: one is to verify the stability of the intelligent classification and matching module in the resource identification task, and the other is to investigate the retrieval response efficiency of the system under different resource scales. In the training stage, the teacher's labeling results were used as the reference standard, and the students 'learning status, course unit category, resource label combination and historical use effect were input into the model together. As shown in Figure 4, as the number of iterations increases, the model loss value continues to decrease, and the accuracy increases synchronously. In the first 50 iterations, the loss decreases rapidly, which indicates that the system can quickly capture the correspondence between music resource labels and teaching needs. After 120 iterations, the curve gradually becomes stable, and the model accuracy stabilizes above 95%, indicating that the module has good convergence. This result means that the system can not only identify the explicit requirements such as "piano basic - rhythm training - medium difficulty", but also make a relatively accurate judgment on the compound resource requests such as "solfegsong error correction - pitch deviation concentration - need to supplement the demonstration audio".

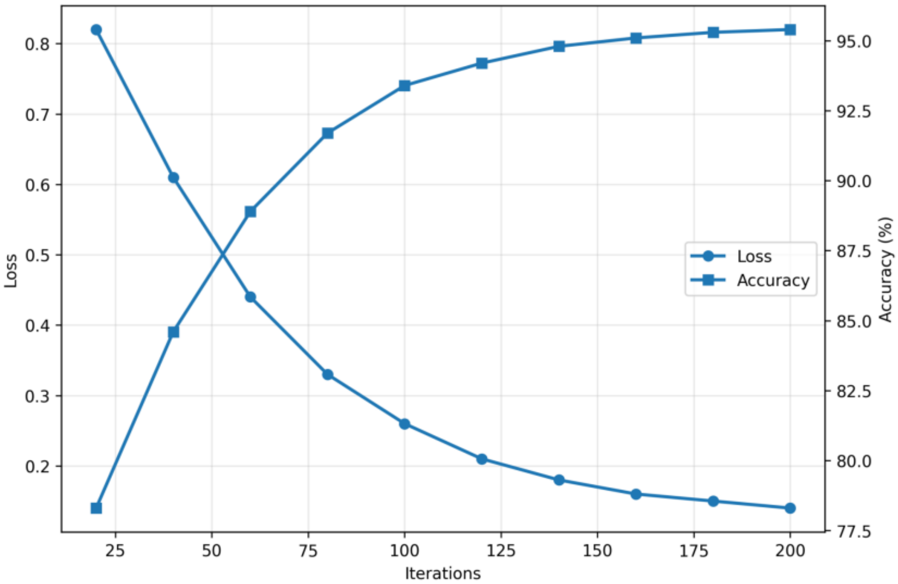

Figure 4: Training process of resource demand identification model

In order to further evaluate the performance of the model, this paper compares the method used with three common classification methods: CNN, LSTM and SVM. The comparison indicators include resource classification accuracy, recall rate, F1 value and average matching time. Table 3 shows that the proposed method achieves better results in all four indicators, especially in the average matching time consumption. Compared with CNN and LSTM, although the structure of the model in this paper is lighter, it is more suitable for deployment in the data scenario of medium scale and strong label correlation such as music teaching resources, because of its low training cost, clear feature mapping, and smoother connection with database retrieval logic. SVM has certain advantages under the condition of small sample size, but its generalization ability and processing efficiency are weaker than the proposed method when facing multi-label and multi-format resource input. It can be seen that combining the resource management logic with the lightweight intelligent recognition model is more in line with the actual needs of the long-term operation of the music education platform.

Table 4: Experimental results of different methods in the task of music teaching resources identification

Method	Accuracy	Recall	F1 Score	Average Matching Time (ms)
CNN	91.8%	90.6%	91.2%	42.7
LSTM	92.6%	91.4%	92.0%	48.3
SVM	89.7%	88.9%	89.3%	36.5
Proposed Method	95.4%	94.8%	95.1%	28.6

After completing the validation of the model, the study continued with system-level response experiments. In the experiment, 10 groups of resource request tasks of different scales are set up, and the total number of resources is gradually increased from 500 to 5000. The system is compared with the traditional resource management platform. The two systems are deployed under the same hardware and software conditions, and two no-load runs are performed before the formal test to eliminate the impact of cache warm-up differences. In the test process, the system randomly receives three types of requests: teacher retrieval, student personalized call and administrator batch query. The average response time is recorded and the average of the three rounds of experiments is taken. As shown in Figure 5, when the resource scale is small, the response difference between the two systems is not obvious. When the number of resources exceeds 2000, the response time of the traditional system increases significantly, but the growth rate of the proposed system is slow, and the average response time remains at 8.7s under the condition of 5000 resources. In contrast, the conventional system reached 15.9 s under the same conditions with a difference of 7.2 s.

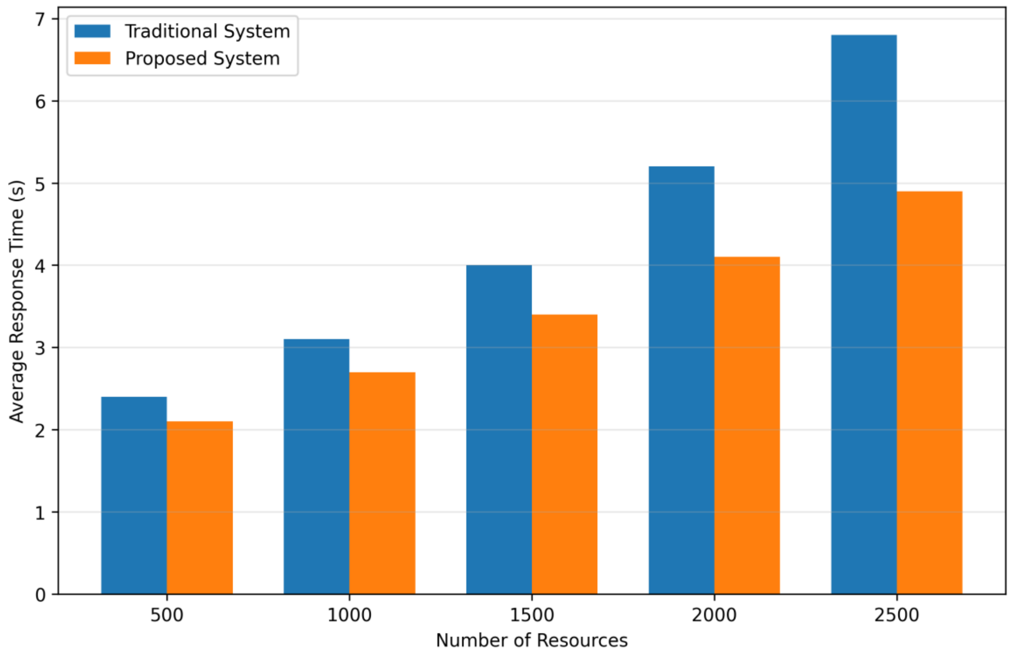

Figure 5: Comparison of the average response time of the system under different resource scales

This difference is not solely due to hardware performance but mainly to the call logic of the system. Traditional platforms rely more on keyword matching and fixed path query in retrieval. When the number of similar resources increases rapidly, the query link is significantly elongated. The proposed system completes label normalization and relationship mapping in the resource loading stage, and uses the requirement identification module to narrow the candidate resource set before calling, so that the retrieval pressure does not linearly overlap even if the total amount of resources is expanded. This is particularly critical for music teaching. Because students often need to quickly obtain targeted demonstration materials in after-class training, once the system delay is too high, the practice coherence will be interrupted, and the willingness to use the platform will also decrease. The experimental results show that the intelligent resource management not only improves the retrieval efficiency, but also enhances the immediacy of teaching support to a certain extent.

5 Discussion

The digital music education intelligent teaching system constructed in this paper shows good application value in the two levels of network course organization and resource integrated management. Combined with the above experimental results, it can be seen that the advantages of the system are not only reflected in the improvement of a certain functional index, but form a more stable collaborative relationship between the continuity of teaching process, the efficiency of resource invocation and the ability of personalized support. This is particularly important for music education. Because music learning is not a process of receiving static knowledge, but a dynamic training process including perception, imitation, correction and re-performance. If the system can only complete resource display or assignment collection, it is difficult to really intervene in the core link of teaching. Through audio feature extraction, learning log recording, tag retrieval and intelligent matching mechanism, the system connects students 'practice behavior and course resource scheduling, making the teaching support turn from experience judgment to data-aided judgment.

From the quantitative results, the mean of expert evaluation of digital music network course design reaches 4.71, indicating that the course model has a high degree of adaptability in goal decomposition, task organization, feedback generation and overall operability. The accuracy of the resource integrated management system in the resource identification task reaches 95.4%, and the average response time is controlled at 8.7 s under the scale of 5000 resources, which is significantly better than the traditional resource platform. This shows that the system has strong stability in the medium scale music teaching resource scene. Compared with the related researches that focus on mobile learning, blended teaching or the design of single interactive tools, this paper lays more emphasis on the overall linkage between course process, resource management and intelligent analysis, so it has certain expansibility in the depth of teaching support. From the qualitative point of view, this system is closer to the structural characteristics of music education itself than the existing research. Most of the existing results discuss the digital ability of teachers, online course experience or virtual practice environment, and the relationship between the resource layer and the teaching layer is not touched. In this paper, music examples, audio, video, MIDI, evaluation records and student training clips are integrated into a unified management framework, so that resources are not only passive storage objects, but also teaching units that can be dynamically invoked according to the learning state. This design can better respond to the actual needs of "the same content needs to be repeated, diverse, hierarchical presentation" in music education, and also shows that the value of computer technology in music teaching should not only be understood as the media update, but also should be understood as the reconstruction of teaching organization.Another point worth discussing is the applicability of the system to different music teaching scenarios. Although this paper mainly verifies the platform in solfeggio training and piano foundation courses, the overall design idea also has transfer value for vocal music, ensemble rehearsal, music appreciation, and even composition-related teaching. In vocal music teaching, the system can emphasize breathing stability, phrase continuity, and pitch fluctuation tracking. In instrumental courses, it can focus on fingering errors, tempo control, and repeated practice intervals. In music appreciation and theory courses, the same platform logic can be extended to listening tasks, score reading records, and knowledge-point-based resource recommendation. This suggests that the value of the intelligent teaching system does not lie in serving a single course type, but in providing a reusable digital framework for multiple music education tasks. Once the underlying data logic and resource governance mechanism are established, the system can support broader curriculum coordination and improve the consistency of teaching management at the departmental level.

At the same time, this paper still has some limitations. The experimental scale is still dominated by the single-school course environment, the total amount of resources and the level of user concurrency are still limited, and the investigation of cross-school sharing, cross-course transfer and long-term learning effects is not sufficient. Emotional expression, stage performance and creative generation in music learning are also difficult to be accurately depicted by existing feature extraction methods. Subsequent research can further introduce richer multi-modal data, such as video movements, expression changes and collaborative performance trajectories, and combine more robust recommendation models and knowledge graph methods to continue to improve the system's ability to explain and adapt to complex music learning scenarios. In this way, the digital music education intelligent teaching system can gradually develop from a local application platform to a supporting teaching reform infrastructure.

6 Conclusions

According to the analysis of the curriculum design evaluation results and the experimental data of the resource management system, it can be believed that the digital music education intelligent teaching system constructed in this paper has good applicability and implementation value. The system takes the network course design as the teaching main line, and takes the comprehensive resource management as the operation support. The audio feature extraction, learning behavior recording, resource label modeling and intelligent matching mechanism are introduced into the music teaching process, which changes the operation mode of traditional music classroom that relies too much on teachers 'experience judgment and static resource distribution to a certain extent. The research results show that the system can not only improve the organization rationality and timeliness of digital music courses, but also maintain high recognition accuracy and fast response efficiency under the condition of resource scale expansion, so as to provide a stable technical foundation for personalized learning support and resource sharing in music education. At the same time, this paper also sees that the complexity of music education can not be fully covered by the present computational model. The differences of students in emotional expression, work understanding, stage performance and creative generation are still difficult to fully describe by only relying on existing log data and audio features. Subsequent research can continue to expand the multi-modal data sources, combine performance movements, expression changes, and collaborative practice process with more fine-grained teaching evaluation, and further optimize the recommendation algorithm and resource association mechanism. Only in this way, the intelligent teaching system of music education under the background of digital technology can gradually develop from a functional platform to a comprehensive infrastructure with teaching support, resource management and learning analysis capabilities.

References

[1] Cheng L, Moir Z, Bell A P, et al. Digital musicianship in post-pandemic popular music education[J]. International journal of music education, 2024: 02557614241287558.

[2] Nugroho M, Biasutti M. Instructors' perspectives on teaching music online after the COVID-19 lockdown: A qualitative analysis in indonesia[J]. Journal of University Teaching and Learning Practice, 2024, 21(3): 1-26.

[3] Hou Z, Sabri S B. The Use of Cloud Platform Technology to Help University Music Teachers Teaching Decision-Making Research[J]. Journal of Education and Educational Research, 2024, 11(1): 54-57.

[4] Arıcı İ. INVESTIGATION OF METAVERSE AND MUSIC EDUCATION[J]. International Online Journal of Education & Teaching, 2024, 11(3).

[5] Toscano F, Galanti T, Giff V, et al. The Mediating Role of Technostress in the Relationship between Social Outcome Expectations and Teacher Satisfaction: Evidence from the COVID-19 Pandemic in Music Education[J]. Research in Learning Technology, 2024, 32: 3086.

[6] Cuervo L, Bonastre C, Camilli C, et al. Digital competences in teacher training and music education via service learning: A mixed-method research project[J]. Education Sciences, 2023, 13(5): 459.

[7] O'Leary E J, Bannerman J K. Technology integration in music education and the COVID-19 pandemic[J]. Bulletin of the Council for Research in Music Education, 2023 (238): 23-40.

[8] Beirnes S, Randles C. A music teacher’s blended teaching and learning experience during COVID-19: Autoethnography of resilience[J]. International Journal of Music Education, 2023, 41(1): 69-83.

[9] Biasutti M, Antonini Philippe R, Schiavio A. Assessing teachers’ perspectives on giving music lessons remotely during the COVID-19 lockdown period[J]. Musicae scientiae, 2022, 26(3): 585-603.

[10] Michałko A, Campo A, Nijs L, et al. Toward a meaningful technology for instrumental music education: Teachers’ voice[C]//Frontiers in education. Frontiers Media SA, 2022, 7: 1027042.

[11] Merchán Sánchez-Jara J F, González Gutiérrez S, Cruz Rodríguez J, et al. Artificial intelligence-assisted music education: A critical synthesis of challenges and opportunities[J]. Education Sciences, 2024, 14(11): 1171.

[12] Lam C K. Technology-enhanced creativity in K-12 music education: A scoping review[J]. International journal of music education, 2024, 42(4): 691-703.

[13] Zhang Y, Beh W F, Zhang C. A systematic review of blended learning strategies and outcomes in music education[J]. Harmonia: Journal of Arts Research and Education, 2024, 24(2): 247-262.

[14] Shin J, Jung J Y. An investigation of Korean music teachers’ perceptions of technology in music classes[J]. International Journal of Music Education, 2024: 02557614241286189.

[15] Cheng L, Lam C Y, Leung C H. Digital competencies of music teachers under the ‘new normal’in Hong Kong[J]. International Journal of Music Education, 2024, 42(4): 535-549.

[16] Chen J C W. Mobile learning as deep learning: Content analysis of in-service primary school music teachers' lesson plans in mobile music creation[J]. International Journal of Music Education, 2024, 42(4): 660-673.

[17] Liu X, Shao X. Modern mobile learning technologies in online piano education: Online educational course design and impact on learning[J]. Interactive Learning Environments, 2024, 32(4): 1279-1290.

[18] Lv H Z. Innovative music education: Using an AI-based flipped classroom[J]. Education and Information Technologies, 2023, 28(11): 15301-15316.

[19] Chen Q. Music teaching software development based on neural network algorithm and user analysis[J]. Entertainment Computing, 2024, 49: 100631.

[20] Lu D. Intelligent interactive piano teaching[J]. International Journal of Music Education, 2023, 41(4): 529-543.

[21] Sai Y. Online music learning based on digital multimedia for virtual reality[J]. Interactive Learning Environments, 2024, 32(5): 1751-1762.

[22] Yang P. Virtual reality tools to support music students to cope with anxiety and overcome stress[J]. Education and Information Technologies, 2024, 29(13): 16525-16540.

[23] Faure-Carvallo A, Gustems-Carnicer J, Guaus Termens E. Music education in the digital age: Challenges associated with sound homogenization in music aimed at adolescents[J]. International Journal of Music Education, 2022, 40(4): 598-612.