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Article

Research on the biomechanical mechanisms of digital music teaching resources in enhancing students' musical expressivity

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Abstract: The goal of this study is to explore the biomechanical mechanism of digital music teaching resources in improving students' musical expression, and to study how to optimize music teaching effect by means of technical means. By introducing collaborative filtering (CF) algorithm into the field of music education, a individualized teaching resource recommendation system is constructed. The system deeply analyzes students' learning behavior, interest preference and learning effect, so as to achieve accurate matching of resources. In order to verify the effectiveness of digital teaching resources and recommendation system, a semester-long empirical study was designed and implemented. Select 100 music majors and divide them into traditional teaching resources group and digital teaching resources group. The study focuses on the differences between the two groups in mastering music theory, improving practical skills (especially musical expression in biomechanics) and stimulating learning interest. The results show that the students' musical expressive power (especially the skills related to biomechanical mechanism) and learning interest in the digital teaching resource group are significantly improved, and the effect is far better than that in the traditional teaching resource group, which proves the great potential of digital teaching resources and individualized recommendation system in music education.

Keywords: digitization; instructional resources; biomechanical mechanism; musical expressive force; collaborative filtering; individualized recommendation

1. Introduction

In today's era when information and digital technology are changing with each passing day, the field of education is undergoing earth-shaking changes. Music education, as a key link in shaping students' artistic temperament, aesthetic concept and innovative ability, also stands at the crossroads of change, facing both challenges and opportunities [1]. With the rapid development of information technology, digital teaching materials play an increasingly important role in music education. They not only improve the instructional level, but also greatly enrich the course content and become an important fire to ignite students' learning enthusiasm [2]. However, how to effectively develop and apply these digital instructional resources to better serve music education is still a problem worthy of in-depth discussion. In the traditional music instructional mode, teachers often pass on music knowledge and skills to students with the help of face-to-face oral instruction [3]. Although this method has its unique charm and value, it also has certain limitations. For example, the limited instructional resources, the neglect of students' individual differences and the singleness of teaching methods all restrict the progress of music education to some extent [4].

Digital instructional resources, with their rich contents, diverse forms and convenient communication methods, have injected new vitality into music education. Digital instructional resources can include music videos, audio materials, music software, online courses, interactive platforms and other forms [5]. They can break through the limitation of time and space, and let students get in touch with high-quality music education resources anytime and anywhere, so as to broaden their horizons and increase their knowledge [6]. Digital instructional resources also have the characteristics of strong interaction, which can carry out individualized learning according to students' needs and interests and improve the pertinence of learning. The development and application of digital instructional resources is not achieved overnight [7]. It is a problem that needs further study and exploration to develop digital instructional resources that conform to the educational laws and stimulate students' interest according to the characteristics and needs of music education [8]. In addition to this perspective, facing the massive digital instructional resources, how to effectively manage and recommend them so that students can quickly find their own learning resources is also an urgent problem.

CF algorithm can analyze users' interests and preferences according to their historical behavior data, so as to recommend similar goods or services for users [9]. In the field of music education, we can use CF algorithm to accurately push digital instructional resources for students. By analyzing students' learning records and points of interest, this method can select the learning materials that best meet their needs [10]. Such individualized recommendation can not only improve learning efficiency, but also enhance students' satisfaction and ensure that digital instructional resources are more fully and utilized [11]. Chen et al. [12] studied how to build a sharing model of digital teaching resources based on big data to improve the utilization rate of resources and teaching effect. Liang et al. [13] proposed a individualized recommendation method based on trust relationship. Ramprasad et al. [14] studied how students' interest in biomechanics affects their participation and performance. Wu et al. [15] studied how to mine effective information from educational big data to support educational decision-making. This study emphasizes the importance of the deep integration of technology and education to improve the teaching effect.

The goal of this study is to analyze the biomechanical mechanism of digital music instructional resources in improving students' musical expression, and to explore how to combine CF algorithm to realize individualized recommendation of these resources. Through this study, the goal is to solve several key problems: the demand and characteristics analysis of digital instructional resources in music education, the effective development strategy and method of biomechanical mechanism for music expression, the concrete application of CF algorithm in resource recommendation system, and the application effect and value of digital instructional resources in improving students' music expression through practical cases. This study aims to enrich music education resources, improve teaching quality, provide new ideas for the development of digital music instructional resources, and further promote the process of education informatization.

Highlights:

(1) This research innovatively applies CF algorithm to the field of music education. Through in-depth analysis of students' learning behavior, interest

preference and learning effect, a individualized instructional resource recommendation system for music expressive force is constructed, with special attention to the improvement of students' biomechanical mechanism.

(2) The recommendation system can intelligently recommend music teaching videos, audio and online courses that meet students' individual needs according to their different learning needs and levels, so as to achieve accurate matching and efficient use of instructional resources.

(3) This research has also developed a cross-platform resource integration and sharing platform that integrates various digital music instructional resources. Combined with CF algorithm, the platform can intelligently recommend cross-platform high-quality resources to meet students' diverse and multi-level learning needs.

At the beginning of the article, the background, core purpose and far-reaching significance of the research are discussed, and then the challenges encountered in using digital instructional resources in the field of music education are deeply analyzed. Then, it expounds the basic principles, implementation steps and diversified concrete presentation forms of the development of digital instructional resources. On this basis, CF algorithm is innovatively introduced to optimize individualized recommendation of instructional resources. Through a series of in-depth analysis of actual teaching scenes, it is proved that digital instructional resources and CF recommendation mechanism have achieved remarkable results in music teaching practice. At the end of the article, the research results are comprehensively combed and summarized, and the future development trend of digital instructional resources in the field of music education and the infinite possibility of CF algorithm being applied in a wider field are expected.

2. Overview of digital instructional resources

2.1. Definition of digital instructional resources

Digital educational resources refer to all kinds of learning materials that are created, preserved, transmitted and used by means of digital technology. They have various forms, including words, pictures, sounds, images, animations and software programs, and can be easily shared and disseminated through various platforms such as the Internet, smart phones and tablets. Compared with traditional instructional resources, digital instructional resources are more flexible, accessible and interactive, which can transcend time and space constraints and bring more abundant and diverse learning experiences to learners.

2.2. Characteristics of digital instructional resources

The biggest feature of digital instructional resources lies in its diversity of forms. From simple texts and pictures to complex multimedia interactive content, digital resources can meet the needs of students with different learning styles and ability levels [16]. This means that students can not only get access to traditional music scores and audio, but also learn playing skills with the help of video tutorials, and even participate in online ensemble, which greatly enriches the learning forms [17]. Digital instructional resources are often designed with interactive links, such as online tests, simulation experiments, virtual performances, etc., to encourage students to actively participate rather than passively accept knowledge. This interaction not only enhances the interest of learning, but also promotes the cultivation of students' active learning ability [18]. Students can practice playing musical instruments with the help of simulation software, get immediate feedback and adjust their playing skills. This kind of immediate feedback mechanism is incomparable to traditional teaching methods.

Another advantage of digital instructional resources to some extent is its wide accessibility. As long as there is an Internet connection, learners can access the required resources at almost any time and anywhere [19]. This means that students in remote areas can also be exposed to the teaching videos of world-class musicians and enjoy high-quality music education resources [20]. Digital resources are easy to update and maintain, can keep up with the pace of the times and reflect the latest teaching ideas and technological progress in time. In the field of music education, new music works, playing skills and teaching theories can be quickly transformed into digital resources for global learners to share.

2.3. The significance of digital instructional resources in music education

Digital instructional resources can display music knowledge intuitively and vividly, and make abstract music theory easy to understand. With the help of animation to demonstrate music structure and video to show playing skills, students can master knowledge points faster and improve learning efficiency [21]. Teachers can use digital resources for differentiated teaching and bring individualized learning resources according to the needs of different students. Digital instructional resources, with their rich forms and interactivity, have stimulated students' interest in music learning [22]. With the help of participatory learning, students can freely explore the music world, try different ways of creation and performance, and cultivate innovative thinking and artistic expression ability [23].

The wide application of digital instructional resources is helpful to break the restrictions of geographical and economic factors on educational resources and realize the balanced distribution of educational resources. Whether in urban or rural areas, students can get high-quality music education resources through the Internet, narrowing the educational gap between urban and rural areas and between schools [24]. In the digital age, learning is no longer limited to school classrooms [25]. Digital instructional resources provide a platform for music lovers to continue learning. Both professional musicians and amateurs can learn new knowledge anytime and anywhere according to their own needs.

2.4. Challenges faced by digital instructional resources

Although digital instructional resources have broad prospects for application in music education, they also face some challenges, such as uneven resource quality, copyright protection issues, and rapid technological updates [26]. Faced with these problems, the government, educational institutions, educators, technology developers and all sectors of society need to go hand in hand. It is needed to strengthen the quality control of educational resources, establish a sound copyright protection system, and constantly improve the digital ability of teachers. In addition, it is needed to increase research and development (R&D) investment to ensure the steady and sustainable development of digital instructional resources.

3. Development of digital music instructional resources for improving music expressiveness

3.1. Demand analysis of the combination of music education and biomechanics

The first step in the development of digital instructional resources is a detailed demand analysis. This step should cover students, teachers, course content and technology platform. With the help of questionnaire, interview or observation, information such as students' learning preferences, basic level of music, interest points and so on are collected to ensure that the developed resources can be close to the actual needs of students. For example, for beginners, it can bring more basic music theory knowledge and introductory videos of musical instrument playing skills [27]. For advanced students, in-depth courses including complex music theory analysis and music creation guidance can be designed.

As direct users of instructional resources, teachers' feedback is very important. By communicating with teachers, we can understand the difficulties they encounter in teaching, the teaching contents they want to supplement, and their specific requirements for resource format and interactivity, so as to ensure that resources are practical and easy to integrate into daily teaching [28].

In terms of course content, it is needed to determine the knowledge points, skills and artistic appreciation content of resources according to the music education syllabus and the characteristics of the times to ensure the comprehensiveness and modernity of resources [29]. Technology platform analysis focuses on the compatibility and accessibility of resources to ensure smooth use in different devices and network environments.

In the selection of participants, this study selected 100 students majoring in music from the Art College of Jingchu Institute of Technology as the research object. The selection of these students is based on their theoretical basis of music, their playing skills and their enthusiasm and participation in music learning. In order to ensure the universality and reliability of the experimental results, participants were randomly assigned to the traditional teaching resource group and the digital teaching resource group, with 50 people in each group. The two groups of students are balanced in age, gender and music learning background to ensure the comparability of experimental conditions.

3.2. Design principles based on biomechanical principles

After clarifying the teaching needs, the design of digital instructional resources should strictly follow the four core principles [30]. The first is the principle of education, which emphasizes that the content of resources must be accurate and closely conform to the standards of music education. The goal is to effectively promote the transfer of knowledge and the improvement of skills. In the design stage, learners' cognitive rules should be deeply considered, and the content should be presented step by step to ensure the efficiency of learning and avoid information overload. Secondly, the principle of artistry. In view of the artistic essence of music education, resources should have excellent artistic expression. In every link of music recording, visual art conception and user interface design, it is needed to pursue aesthetic enjoyment and artistic resonance to ignite students' desire to explore beauty and creativity. In addition, make full use of the unique interactive characteristics of digital media platform, and skillfully design interactive links such as online question and answer, virtual performance and work display. This can not only greatly enhance the interest and participation in learning, but also help teachers to track students' learning dynamics and effectiveness in real time. At the same time, we deeply understand the uniqueness of each student, so we are committed to providing diversified and multi-level learning paths in resource development to ensure that each student can find the most suitable learning journey according to his personal abilities and interests.

3.3. Technical realization

Technology is the key to realize the creativity of digital instructional resources, which constantly promotes the innovation in the field of education. At present, with the vigorous development of cutting-edge technologies such as multimedia technology, artificial intelligence and virtual reality (VR), the development of music education resources has ushered in unprecedented possibilities [31]. With the help of multimedia integration, educators can organically integrate high-definition video, stereo audio, animation demonstration and other media forms to create an immersive learning environment. For example, using 360-degree full-motion video technology, students can feel the shocking atmosphere of the concert scene. The application of intelligent interactive technology makes music education more individualized and efficient. In addition to intelligent accompaniment, AI technology can flexibly adjust the speed and difficulty according to the students' performance level, and also gives students immediate feedback on practice to help them quickly correct their mistakes and find the direction of improvement.

The introduction of VR and augmented reality technology has further enriched the practical experience of music education. VR technology can build a virtual music classroom, allowing students to perform musical instruments, chorus rehearsals and other activities freely in the virtual environment. The augment reality (AR) technology can skillfully superimpose musical elements in the real world. For example, when students watch music scores with the help of AR glasses, they can simultaneously obtain auxiliary information such as fingering tips, so as to greatly improve learning efficiency. The application of cloud platform and big data technology enables music education resources to be stored centrally, retrieved quickly and widely shared. In addition to optimizing resource allocation, it also analyzes students' learning behavior with the help of big data, which provides solid data support for CF recommendation system.

3.4. Quality control

Quality control is an indispensable part in the development of digital instructional resources. In the resource production stage, strict quality standards should be established, including content precision, technical stability, user experience and so on. Experts' assessment, user testing, peer assessment and other methods are adopted to conduct multiple rounds of audit of resources to ensure that the quality meets the standards. Furthermore, establish a feedback mechanism, collect users' use feedback, regularly assess the use effect of resources, and iteratively optimize according to the feedback. Especially in the field of rapid technology update, such as mobile applications, AI interaction, etc., we should maintain technology sensitivity, upgrade resources in time, and maintain its advanced nature and practicality.

4. Recommendation of digital instructional resources based on CF algorithm

4.1. Building a portrait of user behavior

The core of CF algorithm is to use the historical behavior data of users to predict their possible future interests. In the field of music education, these data can include, but are not limited to, students' browsing records, frequency of use of learning resources, study duration, performance feedback, user assessment and interactive behavior. In order to build an accurate portrait of user behavior, it is needed to design a reasonable data collection mechanism first. In the digital instructional resource recommendation system in the field of music education, the emotional analysis of new texts is matched with a specially constructed phrase model base by optimizing word segmentation and part-of-speech tagging, so as to obtain the emotional tendency value of phrases, and comprehensively consider the frequency and position of phrases, calculate the emotional inclination degree of the whole text, and finally give the emotional classification results, so as to accurately capture the emotional needs of users and optimize the recommendation of instructional resources. The flow chart is shown in **Figure 1**.

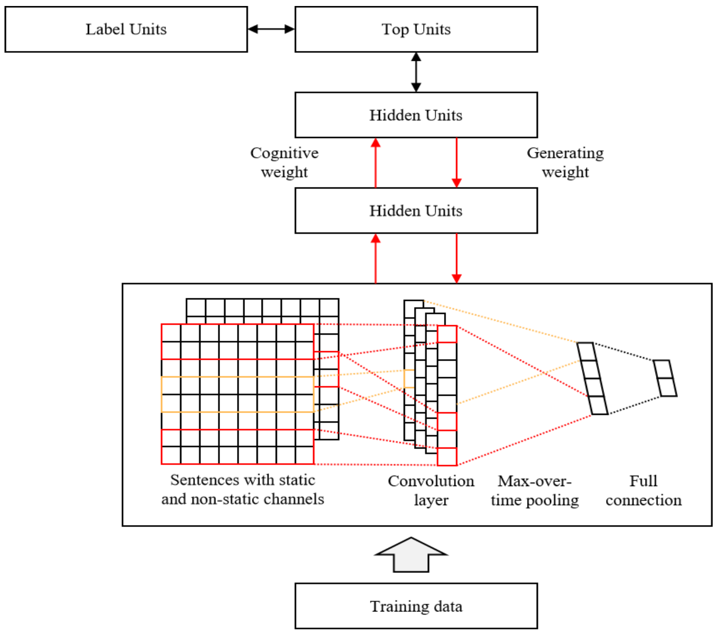

Figure 1. Emotion classification process.

Define the n -dimensional feature vector for student u, v as follows:

$$U = \{X_{u1}, X_{u2}, \cdots, X_{un}\} \quad (1)$$

$$V = \{X_{v1}, X_{v2}, \cdots, X_{vn}\} \quad (2)$$

The characteristic distance of student u, v, based on the Euclidean distance, is as follows:

$$d_{uv} = \sqrt{\sum_{k}^{n} |x_{uk} - x_{vk}|^2} \quad (3)$$

Student characteristic similarity is derived using distance and similarity coefficients:

$$Sim_{uv} = \frac{1}{1 + d_{uv}} = \frac{1}{1 + \sum_{k}^{n} |x_{uk} - x_{vk}|^2} \quad (4)$$

Students' preference for music instructional resources recommendation is influenced by its various characteristics, which have their own strengths and weaknesses. The traditional instructional resource recommendation system often ignores the different importance of students' characteristics. Therefore, in the instructional resource recommendation model constructed in this article, the concept of student feature weight is introduced to make cluster analysis closer to the actual situation. Using the conversion method of distance and similarity coefficient to accurately calculate the similarity between students' characteristics:

$$Sim_{uv} = \frac{1}{1 + d_{uv}} = \frac{1}{1 + \sum_{k=1}^{n} \theta_k |x_{uk} - x_{vk}|^2} \quad (5)$$

After data collection, preprocessing is needed, including data cleaning, data conversion and data normalization. In addition to this angle, considering the particularity of music education resources, we can also introduce music preference labels, such as music style, musical instrument type, composer, etc., as a supplement to the user's portrait, so as to describe the user's music interest more carefully.

4.2. User similarity calculation

CF algorithm can be divided into user-based CF and project-based CF. In music education resource recommendation, user-based CF is more commonly used, that is, by calculating the similarity between users, other users with similar interests to the target users are found, and then resources are recommended according to the behaviors of these neighbors.

User i has assessed project j as follows:

$$r_{ij} = \begin{cases} r_{ij} & If\ i\ scores\ item\ j \\ 0 & If\ i\ doesn't\ grade\ item\ w \end{cases} \quad (6)$$

At the beginning of the project, because there is no user feedback, the assessment record of the new project is in a blank state, which means that it is impossible to assess its similarity with other projects by traditional methods, and it is difficult to find similar recommended items. In order to overcome this initial "cold start" problem, the key is to create more ways for users to contact and assess this new project.

One strategy is to use the category feature data of the project to build a similarity framework. By treating the category attribute matrix of projects as a kind of "pseudo-scoring" matrix, cosine similarity is used as a mathematical tool to measure the similarity of different projects in category characteristics:

$$sim(a,b) = \frac{num(a,b)}{\sqrt{num(a)}\sqrt{num(b)}} \tag{7}$$

$sim(a,b)$ signifies the resemblance between items a,b, while $num(a,b)$ denotes the count of overlapping elements in the attribute category matrix of item a,b. Additionally, $num(a)$ and $num(b)$ represent the counts of non-zero components in the category attribute vector of item a,b. Although traditional cosine similarity addresses individual biases, it only discriminates between individuals without quantifying dimensional differences. This study employs an adjusted cosine similarity measure, discarding negative results:

Although cosine similarity can adjust the bias among individuals to a certain extent, its limitation lies in that it can only identify the directional differences of individuals in each dimension, but can not accurately quantify the specific differences of values in each dimension. In this article, the modified cosine similarity method is used to calculate, and it is decided to reject all negative results and not include them in the analysis:

$$sim(u,v) = \frac{\sum_{i\in I_{u,v}}(R_{u,i}-\bar{R}_u)(R_{v,i}-\bar{R}_v)}{\sqrt{\sum_{i\in I_u}(R_{u,i}-\bar{R}_u)^2}\sqrt{\sum_{i\in I_v}(R_{u,i}-\bar{R}_v)^2}} \tag{8}$$

Vectors $\vec{u}$ and $\vec{v}$ depict user u,v's scores in the n -dimensional project space. I_{uv} denotes a set of items scored by user u,v alongside others. I_u, I_v denotes the items rated by user u,v. $R_{u,i}, R_{v,i}$ is user u,v's rating of project i, while $\bar{R}_u, \bar{R}_v$ signifies the average rating of project i by user u,v.

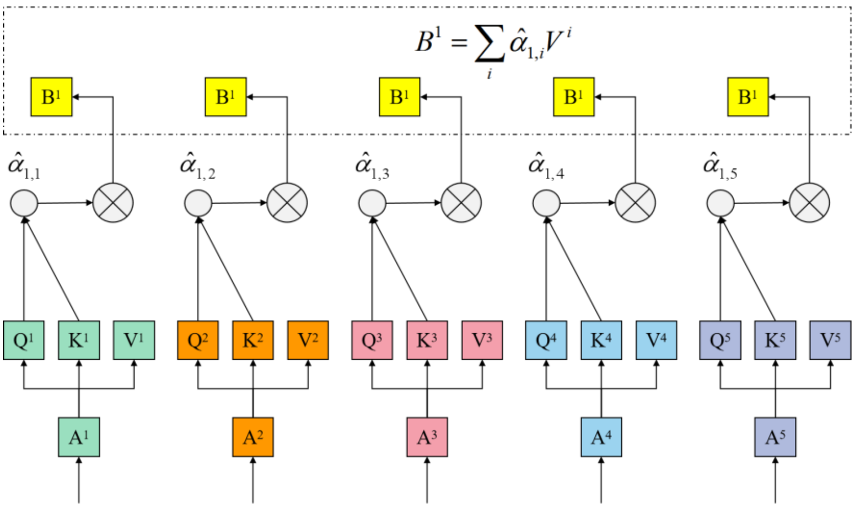

Figure 2. Transformer (Self-Attention).

In the process of constructing and optimizing this model for emotional analysis of music education resources, a series of core technologies and efficient algorithms are integrated. The training of deep learning (DL) model has become the core link to improve the efficiency of the model. In view of the excellent performance of Transformer architecture in natural language processing tasks, this advanced DL model (as shown in **Figure 2**) is specially selected as the basic framework.

In the scene of music instructional resource recommendation, cosine similarity is widely used because it can measure the directional consistency of two vectors in multi-dimensional space. In the concrete calculation, the user's behavior data is represented as vectors, and each dimension represents a kind of resource or behavior feature, and then the similarity is assessed by calculating the cosine of the included angle between the two user vectors.

To assess attribute weights more accurately, normalization is essential. Once the normalized weight set $B = \{b_1, b_2, \cdots, b_m\}$ is established, the concept of weighted support for the attribute set is introduced.

$$w\,sup(B) = \sum_{i=1}^{p} w_{b1} \times \frac{support(B)}{n} \tag{9}$$

If $wsup(X)$ meets or exceeds the minimum support standard set by users, B is regarded as a weighted frequent attribute set. For the weighted Boolean association rule "$B \Rightarrow B^{'}$", the definition of its weighted support is as follows:

$$w\left(sup() \sum_{i=1}^{m+n} w_{b1} \frac{support\left(B \cup B^{'}\right)}{n}\right) \tag{10}$$

The definition of weighted confidence for the Boolean association rule "$B \Rightarrow B^{'}$" is:

$$w(conf) = \frac{support\left(B \cup B^{'}\right)}{support(B)} \tag{11}$$

4.3. Resource recommendation strategy

Based on the calculated user similarity, the recommendation system can generate a individualized resource recommendation list for the target users. The design of recommendation strategy should give consideration to individuality and diversity, not only to ensure that recommendation resources are highly matched with users' interests, but also to avoid users falling into an "information cocoon" because of too single recommendation.

In the regression task, the model will average the predicted values of each tree, and the weights are usually learned automatically according to the importance of the tree or the training stage of the model. In the classification task, each tree will output a category prediction, and the final prediction result will be weighted voting based on the predictions of all trees. Choose the category with the most votes as the final forecast. Assuming K trees for the lifting tree model, the predictions are:

$$\hat{y}_i = \sum_{k=1}^{K} f_k(x_i) \tag{12}$$

The objective function is defined as:

$$ob_j = \sum_{i=1}^{m} l(y_i, \hat{y}_i) + \sum_{k=1}^{K} \Omega(f_k) \tag{13}$$

where l represents the training set's loss function, and $\Omega(f_k)$ denotes the tree's complexity, encompassing factors like the quantity of leaf nodes, tree depth, and leaf node l_2's norm. Once the nearest neighbor set U of user u is identified, the score u will give to item i can be predicted using the following formula:

$$P_{u,i} = \overline{R_u} + \frac{\sum_{u_k \in U} sim(u, u_k) \times \left(R_{u_{k,i}} - \overline{R_{u_k}}\right)}{\sum_{u_k \in U}(|sim(u, u_k)|)} \tag{14}$$

In the formula mentioned, $R_{u_{k,i}}$ denotes the score assigned by user u_k to project i, $\overline{R_{u_k}}$ signifies the mean score of overlapping projects rated by user u_k, and $\overline{R_u}$ represents the overall average score of user u across all projects.

4.4. Algorithm performance test

Precision is related to whether users can get learning resources that meet their individual needs. In order to assess the precision of CF algorithm in music instructional resource recommendation, a comparative experiment was designed. In the experiment, 100 students with different music learning backgrounds and interests and 10 music education experts. These students are required to use the recommendation system to browse and assess the resources recommended to them, and experts manually select a set of ideal resources for them as a reference according to their learning needs and interests.

By comparing the list of resources recommended by the system with those selected by experts, the precision and recall of the recommended system and the F1 score of the comprehensive assessment index are calculated (As shown in **Table 1**). The results show that the average precision of the system is 87%, recall is 82%, and F1 score reaches 84.5%, which indicates that CF algorithm has high precision in music instructional resource recommendation.

Table 1. Precision and recall test results.

Metric	Average	Minimum	Maximum
Precision	87%	65%	95%
Recall	82%	70%	90%
F1 Score	84.5%	72%	92%

With the help of a long-term stress test on the recommendation system, the scenario of a large quantity of users accessing and requesting recommendation resources at the same time is simulated to test the carrying capacity and response speed of the system. The test results show that the system can maintain a stable running state even during peak hours, and there is no crash or performance degradation to some extent, which proves its good stability (As shown in **Table 2**).

Table 2. System stability test results.

Test Scenario	Concurrent Users	Total Requests	Successful Responses	Failed Responses	Avg. Response Time (sec)	System Status
Peak Hour Simulation	1000	10,000	10,000	0	1.8	Stable
Extreme Load Test	5000	50,000	50,000	0	2.5	Stable
Long-Run Test	200 (continuous)	100,000 (cumulative)	100,000 (cumulative)	0	1.6	Stable

Processing speed is one of the key factors that affect the user experience. In order to optimize the processing speed of recommendation system, the algorithm has been iterated and optimized many times, including optimizing the data preprocessing process, reducing the time complexity of similarity calculation and adopting parallel computing technology. Finally, the average response time of a typical user request is shortened to 1.2 seconds, which is far below the delay threshold perceived by users. **Table 3** shows the processing speed optimization test results.

Table 3. Processing speed optimization test results.

Optimization Phase	Data Preprocessing Time (sec)	Similarity Calculation Time (sec)	Total Response Time (sec)	Improvement
Initial Version	5.6	3.8	9.4	-
Optimized Preprocessing	3.2	3.8	7.0	25.5%
Optimized Similarity Calc.	3.2	1.5	4.7	50.0%
Introduced Parallel Computing	3.2	0.6	3.8	21.4%
Final Version	3.2	0.4	1.2	87.2% Total

5. The impact of digital music instructional resources on enhancing music expression

In order to explore the actual effect and advantages of digital instructional resources in music teaching, a comparative study was carried out. In the study, 100 students majoring in music were selected and randomly divided into two groups, each with 50 students. One group uses traditional music instructional resources for teaching, while the other group uses well-developed digital music instructional resources, especially those that combine multimedia, interactive and individualized recommendation functions. The experimental period is one semester, during which key indicators such as students' academic performance, skills improvement and interest in learning are collected and analyzed.

This study uses a variety of data analysis techniques to verify the effectiveness of digital teaching resources and its recommendation system. Specific techniques include descriptive statistical analysis, which is used to analyze the basic situation of music theory scores, performance skills scores and learning interest questionnaire scores of two groups of students before and after the experiment. Paired sample t test is used to compare whether the changes of evaluation indexes before and after the experiment are statistically significant. Analysis of variance (ANOVA) helps to judge whether there are significant differences in these evaluation indexes between the two groups at the end of the experiment. Correlation analysis is used to explore the correlation between students' individualized learning needs and the accuracy of resource recommendation system. The selection of these statistical tests is closely related to the research questions of this study, which helps us to fully understand the effect of digital teaching resources and their recommendation system, and to evaluate the accuracy of the recommendation system to meet students' individualized learning needs.

5.1. Analysis of academic performance

Figure 3 shows the baseline data of the two groups of students' musical theory level and musical practice ability before the experiment. Before the experiment began, the two groups of students had the same ability in music theory and music practice. The average score of the traditional group was 74 points in theory and 64 points in practice. The average score of the digitization group is 76 in theory and 68 in practice, and the difference between the two groups is not necessarily to some extent.

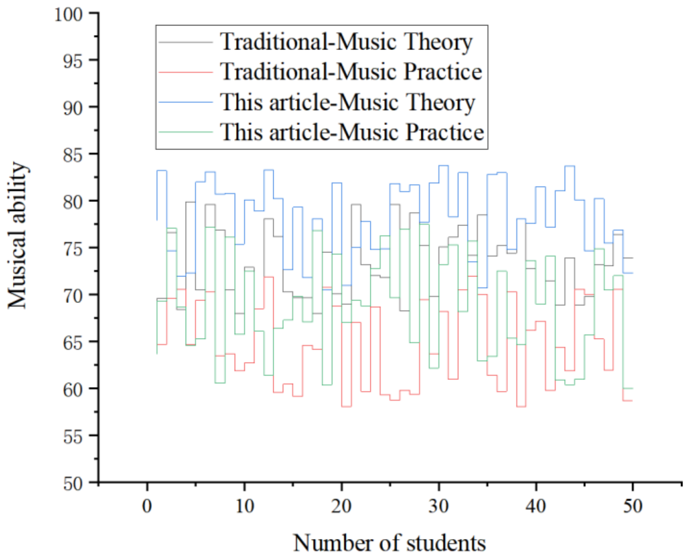

Figure 3. Students' music level (Before experiment).

After a semester's teaching experiment, as shown in **Figure 4**, the musical ability of the two groups of students has been improved, but the students in the digital instructional resources group have made progress to a certain extent. The average theoretical score of the digitization group increased by 8 points to 84 points, while the practical score increased by 12 points to 80 points. The theoretical score of the traditional group only increased by 3 points, and the practical score increased by 7 points, showing the obvious advantages of digital instructional resources in promoting knowledge mastery and skill upgrading.

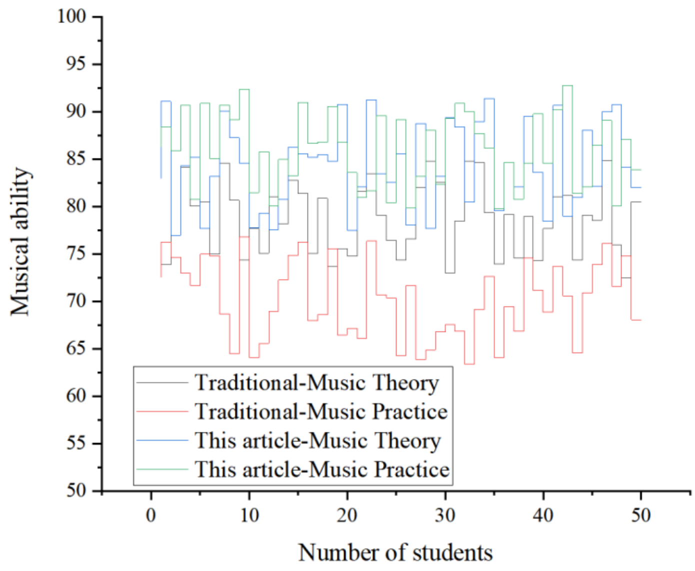

Figure 4. Students' music level (After experiment).

5.2. Learning interest and attitude change

Figure 5 shows the changes of students' interest in music learning before and after the experiment. Before the experiment, the average score of students' interest in music learning in the two groups was 7.1 (out of 10), which indicated that students were interested in music learning to some extent, but not particularly high. After the experiment, the average score of students' interest in the digital group jumped to 9.0, while the traditional group only reached 8.0, although it also improved.

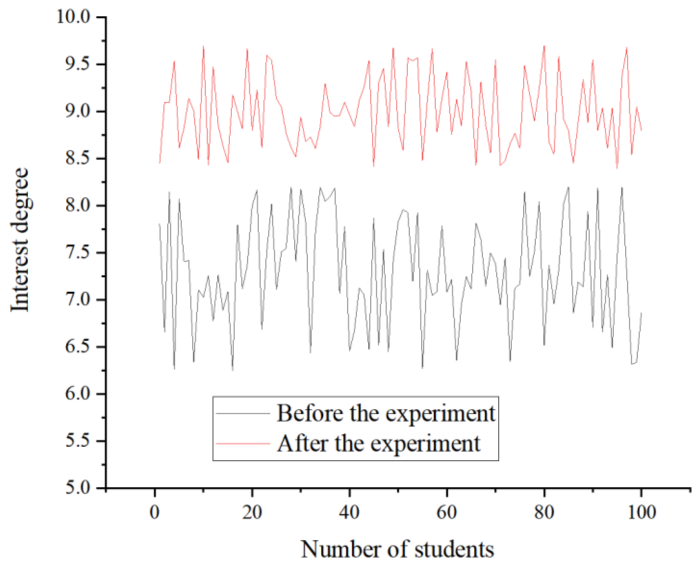

Figure 5. Comparison of students' interest.

This difference shows that digital instructional resources, especially its rich multimedia content, interactive and individualized recommendation functions, greatly stimulate students' interest in learning and make them more actively involved in music learning.

5.3. Discussion

Multimedia integration technology provides students with more vivid and intuitive learning materials by integrating rich and diverse media elements such as high-definition video, stereo audio and dynamic atlas. This greatly enhances the appeal of music theory and helps students to understand and master music skills more deeply. The interactive design of digital resources, such as interactive exercises, simulated performances and online tests, makes the learning process interesting and promotes students' active learning. With these functions, students can get feedback in time and correct their mistakes, thus speeding up the learning process to some extent.

The application of individualized recommendation system based on CF algorithm can accurately push suitable learning materials according to students' interests, learning progress and ability level, effectively avoiding information overload and further improving learning efficiency. In addition, digital resources give students autonomy in learning, and students can freely choose learning content according to their own time schedule and interests.

For music educators and curriculum developers, this study verifies the advantages of digital teaching resources in music education. Educators can actively use digital teaching resources, design more vivid and interesting teaching activities by using their multimedia integration and interaction characteristics, so as to stimulate students' interest and enthusiasm in learning. Curriculum developers can combine individualized recommendation system to develop more intelligent and individualized music courses to meet the learning needs and preferences of different students. This study provides a solid empirical foundation for the development of music education informatization, and encourages educators and developers to continue to explore more application possibilities of digital teaching resources in music education.

6. Conclusions

This study focuses on the application of digital music teaching resources in improving students' musical expression, especially the biomechanical mechanism. Through the development of individualized recommendation system based on CF algorithm and detailed comparative experiments, this paper analyzes the positive influence of digital teaching resources on music education.

The main findings show that digital teaching resources have significantly improved students' music theory level and practical skills by virtue of their multimedia integration, strong interactivity, individualized recommendation and students' autonomous learning. Compared with traditional teaching resources, digital resources not only promote the overall improvement of students' studies, but also greatly stimulate students' enthusiasm and interest in music learning. Individualized recommendation system based on CF algorithm solves the problem of information overload to a certain extent, accurately matches the learning needs of students, and further demonstrates the great potential of digital teaching resources in music education.

The significance of this study is that digital teaching resources have become the key force to promote the Informationization of music education, improve teaching quality and optimize students' musical expression. For future research, it is suggested to continue to deepen the development and innovation of digital resources, and combine advanced technologies such as artificial intelligence, big data and biomechanics to build a more intelligent, efficient and individualized music education ecosystem to meet the diverse and individualized learning needs of students. Specific research directions can include exploring how digital resources can integrate biomechanical principles more deeply, so as to improve the scientific nature of music teaching. At the same time, using big data technology to analyze students' learning behavior, and further optimize individualized recommendation algorithm. In addition, more interactive teaching tools based on artificial intelligence can be developed to enhance students' participation and learning effect.

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