Research Article
Study on the Application of Digital Information Technology in Music Teaching

Hao Cheng, Hao-ze Zhong, and Ke-cheng Ben

Nanchang University, Nanchang 330031, China

Correspondence should be addressed to Hao Cheng; chenghao82@ncu.edu.cn

Received 18 January 2022; Revised 26 February 2022; Accepted 3 March 2022; Published 22 March 2022

Academic Editor: Hoon Ko

Copyright © 2022 Hao Cheng et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

In order to deal with the great challenge of the arrival of information society to the traditional music teaching concept and practice, an overview of the teaching ability structure of music normal students supported by information technology is put forward. The changes in the structure of teaching ability caused by information technology are analyzed, that is, to analyze the cultivation of teaching ability of music normal students by integrating music subject knowledge with information technology platform and promoting relevant elements in combination with teaching activities. By using Fitzgerald and our proposed long + short method to separate Beach Boys songs at the singing music ratio of -6, 0, and +6 dB, the singing signal (left column) and music signal (right column) are relative to the average values of SDR (first row), SIR (second row), and SAR (third row) of pure singing and pure music. Experiments show the effectiveness of this method.

1. Introduction

Music normal students are future teachers. They are a group that will face the task of “preaching, teaching, and solving doubts.” The connection between the level of music teaching in the future and its teaching methods lies in whether they can well adapt to the development of the information society, skills, and social development to some extent, as shown in Figure 1 [1]. Secondly, as teachers of tomorrow, whether music normal students can acquire tomorrow’s teaching ability and skills in today’s teaching activities depends, to some extent, on the display of teaching ability and the application of teaching skills in teachers’ teaching activities. In this sense, in the information age, music normal students are not only the passive bearers of information technology, but also the active communicators of information technology, so that music normal students can acquire and master solid teaching ability, so as to adapt to the mission of preaching, teaching, and puzzle-solving of tomorrow’s teachers [2]. However, in the traditional teaching mode, in order to achieve standardized and efficient teaching effect faster and better, teachers often use one-way indoctrination to carry out teaching activities. Although this method improves the teaching efficiency, it cannot better promote the effective transfer and utilization of normal students’ knowledge and skills because it cannot provide diversified practical situations, which hinders the professional development of music teachers. More importantly, in the current training process of music normal students, professional knowledge, subject teaching knowledge, and educational technology ability, especially educational information technology knowledge, are separated from teaching as a whole [3]. The professional knowledge of music normal students in the college is mainly taught by the professional teachers of the college, the subject teaching knowledge is mainly taught by the teachers of relevant colleges such as the college of education and the college of psychology, and the courses related to education information technology are taught by the teachers of the school of Education Information Technology. The teacher education college conducts skill training and testing of normal students, and the education administrative department uniformly arranges the practice of normal students. This training mode leads to the inability of ordinary music students to integrate professional knowledge, subject teaching knowledge, and educational technology well. Ability in the training process, let alone scientization and systematization...
of music normal students [4]. In order to promote the innovative development of music normal students’ education, it is necessary to further improve the teaching ability of music normal students in combination with the information environment.

2. Literature Review

By 2020, basically build an education informatization system covering all kinds of schools at all levels in urban and rural areas and promote the modernization of educational content, teaching means, and methods” [5]. Hamond et al. found that with the wide rise of new generation information technologies such as Internet, cloud computing, Internet of Things, big data, and VR technology, colleges and universities at all levels have accelerated the construction of educational informatization and gradually moved the construction direction from traditional digital campus to a higher stage of intelligent campus according to the actual teaching and management needs. It has become the theme and trend of current information development [6]. Li believes that the intelligent campus, with the people-oriented concept as the carrier and many application service systems as the media, fully integrates education and teaching, school administration management, teachers' scientific research, and the campus life of teachers and students, which is a high-level form of the development of information-based campus after digital campus [7]. Ross found that the term “smart campus” was proposed on the basis of digital campus construction in the process of educational informatization, which originated from the concept of “smart earth” proposed by IBM in 2008 [8]. Li et al. believe that the so-called “wisdom” not only represents its traditional meaning but also represents a new concept and management mode in the information age, with the extension of digitization, networking, big data, and intelligent interaction. Cerf found that the “smart earth” strategy has been generally approved by all countries, gradually penetrated into various fields related to informatization, and gave birth to many new concepts, including the term smart campus. Different Chinese scholars have interpreted the meaning of smart campus [9]. Robert believes that smart campus is an intelligent campus work, learning, and life integrated environment based on the Internet of Things. This integrated environment takes various application service systems as the carrier to fully integrate teaching, scientific research, management, and campus life [10]. Kazmina believes that smart campus is composed of smart service concept, smart environment, smart application and service (smart teaching, smart management, and smart scientific research), and smart culture and experience and expounds the theoretical basis, methods, and principles of smart design [11]. Habib et al. constructed the “understanding schema of smart education,” and believed that smart campus, like smart classroom and smart terminal, is a learning space for smart education according to different scales and is an integral part of smart education, serving for wisdom education [12]. Paletta et al. proposed that smart campus refers to an open education teaching environment and a convenient and comfortable living environment with the concept of personalized service for teachers and students, which can fully perceive the physical environment, identify learners’ individual characteristics and learning situations, provide seamless network communication, and effectively support teaching process analysis, evaluation, and intelligent decision-making [13]. Wang et al. believe that the smart campus is based on the Internet under the information background, makes full use of the correlation characteristics of various information, changes the interaction mode between teachers and students and between students and school through information technology, and integrates the school’s teaching, scientific research, management and digital resources, and application systems.

**Figure 1: Application process of digital information technology in music teaching.**
so as to realize data sharing and instant visibility, communicate with the outside world, and provide support for teaching decision-making and analysis, to fully realize educational informatization, as shown in Figure 2 [14].

### 3. Method

Teaching process is a unity of students’ learning process and teachers’ teaching process. For quite a long time, the teaching process is basically composed of three basic elements: teachers, students, and teaching content. Teachers transmit information (content) through digital information technology, and students receive information (content) through digital information technology. Information technology has become the main way to present music teaching content [15]. The operability and applicability of information technology determine the clarity and structure of the music teaching content it transmits. At the same time, information technology itself has become an indispensable part of the music education content system, as shown in Figure 3.

Teacher’s ability is the ability that teachers should have to complete certain teaching activities. The analysis here is the requirement for all professional teachers, and for specific disciplines, the teaching ability they need to master is focused [16]. On the basis of teachers’ ability, this paper focuses on the ability that a music teacher should have. The training goal of music normal students is the future music teachers in primary and secondary schools. Clarifying the ability required for future teaching is of great significance to promote the training of music normal students [17]. By analyzing the teaching ability structure of middle school music teachers, it is considered that the teaching ability of middle school music teachers and music normal students is mainly reflected in four aspects: music teaching cognitive ability, music teaching operation ability, music teaching monitoring ability, and music teaching evaluation ability, as shown in Table 1.

In the information age, information literacy has become one of the important indicators for the comprehensive evaluation of talents in today’s society and the basic survival ability of individuals to adapt to social life. As future teachers, the information literacy of normal students directly affects the development of educational informatization and the cultivation of high-quality and compound innovative talents. It is clearly pointed out that “adhere to emancipating the mind, adjust measures to local conditions, develop and innovate, keep pace with the times, pay attention to application, cultivate new primary and secondary school teachers with innovative spirit and practical ability, and comprehensively improve the information literacy of primary and secondary school teachers” [18]. Therefore, facing the torrent of educational informatization development, teachers must bear the brunt of comprehensively improving their information literacy, which is not only the basic path of teachers’ self-lifelong learning and professional sustainable development, but also an important guarantee for the smooth realization of information education. At the same time, this is also determined by the future career of normal students [19]. This higher requirement is reflected as follows: for future teachers, normal students are the recipients,
gatekeepers, and disseminators of information. As the disseminator of knowledge, the information used and disseminated by normal students must be scientific and correct. As a manufacturer of information, its information processing ability, information generation, and expression ability should have higher requirements. As a practitioner of educational informatization, he should not only have the ability to use information technology to construct effective teaching information resources, but also have the ability to use information technology for teaching design and the methods and strategies of integrating information technology in specific subject courses.

In addition, with the in-depth development of the integration of information technology and music curriculum, the information environment looks forward to the comprehensive improvement of the information literacy of music normal students [20]. It actually appears in the following three aspects: first, the awareness of the importance of information technology and information resources needs to be further strengthened. A survey of the conservatory of music of a normal university directly under the Ministry of Education is shown in Table 2. Most music normal students feel that information technology is important to them, accounting for 92% of the respondents. However, the very important proportion instrument is 39%, which is relatively low. In addition, 1% of people think that the importance of information technology is general. Although the proportion is small, there is still room for music normal students to fully adapt to the trend of the information age. In the cognition of the importance of information resources, music normal students have a higher degree of cognition, and more than 50% hold the concept of "very important." As young students, there are subjective and objective reasons for their high awareness of information technology and information resources. However, we should not ignore the problem of improving the cognitive level of some students who are still hesitant and
lack of understanding. The relative amount of these students may be very small, but the absolute amount is still very large [21].

Secondly, the cognition of the importance of information technology and resources is only the first level. At present, the lack of information knowledge of music normal students is a more prominent problem. As shown in Table 3, multimedia teaching is an essential teaching skill in the information environment. The survey shows that 18% of music normal students still do not understand multimedia knowledge, and even fewer music normal students have a deep understanding of the basic principles of network, computer hardware and system maintenance, network security, and computer viruses. Understanding this information knowledge is the premise of using information technology ability. The lack of understanding will inevitably affect the exertion of music normal students’ information skills.

Thirdly, the ability of music normal students to use information technology needs to be improved. As shown in Table 4, among the music normal students surveyed, two-thirds often take the initiative to find information of interest, which accounts for a high proportion, but more than 30% of the music normal students only occasionally, which is still insufficient. For whether to use the Internet to find course-related materials, the proportion is lower, the proportion of frequent use of Internet search is less than 50%, and a small number of students will not use the Internet for preclass learning.

In traditional teaching activities, the unequal authority between teachers and students formed by focusing on the teaching of knowledge is conducive to the mastery of knowledge to some extent, but it is not conducive to the cultivation of students’ ability. The advent of information society has created conditions for teaching reform. It brings the integration of teaching design ability, teaching implementation ability, teaching evaluation, and reflection ability in the information technology platform. The reason why it is an important change is that the three have realized the new integration of teaching relations under the integration of information technology [22]. For example, in the teaching implementation stage, teachers no longer simply rely on the static knowledge provided by textbooks for teaching but may make more use of multimedia and other information-based teaching tools, build a dynamic knowledge display platform based on static book knowledge, and present the teaching content in different ways. Second, to student-centered, the relationship between teaching and learning tends to be equal. Of course, this equal relationship is not absolute equality but emphasizes two-way promotion, two-way incentive, and two-way expansion in the promotion of knowledge and ability, as shown in Figure 4.

The outstanding feature of new students is the expansion of autonomous learning ability. Of course, this is the change of learning environment created by information environment, but whether it can be realized also depends on students’ own learning enthusiasm. In this sense, informatization only provides potential conditions for students’ autonomous learning, and its real effectiveness is inseparable from teachers’ guidance and assistance. However, on the basis of the expansion of autonomy, more importantly, students’ collaborative ability has been enhanced. In traditional teaching activities, the expansion of students’ autonomy is limited by many conditions. However, in the information environment, students’ autonomous learning ability and opportunities have been enhanced. At the same time, in the same teaching activity, through mutual observation and reference, exchange and discussion, and mutual cooperation, the ability of students has been improved, and the learning efficiency is bound to increase [23]. At the same time, for normal students, the enhancement of learning ability based on self-experience has a great enlightenment for their future teaching activities, as shown in Figure 5.

<table>
<thead>
<tr>
<th>Type</th>
<th>Very important</th>
<th>Importance</th>
<th>General</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance of information technology</td>
<td>39</td>
<td>53</td>
<td>7</td>
<td>100</td>
</tr>
<tr>
<td>Importance of information resources</td>
<td>53</td>
<td>46</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type</th>
<th>Deep understanding</th>
<th>General</th>
<th>Lack of understanding</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multimedia knowledge</td>
<td>84</td>
<td>15</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Basic principles of network</td>
<td>67</td>
<td>32</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Computer hardware and system maintenance</td>
<td>28</td>
<td>54</td>
<td>7.14</td>
<td>100</td>
</tr>
<tr>
<td>Network security and computer viruses</td>
<td>32</td>
<td>60</td>
<td>7.14</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type</th>
<th>Often</th>
<th>Occasionally</th>
<th>No searching</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Take the initiative to find information of interest</td>
<td>67</td>
<td>32</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Use the Internet to find course-related materials</td>
<td>32</td>
<td>60</td>
<td>7</td>
<td>100</td>
</tr>
<tr>
<td>Use the Internet for preclass learning</td>
<td>46</td>
<td>53</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>
4. Experiment and Discussion

Short-time Fourier transform (STFT) is an effective tool to describe the local spectrum distribution of signal and its change with time. It is also the most commonly used time-frequency transform method in music information retrieval. Given a discrete-time signal $x$ with sampling rate $F_s$, the STFT of $x$ can be obtained by the following steps: firstly, $x$ is divided into frames on the time axis, and there is generally a certain proportion of overlap between adjacent time frames. Then, add windows for each time frame, such as Hamming window and Hanning window, to reduce spectrum leakage. Finally, each windowed time frame is Fourier transformed, and the results are spliced frame by frame. Assuming that the frame length used for STFT is $N$, the overlap is 50%, and the window used is $w$, the STFT result of $X$ can be written as follows:

$$X(k, t) = \sum_{n=1}^{N} w(n)x\left(n + \frac{t - 1N}{2}\right) \times \exp \left\{-j2\pi(k - 1)\frac{(n - 1)}{N}\right\},$$  

(1)
where \( k = 1, k \) and \( t = 1, \ldots, t \) is the index of frequency band and time frame, respectively, \( k = N/2 + 1 \), and \( t \) is the number of frequency band and time frame, respectively. The time corresponding to \( X(k, t) \) is \((t - 1)N/(2F_s)\) (in seconds), and the frequency is \((k - 1)F_s/N\) (in Hertz).

The frequency scale of STFT is linear, which is inconsistent with human perception of music. At present, the popular music theory uses a logarithmic frequency scale, which defines that the distance between each frequency and twice its frequency (i.e., an octave) corresponds to an interval of the same length. Influenced by this theory, researchers began to use the time-frequency representation of logarithmic frequency scale in music information retrieval. The center frequency of each frequency band is calculated according to the following formula:

\[
f_k = f_1 \cdot 2^{k - 1}/B,
\]

where \( k = 1, k \) stands for Band Index, \( k \) represents the number of frequency bands, \( f_1 \) is the center frequency of the lowest frequency band, and \( B \) stands for the number of bands per octave. Note that the ratio of the bandwidth of each band to the center frequency is a constant:

\[
Q = \frac{f_k + 1 - f_k}{f_k} = \frac{f_k + 1}{f_k} - 1 = 2\varphi - 1.
\]

Therefore, the logarithmic frequency scale time-frequency transform is also called constant \( Q \) transform (CQT).

The time-frequency representation based on Gammatone filter bank is commonly used in computational auditory scene analysis (CASA). Given a piece of music signal, this time-frequency representation can be calculated by the following steps: (1) make the input signal pass through a gamma pass filter bank (usually 128 frequency band), and the center frequencies of each frequency band are distributed in proportion to the equivalent rectangular bandwidth (ERB). The Gammatone filter bank is the standard model of cochlear filtering, in which the impulse response of the Gammatone filter bank with center frequency \( f \) is as follows:

\[
g(t) = t^{N-1} \exp \{-2\pi bt\} \cos (2\pi ft),
\]

where \( N \) is the rank of the filter and \( b \) is the equivalent rectangular bandwidth. (2) Let the response signal of each filter band pass through a hair cell transduction model, which simulates many characteristics of auditory nerve response. (3) In each filter band, the output signal is divided into frames on the time axis, and there must be some overlap between adjacent frames.

Matrix decomposition is a technique to decompose the input matrix into the product of two or more matrices. In the field of music information retrieval, a popular matrix decomposition method in recent years, nonnegative matrix factorization (NMF) has been used. NMF is an unsupervised use of linear representations for nonnegative data. Given a nonnegative matrix \( X \) of dimension \( K \times T \) and a positive integer \( J \), NMF will find an approximate decomposition:

\[
X \approx BG.
\]

NMF imposes nonnegative restrictions, allowing only addition to the original data rather than subtraction combination, resulting in part-based representation.

In NMF decomposition, formula (5), in this process, the elements of all matrices are limited to nonnegative. For audio applications, the most frequently used cost function is Kullback-Leibler (K-L) divergence, as shown in the following formula:

\[
D(X\|BG) = \sum_{k=1}^{K} \sum_{t=1}^{T} X_{k,t} \log \frac{X_{k,t}}{[BG]_{k,t}} - X_{k,t} + [BG]_{k,t}.
\]

So it is closer to human auditory perception system. Two new mono singing and accompaniment separation algorithms will be proposed. In these two algorithms, we will also use K-L divergence as the cost function to solve NMF. In order to solve the minimization problem of K-L divergence, a simple method is proposed. This method first initializes \( B \) and \( G \) with random positive numbers and then iteratively updates \( B \) and \( G \) with the following multiplication rules.

\[
B - B \odot \frac{(X/BG)G^T}{1G^T},
\]

\[
G - G \odot \frac{B^T(X/BG)}{B^T1},
\]

where \( A \odot B \) and \( A/B \) are multiplication and division between \( A \) and \( B \), respectively, and \( 1 \) is a full 1 matrix of the same size as \( X \). The CQT time spectrum is converted into gray image for image feature extraction. In order to achieve this goal, we first logarithmicize the amplitude of the time spectrum according to the following formula:

\[
s(k, t) = \log |Y(k, t)|,
\]

where \( Y \) is the spectrum at CQT and \( k \) and \( t \) are the indexes of frequency band and time frame, respectively. Compared with the original time spectrum, the logarithmicized time spectrum strengthens the components with smaller amplitude, and robust local features can be extracted from these components. After obtaining \( S \), we then construct the time spectrum image \( I \):

\[
I(k, t) = \frac{S(k, t) - \min (S)}{\max (S) - \min (S)} \times 255,
\]

where \( \min (S) \) and \( \max (S) \) are the minimum and maximum values of \( S \), respectively.

In order to more clearly explain the above contents, we will make a more formal explanation for the relationship between pitch translation and spectral image translation.
during CQT. Given a signal component with frequency $f$, its energy is distributed around the $y(f)$-th subband, and $y(f)$ can be obtained by transforming formula (2) into the following formula ($B = 12$).

$$y(f) = \left\lfloor 12 \times \log_2 \frac{f}{f_1} + 1 \right\rfloor,$$  \hspace{1cm} (11)$$

where $\lfloor x \rfloor$ finds the nearest integer of $x$. If the signal component is subjected to pitch translation with a factor of $k$ ($k$ is a negative number indicating pitch decrease and a positive number indicating pitch increase), its frequency becomes $(1 + k)f$ and its energy will be transferred around the $y(1 + k)$ subband. Note that the position change of the energy of the signal component on the frequency axis is independent of the value of $f$, as shown in the following formula:

$$y(1 + k)f - y(f) = \left\lfloor 12 \times \log_2 (1 + k) \right\rfloor.$$  \hspace{1cm} (12)$$

**Experimental results:** as shown in Figure 6, by using the HMM-based classification method, the singing and nonsinging areas in the input song can be accurately distinguished. In particular, the accuracy of the singing area is very high for all three singing music ratios.

Figure 6 shows the precision, recall, and overall accuracy of song location for song segments in MIR-1K data set under the singing music ratio of -5, 0, and +5 dB.

Figure 7 shows the accuracy of song sound extraction for song segments in MIR-1K data set is high under the singing music ratio of -5, 0, and +5 dB.

Figure 8 shows using GNSDR for song separation of song segments in MIR-1K data set under the singing music ratio of -5, 0, and +5 dB based on the comparison among REPET proposed by Rafi, the RPCA, proposed multilayer NMF (MSNMF), the traditional pitch inference method (pitch), and improved pitch+SEG.

5. Conclusion

By using Fitzgerald and our proposed long+short method to separate Beach Boys songs at the singing music ratio of -6, 0, and +6 dB, the singing signal (left column) and music signal (right column) are relative to the average values of SDR (first row), sir (second row), and SAR (third row) of pure net singing and pure music. The cultivation of music normal students’ teaching ability supported by information technology emphasizes the deep integration of technology, teaching method, and music subject knowledge, which is helpful to stimulate and maintain music normal students’ learning motivation, understand and improve music
knowledge and skills, and master and apply teaching method knowledge and skills. Firstly, the learning motivation has been stimulated and maintained, which is mainly reflected in the fact that the music normal students have greatly improved their initiative and enthusiasm in the process of technology integrated learning with the support of information technology, especially in the increase of the interaction frequency between teachers and students and the enhancement of learners' desire for in-depth learning after class. Secondly, the mastery of the learned knowledge is more solid and reliable, which is highlighted in the achievements made by music normal students through learning, whether in music knowledge test or music creation, reflecting not only in the average score of students, but also in the number of high segments. Finally, students' mastery and application level of teaching methods have been greatly improved, which is prominently reflected in the fact that music normal students can skillfully master the knowledge of teaching methods through learning and practice, specifically reflected in the improvement of test scores. On the other hand, they can flexibly use the knowledge of teaching methods and even explore their own teaching methods in combination with their own reality. It is embodied in the improvement of the quality of its teaching design works.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

References


