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Status and Reform of Piano Teaching in Public Art Education in Colleges and Universities under the Background of Deep Learning

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Abstract This paper integrates the advantages of piano teaching online and offline learning process to construct a blended teaching model. The TDINA model is used to analyze the cognitive diagnosis of online learning. The TDINA model is used to analyze the cognitive diagnosis of online learning. The TDINA model is used to obtain the personality characteristics of the student users such as learning objectives and cognitive ability level, and based on the EM algorithm, the TDINA model is used to fully explore the personality characteristics of the student users and the implicit information in the teaching resources, and the teaching resources matched with the learning level of the student users are pushed to the students. The questionnaire was used to understand the current status of piano teaching in University Z, and to explore the differences between online and offline teaching and the effectiveness of blended teaching. The results show that the P-values of the students who received online and offline teaching in terms of teaching matching, teaching interaction and teaching effect are P=0.32, P=0.003 and P=0.36 respectively.The average time of single-note playing, interval and chord and two-handed ensemble playing of Group I in the post-test is 36, 43 and 6 s faster than the average time of the pre-test, respectively.Therefore, blended teaching has a significant effect on the fingering and speed of piano playing. significant effect on the fingering and speed of piano playing.

Index Terms deep learning, blended learning, TDINA model, teaching resources

I. Introduction

The promotion of piano art through piano teaching in colleges and universities holds significant importance. In the context of an expanding enrollment scale, the number of piano students in higher education institutions has significantly increased. As these institutions cultivate a larger pool of piano students, they simultaneously offer numerous opportunities for students to perform on stage. Each performance contributes to the artistic and cultural development of the school, regardless of its scale [1-3].

Currently, while most colleges and universities have introduced piano classes, inadequate attention is given to this discipline, neglecting its development. Furthermore, professional input and support for piano education are relatively weak, with irregular tuning and maintenance of school pianos, and faulty instruments often not being promptly repaired or replaced. This significantly impacts students' motivation to practice and the overall quality of piano education in these institutions. These issues stem from the institutions' inadequate understanding of the importance of piano teaching [4-6]. Additionally, some college and university teachers continue to employ traditional teaching methods, where students are passive recipients of knowledge, hindering their ability to develop independence, initiative, and sustain their interest and motivation in learning. Consequently, the teaching outcomes fail to meet students' actual needs. Moreover, academic exchanges among college piano teachers are overlooked, and there is a lack of focus on building a high-quality teaching staff. Teaching seminars and teacher evaluations are often formalistic, impeding teachers' personal and professional growth and innovation. Chinese colleges and universities' piano teaching has been influenced by traditional teaching models for years. Despite recent reforms and changes, the teaching mode remains outdated, and the teaching environment generally lacks motivation, unable to inspire students' passion for the piano or achieve ideal teaching goals [7-9]. Firstly, the traditional concept of piano teaching is deeply entrenched, and college piano teaching often prioritizes technical skills over comprehensive development.

Literature [11] investigates the application of Internet of Things technology and multimedia technology, selecting suitable specific algorithms to conduct in-depth research on piano intelligent teaching. This research aims to enhance the effectiveness of current piano intelligent teaching systems and holds significant reference value for the development of this field. Ref. [12] outlines the direction of network informatiza-

tion reform and construction for piano majors in colleges and universities, encompassing three primary aspects: integrating piano "micro-lesson" teaching into traditional classroom settings, leveraging new media to establish a networked piano learning environment, and constructing a "MOOC" platform tailored to piano instruction.Literature [13] examines the implementation strategies of piano teaching systems and introduces a neural network model-based method to assess piano performance, addressing the limitations of one-way knowledge transfer and lack of interaction in computerized piano instruction. This approach simulates teacher guidance during practice sessions, thereby contributing significantly to piano teaching.Literature [14] delves into the essence and defining features of intelligent teaching for music teachers within the framework of "Internet +" education, while also identifying the key factors that influence the development of intelligent teaching practices among music educators. The study emphasizes the importance of harnessing network technology to optimize traditional teaching methodologies, enhance teaching efficiency, and foster the cultivation of musical talents for the nation.

By leveraging network technology to its fullest potential, we can optimize traditional teaching methodologies, enhance teaching efficiency, and foster the development of numerous musical talents for the nation. Literature [15] devised a system model tailored to the specific requirements of music classroom instruction, implementing speech feature recognition through the utilization of intelligent speech recognition technology. Experimental research was conducted to validate and analyze the performance of this constructed system, revealing its notable impact on the music classroom assisted teaching system.Literature [16] employs a comprehensive array of next-generation information technologies, including big data, the Internet of Things, mobile internet, and artificial intelligence, to formulate a scientifically rigorous and intelligent music teaching design model. This approach has, to a considerable extent, catalyzed the transition towards more intelligent teaching and learning methodologies, making music classroom instruction more targeted and efficacious.

In this paper, we employ the TDINA model and the EM algorithm within the framework of deep learning to achieve cognitive diagnosis for an online piano teaching platform. Specifically, we derive a personalized student-user model and a student-knowledge mastery matrix. Furthermore, we integrate the education recommendation domain with deep learning techniques to facilitate the recommendation of teaching resources tailored to students' proficiency levels. The TDINA model is leveraged to model students' cognitive abilities by analyzing the collected student response data, thereby generating the student-knowledge mastery matrix. We proceed to analyze and compare the online teaching effectiveness of the piano course with its offline counterpart, delving into the respective merits and drawbacks. Subsequently, we synthesize the advantages of both online and offline teaching to construct a hybrid piano teaching model. By adopting control variables, we compare and analyze the efficacy of this hybrid approach,

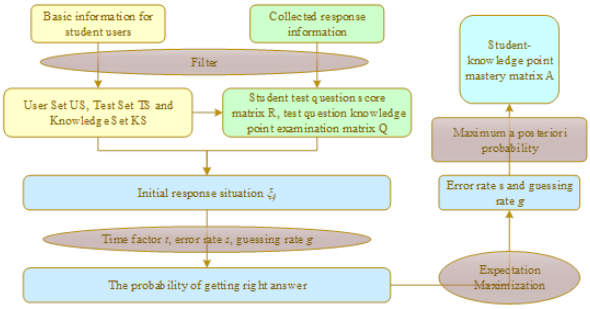

Figure 1: TDINA model algorithm process

ultimately aiming to drive an innovative reform in piano teaching methodologies.

II. The TDINA Model for Cognitive Diagnosis in the Online Piano Classroom

Currently, in the majority of piano classroom settings, online education platforms, and smart classrooms, piano students are typically assessed via traditional examination papers. However, these test results primarily mirror the students' scores in piano majors, overlooking the intricacies of their cognitive processes, knowledge structures, and cognitive ability levels as evidenced through their specific responses. Consequently, there exists a deficiency in mechanisms designed to delve deeper into the nuances of piano majors' answer patterns. The development of an accurate algorithmic model aimed at determining the knowledge and ability levels of piano major students' users holds the potential to enhance our current understanding of their cognitive ability levels. This endeavor is pivotal in addressing the aforementioned issues.

A. Tdins modeling

The algorithmic flowchart of the TDINA model is presented in Figure 1. The TDINA model belongs to the realm of potential classification models within the broader framework of cognitive diagnostic modeling. It is particularly suited for the cognitive diagnosis of dichotomously scored item tests. In detail, the model's operation can be delineated into eight distinct steps.

- Step 1: Assuming that the target piano student user is u_i, filter the redundant data with small relationship according to the basic information (e.g., grade information, subject information, etc.) of the piano student user u_i, so as to obtain the initial piano student user set $US = \{u_1, u_2, u_3, \ldots, u_m\}$, test question set $TS = \{t_1, t_2, t_3, \ldots, t_n\}$ and knowledge point set $KS = \{k_1, k_2, k_3, \ldots, k_l\}$.
- Step 2: Construct the piano student-test score matrix from the behavioral data (mainly answer data) collected by the system, which is denoted as $R_{m\times n}$. Construct the test question-knowledge point examination matrix from the knowledge point data annotated by some piano experts in universities, which is denoted as $Q_{n\times l}$.

- Step 3: Define that each piano student user u_i can obtain a knowledge point mastery vector $\vec{\alpha}_i = \{\propto_{i1}, \propto_{i1}, \propto_{i1}, \ldots, \propto_{il}\}$, where $\propto_{ij}= 1$ indicates that the piano student u_i has mastered the knowledge point k_j, and $\propto_{ij}= 0$ indicates that the piano student u_i has not mastered the knowledge point k_j.The final purpose of the TDINA model is to find out the piano student-knowledge point mastery matrix $A = \{\overrightarrow{\propto_1}, \overrightarrow{\propto_2}, \overrightarrow{\propto_3}, \ldots, \overrightarrow{\propto_m}\}$.
- Step 4: Define the initial response of the piano student as in (1), where $\xi_{ij} = 1$ indicates that the piano student user u_i has mastered all the knowledge points examined in test question t_j. On the contrary, $\xi_{ij} = 0$ means that the piano student user u_i has not fully mastered all the knowledge points examined in test question t_j:

$$\xi_{ij} = \prod_{k=1}^{l} \alpha_{ik}^{q_{jk}}. \tag{1}$$

- Step 5: Combine the actual situation of piano student users, i.e., piano students have a certain amount of mistakes and guesses when answering a certain test question. Therefore, the error rate and guessing rate are defined as (2) and (3), respectively:

$$s_j = p\left(r_{ij} = 0 \left|\xi_{ij} = 1\right.\right). \tag{2}$$

$$g_j = p\left(r_{ij} = 1 \left|\xi_{ij} = 0\right.\right). \tag{3}$$

- Step 6: Combine the formulas defined in the previous steps as well as the matrices to compute the positive answer rate $p\left(r_{ij} = 1 \left|\alpha_i\right.\right)$ on test t_j, which is represented by the formula as in (4):

$$p\left(r_{ij} = 1 \left|\alpha_i\right.\right) = \left(1 - s_j\right)^{\xi_{ij}} {g_j}^{1-\xi_{ij}}. \tag{4}$$

- Step 7: Analyzing from the perspective of piano students, the positive answer rate of piano students for the test questions changes with the continuous change of their own personality, the piano students' own personality information has a great influence on the calculation of the positive answer rate, among all the personality information of piano students, some information is relatively stable such as name, gender, subjects studied, etc., but there is also part of the information is constantly changing such as the answer record time, the number of times the knowledge point is answered, and the mastery rate of the knowledge point. The TDINA model proposed in this study takes into account the fact that piano students have a forgetting effect on the history of answered questions and a consolidation memory effect on the number of times they answered Question t_j, and that both of these effects are a function of time. Based on this, this paper improves the DINA model by introducing these two aspects simultaneously into the time factor τ_j, where the time factor is defined as in (5):

$$\tau_j = T\left(\lambda, \alpha, \beta\right) = \frac{\sum \beta\left(1 - \lambda t^{\alpha}\right)}{count\left(\beta\right)}, \tag{5}$$

where λ and α are constant parameters used to fit the Ebbinghaus forgetting curve, β parameter for the piano student user history of answering question t_j, if the piano student answered correctly then 1, otherwise the value of 0, $count\left(\beta\right)$ represents the number of times the piano student answered question t_j, combined with the positive answer rate in Step 6 to get the final formula for the positive answer rate of the piano student as formula (6):

$$p'\left(r_{ij} = 1 \left|\alpha_i\right.\right) = T(\lambda, \alpha, \beta)\left(1 - s_j\right)^{\xi_{ij}} {g_j}^{1-\xi_{ij}}. \tag{6}$$

- Step 8: Maximize the marginal likelihood in Eq. (6) by the EM algorithm to find the maximum likelihood estimator for the miss rate $\hat{j}$ and the maximum likelihood estimator for the guess rate $\widehat{g_j}$. Finally, the maximum posterior probability algorithm is used to find the knowledge point mastery vector estimator for this piano student-user $\hat{\vec{\alpha}}$.

B. EM algorithm solution

Since there are several hidden variables in the TDINA model that are not directly observable, the EM algorithm is needed to solve the parameter estimation problem for incomplete data.The TDINA model is a conditional distribution of response data r_{ij} given the knowledge point mastery vector $\overrightarrow{\alpha_1}$ of piano students. Here it is assumed that the piano students' responses to each question are independent given the attribute vectors.

Thus the conditional distribution of $\vec{r}$ is obtained as in (7):

$$L\left(\vec{r}_i \left|\alpha_i\right.\right) = \prod_{j=1}^{n} p'\left(r_{ij} = 1 \left|\overrightarrow{\alpha_i}\right.\right)^{r_{ij}} \left(1 - p'\left(r_{ij} = 1 \left|\overrightarrow{\alpha_i}\right.\right)\right)^{1-r_{ij}}. \tag{7}$$

The conditional probability distribution of the score matrix R for m piano student U can be obtained from (6) as in (8):

$$L\left(R \left|A\right.\right) = \prod_{i=1}^{m} L\left(\overrightarrow{r_i} \left|\alpha_i\right.\right) \tag{8}$$

$$= \prod_{i=1}^{m}\prod_{j=1}^{n} p'\left(r_{ij} = 1 \left|\overrightarrow{\alpha_i}\right.\right)^{r_{ij}} \left(1 - p'\left(r_{ij} = 1 \left|\overrightarrow{\alpha_i}\right.\right)\right)^{1-r_{ij}}. \tag{9}$$

In order to calculate the estimates of the guess factor and the miss factor, the total likelihood function of the response data is given as (10):

$$L\left(R\right) = \prod_{i=1}^{m} L\left(\overrightarrow{r_i}\right) = \prod_{i=1}^{m}\sum_{j=1}^{2^k} p\left(\overrightarrow{r_i} \left|\overrightarrow{\alpha_j}\right.\right) p\left(\overrightarrow{\alpha_j}\right). \tag{10}$$

Randomly given $\Theta = \{\left(s_1, g_1\right), \left(s_2, g_2\right), \left(s_3, g_3\right), \ldots, \left(s_n, g_n\right)\}$ set of initial values. Then step E & M of the EM algorithm is executed.

Step E: Compute matrix $P\left(R \left|A\right.\right) = \left[p\left(\overrightarrow{r_i} \left|\overrightarrow{\alpha_j}\right.\right)\right]_{m\times 2^k}$ using the s_j & g_j estimates obtained from the previous

round of EM and compute the values of matrix $P(A|R) = [p(\overrightarrow{\alpha_j}|\overrightarrow{r_i})]_{m\times 2^k}$ using $P(R|A)$, where $i = 1, 2, \ldots, m$, $j = 1, 2, \ldots, 2^k$.

Step M: Let equations $\frac{\partial \log L(R)}{\partial s_j}$ and $\frac{\partial \log L(R)}{\partial g_j}$ be 0, respectively, to obtain:

$$\widehat{s_J} = \frac{I_{jk}^{(1)} - R_{jk}^{(1)}}{I_{jk}^{(1)}}, \widehat{g_j} = \frac{R_{jk}^{(0)}}{I_{jk}^{(0)}}, \tag{11}$$

where $I_{jk}^{(0)}$ represents the number of piano students who have fully mastered all the knowledge points examined in question j, which is the expected value of the number of piano students in the k knowledge point mastery mode, $R_{jk}^{(0)}$ represents the expectation of the number of piano students who answer question j correctly in question $I_{jk}^{(0)}$, and the meanings of $I_{jk}^{(1)}$ and $R_{jk}^{(1)}$ are similar to those of $I_{jk}^{(0)}$ and $R_{jk}^{(0)}$, except that $I_{jk}^{(1)}$ and $R_{jk}^{(1)}$ are the values obtained by piano students if they master all the knowledge points examined in question j. Therefore, the estimates calculated in step E can be used to calculate the values of $I_{jk}^{(0)}$, $R_{jk}^{(0)}$, $I_{jk}^{(1)}$, and $R_{jk}^{(1)}$, and from these, a new estimate of the miss rate s_j versus the guess rate g_j can be obtained.

Repeat steps E and M until each θ-component converges. Find the maximum likelihood estimator of the error rate $\hat{S}$ and the maximum likelihood estimator of the guessing rate $\widehat{g_j}$. Finally, find the knowledge point mastery vector estimator $\widehat{\alpha}_i$ of the piano student-user through Eq. (6) in combination with the maximum a posteriori probability algorithm (i.e., Bayes' Theorem), which leads to the piano student-knowledge point mastery matrix A, thus completing the diagnosis of the cognitive ability level of the piano student-user.

III. Blended Online and Offline Teaching Based On Deep Learning

In the new era of online education, marked by the emergence of novel changes and trends in piano teaching, such as the integration of online and offline piano instruction and the formulation of hybrid teaching methodologies, piano education necessitates leveraging the Internet to transcend the constraints of traditional teaching in terms of time and space. The aim is to achieve a seamless blend of online and offline instruction, as well as individual and collective teaching approaches, thereby enhancing students' piano learning efficiency in today's technologically advanced landscape. Utilizing deep learning technology, we can analyze the vast array of college piano online teaching data, examining the behavioral patterns emanating from daily teaching activities of both educators and learners. This analysis facilitates a deeper and more nuanced understanding of teachers' instructional strategies and students' piano practice progress.The utilization of big data systems can assist piano teachers in comprehending and managing the learning status of students with greater precision and efficacy. By conducting big data analysis, teachers can accurately discern students' learning preferences and needs, thereby fostering their independent thinking and problem-solving abilities, rendering piano instruction more tailored to individual needs. Currently, universities and colleges face a phenomenon of "theory neglect" in piano teaching, partly stemming from the "one-size-fits-all" approach in classroom instruction and partly due to students' disinterest in theoretical classes, leading to inadequate grasp of theoretical knowledge. Consequently, there is an objective imperative for an effective assessment of theoretical knowledge mastery. This assessment should transcend the confines of midterm and final exams, incorporating the distribution of knowledge points and harnessing the big data network platform to administer tests of varying difficulty levels, tailored to the students' diverse capabilities. This approach will better evaluate students' theoretical knowledge mastery and enhance their theoretical knowledge base.

IV. The Current Situation of Piano Teaching and the Practice Of Mixed Teaching Reforms

This chapter will analyze the students' piano skills in the tdina model and the em algorithm.

A. Status of piano teaching

This study selects University Z as the target institution for investigation. To ensure the comprehensiveness and specificity of the survey, a substantial number of questionnaires were administered, with 420 student questionnaires distributed and all 420 returned as valid responses. The outcomes pertaining to the current state of piano teaching are presented in Table 1. Subsequent to a meticulous analysis of the survey results, targeted in-depth interviews were conducted to delve into the typical and salient issues identified.

The overwhelming majority of students express satisfaction with the level of sophistication and adequacy of classroom teaching equipment, which fulfills the stipulated requirements. Nonetheless, the integration of more advanced intelligent equipment remains to be implemented.

The overall situation is generally satisfactory, with an overwhelming 90.71% of students perceiving the equipment available for after-school practice as either very adequate or more than adequate.

A total of 16.67% of students perceive reading music as the primary obstacle in piano learning, whereas 45.24% consider the coordination of hands to be the greatest challenge. Additionally, 31.19% of students cite rhythm as the primary difficulty, and 6.9% select 'others' as their primary concern. Further interviews reveal that fingering and tempo issues, among others, also pose significant challenges in the process of piano learning.

A significant proportion of 69.76% of the students reported that their learning ability had been enhanced through piano lessons, while 29.05% perceived no improvement, and a marginal 1.19% expressed that their learning ability had declined. Nonetheless, the overall trend remains positive and optimistic.

B. Exploring the differences between online and offline piano teaching

	N	Proportion
Piano equipment improvement		
Perfect	166	39.52%
General perfection	244	58.10%
Imperfection	10	2.38%
Whether the student is adequate after class		
Adequacy	138	32.86%
General adequacy	243	57.86%
Inadequacy	39	9.29%
Piano lessons are difficult to learn		
Read the five line spectrum difficulties	70	16.67%
Hands fit	190	45.24%
Rhythm uncertainty	131	31.19%
Other	29	6.90%
Learning ability improvement survey		
Ability to improve	293	69.76%
Ability not to ascend	122	29.05%
Reduced ability	5	1.19%

Table 1: The present situation of piano teaching at z university

Dimension	F	Sig.	T	df	Sig. (two side)
Teaching compatibility	0.276	0.604	-2.171	117	0.032
Teaching interactivity	0.377	0.544	3.374	108	0.003
Teaching effect	1.333	0.253	2.149	129	0.036

Table 2: Mixed teaching differences

1) Differences in teaching models

The target of this questionnaire is the students in three grades of University Z, 2023, 2022 and 2021, the questionnaire recovered a total of 350 copies, and finally got 320 valid questionnaires, with a validity rate of 91.4%.Teaching compatibility is a questionnaire dimension based on the degree of adaptability between the students and the teaching methods, and whether or not the teaching of the different teaching methods can be adapted by the students. Teaching interactivity is to verify the students' activity in classroom teaching, and the issue of classroom activity in different teaching formats also affects the teacher's teaching. Learning Effectiveness is to understand the respondents' self-assessment of their own learning, and to provide feedback on teaching effectiveness from the students' own point of view. It is generally assumed that online teaching will make the students' interaction quality better, and the participation and learning motivation of the offline teaching students is better. In order to objectively show whether there is a difference between students' learning in piano courses under different teaching modes, an independent sample t-test was conducted on the data by assigning values in SPSS software, and the statistical data results are shown in Table 2, which shows that there is still a difference between online piano course teaching and offline piano course teaching. In terms of pedagogical matching, there is a significant difference between students who receive online instruction and those who receive offline instruction ($P=0.32 < 0.05$). In terms of teaching interactivity ($P=0.003<0.05$). In terms of teaching effectiveness ($P=0.36<0.05$).

2) Pedagogical matching

The descriptive statistics method in SPSS was utilized to analyze the students' perceptions of instructional compatibility across various teaching modes, and the corresponding survey data are presented in Table 3. The data in the table indicates that, in relation to the teaching methodology of the piano course, students participating in the online teaching mode expressed less satisfaction with the adopted teaching method compared to those engaged in the offline teaching mode, who reported a high level of comfort with the teaching approach. Regarding teaching objectives, students in the online setting (with a mean score of 4.6318) demonstrated a clear understanding of the objectives and tasks of the piano course, whereas those in the offline setting (mean score: 3.2813) had a more moderate comprehension of the same, indicating suboptimal performance. In terms of content, students in the online instruction group (mean score: 3.0508) did not perceive the online piano course content as sufficiently rich, whereas those in the offline instruction group felt that the traditionally taught piano classroom offered a diverse and engaging content experience (mean score: 4.8207). Lastly, concerning learning needs, students who experienced both online and offline teaching modes did not exhibit a significant discrepancy in their assessments, acknowledging that both modes were equally capable of catering to their piano learning requirements.

3) Pedagogical interactivity

Teaching interactivity is categorized into three indicators: teacher-student interaction, student-student interaction, and diversification of interaction modes. Descriptive statistics were conducted by importing the relevant data, and the statistical outcomes are presented in Table 4. Based on the data in the table, it can be inferred that there are notable differences in teaching interactivity between online and offline teaching modes.In terms of teacher-student interaction, the level of engagement between students and teachers in online teaching is lower, with students exhibiting less willingness to communicate with teachers regarding piano-related issues and displaying weaker initiative. Conversely, in the traditional offline teaching mode, students were more inclined to seek out opportunities to discuss piano-related matters in the piano classroom and demonstrated higher levels of initiative.Regarding student-student interaction, the initiative displayed by students in the online teaching environment (mean score: 3.646) remains lower than that of students in the traditional offline setting (mean score: 4.2535). Notably, most students in the online setting communicate with peers at a general level and fail to actively form piano study groups. In contrast, students in the offline mode were more proactive in engaging with their peers, often forming piano groups centered around various piano-related activities to explore and discuss lesson content.Concerning the diversity of interaction methods, both online and offline teaching modes were perceived as lacking significant diversity in communication channels. Surprisingly, however, students in the online mode reported perceiving a wider array of ways to communicate with their teachers, albeit with less proactivity, believing that online teaching offered more diverse interaction avenues with instructors.

Index	Teaching mode	Sample size	Minimum value	Maximum value	Mean	Standard deviation
Course teaching	Online teaching	102	1	5	2.5148	1.03255
	Offline teaching	218			4.1435	0.69016
Teaching target	Online teaching	102	1	5	4.6318	0.87066
	Offline teaching	218			3.2813	1.13011
Teaching content	Online teaching	102	1	5	3.0508	1.22509
	Offline teaching	218			4.8207	2.13959
Learning demand	Online teaching	102	1	5	3.8207	1.27355
	Offline teaching	218			3.9432	1.21979

Table 3: The mean and standard deviation of the teaching matching index

Index	Teaching mode	Sample size	Minimum value	Maximum value	Mean	Standard deviation
Student-teacher interaction	Online teaching	102	1	5	3.06	1.21303
	Offline teaching	218			4.0425	1.03229
Student-student interaction	Online teaching	102	1	5	3.646	1.19192
	Offline teaching	218			4.2535	1.22774
Interaction	Online teaching	102	1	5	3.9306	1.11922
	Offline teaching	218			3.6667	2.04455

Table 4: The mean and standard deviation of the teaching interactivity index

4) Teaching effectiveness

Teaching effectiveness is categorized into four distinct indicators: self-assessment of learning outcomes, classroom performance, perceived learning pressure, and evaluation of teaching methodologies. These indicators can be quantitatively analyzed using descriptive statistical methods, and the results are presented in Figure 2.In terms of classroom performance, students who participated in online teaching (mean score: 8.27) perceived their engagement and focus to be high. It is conceivable that the offline teaching mode, due to its potentially less interactive nature, did not elicit a similarly positive assessment from students regarding their classroom performance. Regarding learning pressure, there was minimal disparity between the offline and online modes, with students rating the overall pressure of piano lessons as moderate. Specifically, students in the offline teaching mode (mean score: 3.625) reported slightly lower stress levels compared to those in the online mode (mean score: 3.429), possibly owing to the online experience's stronger emphasis on enjoyable piano activities. As for the evaluation of teaching styles, both offline and online modes were met with general satisfaction, with students from both groups concurring on the effectiveness of the instructor's teaching style and course approach. Nevertheless, when directly compared, students in the offline mode appeared to be less enthused about their teaching method compared to the online piano teaching mode, indicating a lesser degree of adaptability to the offline mode.

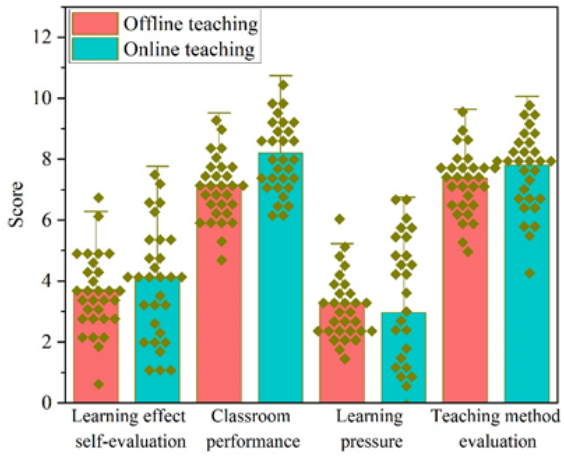

Figure 2: The mean and standard deviation of the teaching effect index

C. Measuring the effectiveness of online-offline blended teaching with deep learning

To ascertain the genuine impact of online-offline blended teaching within the framework of deep learning, a phased assessment was implemented utilizing an experimental control design. Specifically, four students constituted the non-experimental group (Group II), who underwent traditional teaching methods, while the experimental group (Group I) received online-offline blended teaching grounded in deep learning principles. In this setup, the independent variable was the implementation of online-offline blended teaching within the context of deep learning, and the dependent variable was the teaching effectiveness. To enhance the rigor of the experiment, a pre-test was administered within two days prior to the commencement of the course, and a post-test was scheduled three days subsequent to the conclusion of the course, thereby affording students sufficient time for self-directed practice.

Subjects were presented with two sets of single tones, consisting of 25 tones each for the pre-test and post-test. Members of both the experimental and non-experimental groups were tasked with playing these tones correctly in the shortest possible time. The aim of this part of the experiment was to assess the subjects' proficiency in correctly identifying the names of the single tones, and the results are summarized in Table 5.Additionally, subjects were given two sets of intervals and chords, also comprising 25 items each for the pre-test and post-test. Participants in both groups were required to play the intervals and chords accurately in the shortest time frame, with

	N	Average time (second)
Monotone		
Pre-experimental test(II)	4	228
After test(II)	4	219
Pre-experimental test(I)	4	237
After test(I)	4	201
Melody and chords		
Pre-experimental test(II)	4	332
After test(II)	4	305
Pre-experimental test(I)	4	321
After test(I)	4	278
Duplex		
Pre-experimental test(II)	4	40
After test(II)	4	37
Pre-experimental test(I)	4	38
After test(I)	4	32

Table 5: Experimental results

the objective being to evaluate their ability to correctly recognize these musical elements.Furthermore, for the pre-test and post-test, "Pumpkin Boogie Woogie" and "The Performer" were selected as the performance pieces. Members of both groups were instructed to complete playing these pieces as quickly and accurately as possible. The goal here was to measure the subjects' accuracy in recognizing the musical content of the pieces. Notably, subjects were only required to perform the two-handed ensemble sections, and the level of proficiency was not factored into the assessment.Regarding the results of the single-tone playing test (Group I), the average playing time for the pre-test was 237 seconds, while the average for the post-test was 201 seconds. For the mixed online and offline intervals and chords playing test (Group I), the average pre-test time was 321 seconds, decreasing to 278 seconds in the post-test. Notably, the average time taken to complete the two-handed ensemble performance in the post-test for Group I was 6 seconds lower than that of the pre-test, indicating a certain teaching effect.

V. Conclusion

This paper proposes the development of an online platform and a smart classroom for piano education, grounded in the TDINA model. This integration with traditional offline teaching methodologies fosters an online-offline hybrid approach to piano instruction within the framework of deep learning, thereby achieving significant reform and innovation in piano teaching methodologies. Through a comprehensive analysis of the current state of piano teaching at University Z, we conduct a comparative evaluation of the distinctiveness in teaching effectiveness between the online and offline modalities. Furthermore, we implement controlled experiments to delve into the authentic impact of the hybrid teaching approach. The outcomes of these experiments reveal the following:

- Approximately 40% of the students expressed a high level of satisfaction with the piano teaching facilities, whereas a substantial portion of them perceived that the existing piano teaching methodology at University Z did not significantly contribute to their learning capabilities.
- There is a significant difference in the difference between students who receive online and offline teaching ($P=0.36<0.05$), which is analyzed from the three specific aspects of teaching matching, teaching interactivity and teaching effect, respectively, online and offline piano teaching have their own strengths and weaknesses, and therefore they are combined to form a blended teaching.
- Hybrid teaching improves the speed of piano learners in recognizing music and has very good teaching effect.

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