Environment and Social Psychology (2024) Volume 9 Issue 11
doi: 10.59429/esp.v9i11.3208

RESEARCH ARTICLE

Mechanisms of teacher-student interaction and music teaching climate: A moderated analysis based on different social factors

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ABSTRACT

Creating a positive classroom atmosphere through teacher-student interaction is crucial for effective teaching in art disciplines, enabling students to experience the joy of learning in a relaxed and engaging environment. While existing research highlights the significant role of teacher-student interaction in shaping the classroom climate, particularly in music education, the current music teaching landscape in China faces unique challenges. Exam-oriented education continues to dominate, leaving limited emphasis on fostering a quality-driven, enjoyable learning experience, inhibiting the development of a harmonious and engaging teaching environment. This study investigates the mechanisms of teacher-student interaction and their impact on the music teaching atmosphere, focusing on external moderating factors. Using a sample of 110 music teachers and 390 primary music students from universities in Guangxi, the research employs quantitative analysis to explore the relationships between teacher-student interaction, classroom climate, and various moderating social factors. The findings reveal that teacher-student interaction positively correlates with the music-teaching atmosphere. Furthermore, family, technological, and school factors significantly moderate this relationship, either enhancing or constraining the overall classroom climate. This study contributes to the field of music education by identifying fundamental mechanisms and moderators influencing the classroom atmosphere. The findings provide actionable insights for improving teacher-student interactions and creating a more inclusive and enjoyable music-teaching environment, addressing the challenges posed by exam-oriented education in China. Future efforts should focus on integrating these findings into practical strategies for fostering a harmonious and engaging classroom climate in music education.

Keywords: Teacher-student interaction relationship; Music classroom atmosphere; External factors; Music education; Moderated analysis

1. Introduction

In recent years, with the deepening of China's quality education reform, the choice of teaching strategies in music education has received more and more attention[1]. In most of the studies, government financial

ARTICLE INFO
Received: 9 October 2024 | Accepted: 11 Novbember 2024 | Available online: 16 Novbember 2024

CITATION
Liu JW, Assim MISA, Taasim SIB. Mechanisms of teacher-student interaction and music teaching climate: a moderated analysis based on different social factors. *Environment and Social Psychology* 2024; 9(11): 3208 doi: 10.59429/esp.v9i11.3208

support, policy priorities, curriculum implementation and pedagogical innovations have been proposed as the prevailing solutions to address the unsatisfactory state of music education[2]. They also advocate that art teaching, including music, should be conducted in an accessible, relaxed classroom atmosphere. They also emphasize that teacher-student interaction is essential for creating such an atmosphere[3]. These interactions go beyond traditional verbal communication to encompass musical cooperation, body language, and emotional empathy, thus enriching the educational and humanistic values of the classroom[4]. Teacher-student interactions exhibit unique dynamics in different teaching and learning situations. These dynamics not only affect the quality of the interaction but also reflect the underlying educational philosophy and cultural values. For example, Huang[5] found that quality contact between teachers and students is needed in the music classroom to achieve the goals of teacher supervision and student subjectivity and proposed a computer-assisted system-based approach to music education. Li & Timmers[6] observed three pairs of college-level teachers and students in lessons to study the teaching and learning of piano timbre. They found that the meaning of timbral goals in piano lessons manifested through 'immediate' bodily experience and the action of playing. Yuting[7] conducted comprehensive quantitative and qualitative analyses of students' participation, satisfaction, and improvement of musical ability by constructing an effect evaluation system, and the results showed that the interactive teaching mode significantly improved students' interest and skill level in music learning.

However, although the relationship between teacher-student interaction and teaching climate has been widely verified, there is a relative lack of research on the moderate variables in the path of its influence[8,9]. Research on "under what conditions teacher-student interaction can better create music teaching atmosphere" is still not systematic enough[10]. In other words, existing literature has explored chiefly the issue from a single dimension and has not yet constructed a comprehensive analysis framework. From the perspective of external factors, the external variables affecting teacher-student interaction and teaching atmosphere may include family, school environment, social and cultural background, etc[11]. Unfortunately, many scholars only stay at the level of theoretical discussion, lacking empirical data support, especially in research on how external variables regulate the relationship between teacher-student interaction and teaching atmosphere. There is a noticeable gap[12].

Based on the above background, this study uses music teachers and students in Guangxi as research respondents. Quantitative research analyses the key factors and their paths affecting the relationship between teacher-student interactions and the music teaching atmosphere, especially exploring the moderating role of external social factors. The innovation of this study is that it combines teacher-student interaction, teaching climate, and social aspects, constructs a comprehensive theoretical model, and systematically analyses the complex interaction between these variables. The results of this study not only fill the gaps in existing research but also provide a scientific basis for the practice of music education, helping music teachers to design their teaching strategies better and optimize the teaching atmosphere according to the local conditions, thus promoting the high-quality development of art education in the context of a pluralistic society.

2. Literature review

2.1. Conceptual definition

2.1.1. Teacher-student interaction

Teacher-student interaction refers to all communication and engagement between teachers and students, especially in music education. This includes verbal and nonverbal communication, teaching methods, and feedback mechanisms[13]. In the scale design process, the study fully adopted Aussieker[14] and Liu et al.[15]

conducted measurements in the relevant fields, focusing on the implementation of teacher-student interaction teaching methods, the effectiveness of teacher-student interaction, and the status of teacher-student interaction. The scale content can be found in **Table 1**.

Table 1. Questionnaire for teacher-student interaction.

No.	Items	Scoring				
Q1	I am very satisfied with the teacher-student relationship	1	2	3	4	5
Q2	There is an intimate teacher-student relationship between teachers and students	1	2	3	4	5
Q3	Students are free to express their opinions in class	1	2	3	4	5
Q4	Teachers engaged in rich interactive behaviors in the classroom	1	2	3	4	5
Q5	In the process of music teaching, teachers will enthusiastically answer students' questions	1	2	3	4	5
Q6	Teachers will join students in teaching and singing	1	2	3	4	5
Q7	I think I will take the initiative to ask the music teacher for help	1	2	3	4	5
Q8	I believe that good interactive relationships can advance classroom teaching progress	1	2	3	4	5
Q9	I enjoy teacher-student communication in music classes	1	2	3	4	5
Q10	I believe that classroom interaction will not disrupt regular classroom management order	1	2	3	4	5

2.1.2. Learning climate

Learning climate in the music classroom is a multidimensional concept that includes emotional, cognitive, and behavioral climate. It reflects the quality and effectiveness of teaching and learning and influences students' learning outcomes and satisfaction[16]. This section was designed to assess the learning environment of the music classroom, including the classroom setting, instructional resources used, peer relationships, and overall classroom climate. The learning environment significantly impacts students' learning experiences and fulfillment; therefore, this section aims to reveal how to create an environment conducive to music learning. In the process of measuring dependent variables, the study was based on the scale of De Santiago et al.[17] in terms of learning atmosphere, and combined with the actual situation of music teaching, specific deletions and modifications were made to obtain the music teaching atmosphere scale studied in this article. The scale content can be found in **Table 2**.

Table 2. Questionnaire for learning climate.

No.	Items	Scoring				
Q11	I think that technology is a crucial learning environment	1	2	3	4	5
Q12	I think good peer relationships are an essential learning environment	1	2	3	4	5
Q13	I think a good teacher-student relationship is a crucial learning environment	1	2	3	4	5
Q14	The instructor encourages mutual respect among all students	1	2	3	4	5
Q15	an environment for free and open expression of ideas	1	2	3	4	5
Q16	The instructor takes into consideration differences among students	1	2	3	4	5
Q17	The instructor is fair and unbiased in the treatment of all students	1	2	3	4	5
Q18	The instructor encourages equal participation of all students	1	2	3	4	5
Q19	The physical environment (furniture and equipment, light, Indoor air quality, safety aspects) is comfortable and accessible for all students	1	2	3	4	5

2.1.3. Family factors

As the "second classroom" for students to receive education, the family plays a vital role in their education process. In the process of teacher-student interaction, families must cultivate open and brave personalities in daily life to enable students to participate in teacher-student interaction[18]. On the other hand, family education can provide students with a good foundation of quality, enabling them to have the ability to participate in teacher-student interaction, thereby making the establishment of interactive relationships between teachers and students more quality-oriented[19]. This article explores the interaction between teachers and students and the construction of a music-teaching atmosphere. We introduce family atmosphere as one of the moderating variables and analyze whether the impact of family on students will further enhance the interaction between teachers and students in constructing a music-teaching atmosphere. During the investigation process, the research focuses on analyzing two aspects of family factors, one of which is the impact of the family art atmosphere on students' music skills. The second is that the family encourages the atmosphere to cultivate students' confidence and quality. However, overall, the impact of both on students is formed by creating a good family atmosphere. Research suggests that students may have better musical literacy or bravery to respond to teacher-student interaction behavior under a good family atmosphere. In the process of measuring this variable, the study was based on the "Family Environment Scale" (FES) developed by Moss and the "Structural Family Systems Rating Scale (SFSR)" in Szapocznik's family assessment model[20,21]. Fine adjustments were made with the direction of art education to obtain the survey scale for this article, as shown in **Table 3**.

Table 3. Questionnaire for family factors.

No.	Items	Scoring				
Q20	I/My students can receive good cultural influence in their families	1	2	3	4	5
Q21	I/My students have received a good education in their families	1	2	3	4	5
Q22	I/My student's family attaches great importance to the role of family education	1	2	3	4	5
Q23	I/My students are very harmonious in their families and can actively communicate with their parents	1	2	3	4	5

2.1.4. Technical factors

With the development of modern educational technology, forms such as "online courses" and "multimedia teaching" have significantly impacted education development. On the one hand, they provide a way and means for online classrooms to be carried out. On the other hand, they offer more diverse technical means for offline teaching[22]. Regarding teacher-student interaction, teachers can use multimedia digital means in current educational activities to carry out more diverse teacher-student interaction behaviors. They can also use self-media platforms or short video channels to consolidate learning content for students after class and share excellent music and artwork to strengthen communication between teachers and students. Zhang[23] pointed out in his research that technology has enhanced the development of teacher-student interaction behavior and constructed a better classroom teaching environment. Aljaloud et al.[24] used music classrooms in Saudi universities as an example in their research, pointing out that using smartphone app technology to reform classroom teaching methods can significantly enhance the interaction between teachers and students. In this article, the technological factors selected in analyzing the impact path of teacher-student interaction and classroom atmosphere construction mainly refer to the development of educational technology. The impact of technological development on the form and content of classroom education is analyzed to see if it provides a better path for teacher-student interaction, thereby improving the classroom atmosphere. In the process of variable measurement, based on the ETSS scale in Naci Coklar & Ferhan Odabasi[25], a technical factor scale was developed in this study, as shown in **Table 4.**

Table 4. Questionnaire for technical factors.

No.	Items	Scoring				
Q24	I/My music class adopts an online and offline teaching mode for teaching	1	2	3	4	5
Q25	Digital education technology runs through our school's music classroom	1	2	3	4	5
Q26	I/My teacher is very skilled in using technology to improve the music teaching level	1	2	3	4	5

2.1.5. School factors

As the foundation of education, schools play a supportive role in developing music education. Englehart[26] noted in his literature review on teacher-student interaction that constructing a campus environment strongly impacts teacher-student interaction development. On the one hand, the artistic and cultural atmosphere created by schools can support the development of music teaching. On the other hand, the hardware facilities of the classroom provide support for educational activities, provide an essential platform for teacher-student interaction, and provide possibilities for the application of advanced educational technologies[27]. In exploring the interaction between teachers and students and the influence of the teaching atmosphere in this article, the research focuses on analyzing the impact of campus environmental factors. The definition of campus environment analyzed in this article includes the classroom hardware resources provided by the school for teaching activities and the artistic atmosphere software resources in the campus environment. While measuring variables, the study was based on the scales used by Amanda[28] and Abril & Bannerman[29], adjusted to meet the actual needs of building an art education atmosphere. The survey scale for this article was obtained, as shown in **Table 5**.

Table 5. Questionnaire for school factors.

No.	Items	Scoring				
Q27	My school is full of music atmosphere	1	2	3	4	5
Q28	The construction level of music classrooms in my school is very high	1	2	3	4	5
Q29	My school has invested much in the hardware construction of music education	1	2	3	4	5

2.2. Hypothesis formulation

This section evaluates the quality of interaction between teachers and students, including the frequency and depth of communication and the nature of the teacher-student relationship. By analyzing teacher-student interaction, this study aims to understand how this interaction affects student learning outcomes and classroom atmosphere. From previous literature research, many scholars have demonstrated that interactivity in teaching activities between teachers and students can build a positive teaching atmosphere, but they have not explicitly applied the research to music teaching[30,31]. Therefore, the study makes the following assumptions:

H1: In music teaching activities, teacher-student interaction behavior will positively impact the teaching atmosphere.

On this basis, the study aims to analyze which external factors can regulate the influence of teacher-student interaction on the teaching atmosphere. Through literature research, the article found that these potential influencing factors can be broadly divided into three aspects: family factors, technological factors, and school factors. Therefore, the research proposes the following hypotheses:

H2: Family factors will play a moderating role in influencing teacher-student interaction in the music teaching atmosphere.

H3: Technical factors will regulate the interaction between teachers and students, affecting the atmosphere of music teaching.

H4: School factors will moderate the interaction between teachers and students, affecting the music teaching atmosphere.

3. Materials and methods

3.1. Research method

A cross-sectional design was used in this study to collect data from both teachers and students. This method allowed for the examination of the relationship between teacher-student interactions and the perceived music teaching climate of both groups. This study also is a purely quantitative study, with data mainly collected through online and paper questionnaires[32]. The questionnaire (See **Table 1** to **Table 5**) aims to quantitatively evaluate the impact mechanism between the components of teacher-student interaction and music teaching atmosphere and explore the moderating variables involved. The time frame for this study is one year, which allowed for observation and analysis of changes in teaching interaction and learning environment over time, especially when comparing semesters. This period will help reveal the long-term and short-term trends in teacher-student interaction in music education. The survey design of this study focuses on understanding various aspects of teacher-student interaction in music education. The questionnaire has been carefully designed to ensure effective data collection on teacher-student interaction, teaching atmosphere, family, technical, and school factors. This design considers participants of different ages and educational backgrounds to improve the questionnaire's generalizability and the data's representativeness. In addition, this survey aims to deepen the understanding of the problems existing in music education practice and explore possible improvement measures. The design and implementation of the questionnaire are closely aligned with the research objectives to ensure that the collected data can effectively support the validation of research hypotheses.

3.2. Research materials

The sample size for this study was determined according to Cohen's[33] guidelines for statistical power analyses. The power of 0.80 was used to detect medium to large effect sizes with a minimum of 120 teachers and 400 students. This sample size ensured that there was sufficient power for the regression analyses and other statistical tests conducted in the study. A purposive sampling technique was used in this study to select a sample of 120 music teachers and 400 students from five universities in the Guangxi region. This sampling technique allows the researcher to choose purposively a specific sample group, thus ensuring that the sample is representative of the population of interest for the study. The study locations included the Guangxi Arts Institute, Guangxi Normal University, Guangxi University of Science and Technology, Liuzhou Institute of Vocational Technology, and Guangxi Urban Vocational and Technical Institute. These locations were chosen to cover different types of higher education institutions in the Guangxi region, thus ensuring that the study results are broadly applicable and representative. In the process of data sample collection, the WeChat mini program "Question Star" APP was used as the data collection method, and Excel software and SPSSAU® software were used to collect and analyze empirical data. The study population consisted of music teachers and students from five universities in the Guangxi region. During the survey, music teachers were selected from primary music schools in Guangxi for a scale survey. 120 interviewees and teachers were selected during the study, and 120 questionnaires were distributed. 110 teacher interviewee questionnaires

were collected, with an effective response rate of 91.67%. In conducting a population information survey, the author focused on investigating the gender, age, education level, and years of service of the surveyed teachers for the classroom group during the introductory information survey. The population census of the teacher group respondents is shown in **Table 6**.

Table 6. Population information census of respondents from the teacher group.

Project	Option	N	Percentage
Gender	Male	54	49.09%
	Female	56	51.91%
Age	21-30	57	51.82%
	31-40	26	23.64%
	41-50	17	15.45%
	Over 50	10	9.09%
Educational Background	Undergraduate	8	7.27%
	Master	98	89.09%
	Doctor	4	3.64%
Working life	Under 2	25	22.73%
	3-5	45	40.91%
	5-10	32	29.09%
	Over 10	8	7.27%

In the sample selection process of student respondents, the article selected 400 students from five music schools in Guangxi as the survey scope and distributed a survey questionnaire. 400 questionnaires were distributed, and 390 valid questionnaires were collected, with an effective response rate of 97.5%. In a population information survey, the author investigated the gender, grade, and student type of the subjects in the primary information survey, distinguishing between music performance and music education, the two leading professional learning directions for music students in current universities. The population census of student respondents is shown in **Table 7**.

Table 7. Population information census of respondents from the student group.

Project	Option	N	Percentage
Gender	Male	200	51.28%
	Female	190	48.72%
Grade	G1	118	30.26%
	G2	141	36.15%
	G3	131	33.59%
Student type	Music education	37	9.49%
	Musical performance	353	90.51%

3.3. Reliability and validity testing

3.3.1. Reliability

Reliability analysis is used to assess the consistency and stability of the results of a measurement instrument under different measurement conditions, often reflecting the internal consistency reliability of a questionnaire through the Cronbach alpha value[34,35]. From the results of the reliability analysis (see **Table**

8), the Cronbach alpha values of the dimensions as well as the overall scale were significantly higher than the recognized reliability standard (0.7), indicating that the questionnaire has a high degree of internal consistency and is suitable for use as a measurement tool. Cronbach's alpha value for the overall scale was 0.981, indicating that the consistency of all the entries regarding measurement objectives was very high, and the questionnaire was very reliable in its overall design[36]. The Cronbach's alpha values for each sub-dimension ranged from 0.929 to 0.985. The highest reliabilities were found for school factors (0.985) and family factors (0.983), indicating that the internal consistency of these entries was particularly significant, reflecting the stability of these entries in measuring the topics of interest. Relatively low reliability was found for Teaching Climate (0.929), but it was still well above the minimum standard, indicating that the entries were well-designed and consistent.

Table 8. Results of reliability analysis.

Scale	Cronbach α
Overall	0.981
Teacher-student interaction relationship	0.974
Teaching atmosphere	0.929
Family factors	0.983
Technical factors	0.969
School factors	0.985

Validity analysis is used to assess whether a measurement instrument accurately reflects the concepts it is designed to measure, often verifying the structural soundness and applicability of the questionnaire through methods such as KMO values and Butterball tests[37,38]. The results of the validity analysis are shown in **Table 9**. In this case, the KMO (Kaiser-Meyer-Olkin) is 0.914, which indicates that the data's fitness is very good (0.9 and above is usually considered excellent)[39]. The data was well-suited for factor analysis. Second, p-value = 0.000 indicates that Bart's sphericity test is significant, and the correlation matrix significantly deviates from the unit matrix, making it suitable for factor analysis[40].

Table 9. Results of validity analysis.

Items	Cronbach α
KMO	0.914
Barthelle's sphere value	6350.456
df	0.864
p-value	0.000

4. Results

4.1. Descriptive statistical analysis

From the descriptive statistics (See **Table 10**), the mean of most of the questionnaire items is close to 4.8, which indicates that the respondents rated each item highly and tended to be in the range of "Very Satisfied" or "Agree." The lowest rating is 2, and the highest is 5, showing a range of ratings. However, the overall distribution is favorable, indicating that the respondents generally have a positive attitude toward teacher-student interaction, learning atmosphere, family, and technical support in the questionnaire. Most Standard Deviation values are between 0.5 and 0.6, indicating that the data distribution is relatively concentrated. However, some questions (e.g., Q11, Q16, Q19, etc.) with Standard Deviation close to 0.64,

indicating a slightly more significant difference of opinion among the sample for these items. In particular, the standard deviation of Q11 ("Technology is a key learning environment") is 0.646, which may reflect the differences in the perception of the importance of technology among different respondents. Overall, the questionnaire results revealed good acceptance of the questionnaire entries among the target group. However, some of the entries may need to be further explored for their potential reasons for disagreement. For example, the slightly lower meaning value of family and technology support-related entries (Q20-Q29) compared to classroom interaction entries (about 4.66) may suggest that the impact of these factors is less perceived in actual teaching and learning. Such differences should be explored in depth in subsequent analyses to optimize relevant teaching strategies better.

Table 10. Results of descriptive statistics.

Items	N	Minimum	Maximum	Mean	Standard deviation
Q1	500	2	5	4.84	.508
Q2	500	2	5	4.84	.502
Q3	500	3	5	4.84	.498
Q4	500	2	5	4.84	.501
Q5	500	3	5	4.84	.500
Q6	500	2	5	4.81	.539
Q7	500	2	5	4.84	.498
Q8	500	2	5	4.80	.568
Q9	500	2	5	4.84	.524
Q10	500	2	5	4.85	.507
Q11	500	2	5	4.66	.646
Q12	500	2	5	4.67	.641
Q13	500	2	5	4.86	.491
Q14	500	3	5	4.87	.465
Q15	500	2	5	4.85	.497
Q16	500	2	5	4.67	.641
Q17	500	2	5	4.72	.586
Q18	500	2	5	4.81	.534
Q19	500	2	5	4.67	.638
Q20	500	2	5	4.67	.641
Q21	500	2	5	4.66	.650
Q22	500	2	5	4.66	.640
Q23	500	2	5	4.66	.632
Q24	500	2	5	4.66	.629
Q25	500	2	5	4.66	.643
Q26	500	2	5	4.67	.641
Q27	500	2	5	4.66	.643
Q28	500	2	5	4.66	.633
Q29	500	2	5	4.67	.629
Effective number of cases (in columns)	500				

4.2. Analysis of variance (ANOVA)

Analysis of variance (ANOVA) examines the difference of X (fixed category) for Y (quantitative), such as the differential relationship between different professions (students and teachers) on teacher-student interactions[41]. It consists of four steps. First, it analyzes whether X and Y show significance (p-value less than 0.05 or 0.01); second, if significance is shown; it describes where the specific differences lie by

specifically comparing the magnitude of the means; third, if significance is not shown; it indicates that there is no difference in Y under the different groupings of X; and, fourth, it summarizes the analysis[42].

The results of the ANOVA (See **Table 11**) showed significant differences between students and teachers in all items, with p-values consistently below 0.01. Students' mean scores (ranging from 4.80 to 4.97) were consistently higher than those of the teachers (ranging from 4.14 to 4.55), suggesting that students have a more favorable view of the measured aspects of teacher-student interactions or instructional climate than do teachers. This result highlights the gap that may exist between these two groups when experiencing or evaluating the same factors related to teaching and learning. Teachers had consistently higher standard deviations (0.81-0.94) compared to students (0.17-0.49), suggesting greater variability in teacher responses. This variability stems from differences in teaching environments, personal experiences, or personal perspectives, all of which can affect teachers' ratings of these items. In contrast, there was relatively little variability among students, which implies more uniformity in student perceptions due to shared classroom experiences. These results emphasize the importance of addressing the cognitive gap between students and teachers to promote better alignment.

Table 11. ANOVA results.

Items	Items	N	Mean	St. D	*F*	*p*
Q1	Student	390	4.95	0.23	105.787	0.000**
	Teacher	110	4.44	0.88		
Q2	Student	390	4.95	0.23	103.911	0.000**
	Teacher	110	4.45	0.87		
Q3	Student	390	4.95	0.23	112.026	0.000**
	Teacher	110	4.44	0.86		
Q4	Student	390	4.95	0.22	111.932	0.000**
	Teacher	110	4.44	0.87		
Q5	Student	390	4.95	0.23	109.935	0.000**
	Teacher	110	4.44	0.86		
Q6	Student	390	4.94	0.27	132.348	0.000**
	Teacher	110	4.35	0.89		
Q7	Student	390	4.96	0.21	129.597	0.000**
	Teacher	110	4.42	0.86		
Q8	Student	390	4.94	0.28	136.253	0.000**
	Teacher	110	4.31	0.94		
Q9	Student	390	4.97	0.22	137.029	0.000**
	Teacher	110	4.38	0.90		
Q10	Student	390	4.96	0.23	96.415	0.000**
	Teacher	110	4.46	0.90		
Q11	Student	390	4.81	0.48	108.825	0.000**
	Teacher	110	4.15	0.85		
Q12	Student	390	4.80	0.49	95.633	0.000**
	Teacher	110	4.18	0.86		
Q13	Student	390	4.98	0.17	125.765	0.000**
	Teacher	110	4.45	0.88		
Q14	Student	390	4.95	0.23	72.212	0.000**
	Teacher	110	4.55	0.82		
Q15	Student	390	4.96	0.23	98.310	0.000**
	Teacher	110	4.47	0.86		

Table 11. (*Continued*)

Q16	Student	390	4.80	0.49	91.423	0.000**
	Teacher	110	4.19	0.86		
Q17	Student	390	4.81	0.45	48.120	0.000**
	Teacher	110	4.39	0.84		
Q18	Student	390	4.92	0.34	102.651	0.000**
	Teacher	110	4.39	0.81		
Items	**Items**	**N**	**Mean**	**St. D**	***F***	***p***
Q19	Student	390	4.80	0.49	96.757	0.000**
	Teacher	110	4.18	0.85		
Q20	Student	390	4.81	0.48	99.986	0.000**
	Teacher	110	4.17	0.86		
Q21	Student	390	4.81	0.48	111.012	0.000**
	Teacher	110	4.14	0.86		
Q22	Student	390	4.81	0.48	111.434	0.000**
	Teacher	110	4.15	0.83		
Q23	Student	390	4.80	0.49	102.408	0.000**
	Teacher	110	4.17	0.82		
Q24	Student	390	4.81	0.48	108.375	0.000**
	Teacher	110	4.16	0.81		
Q25	Student	390	4.81	0.48	110.114	0.000**
	Teacher	110	4.15	0.84		
Q26	Student	390	4.81	0.48	99.986	0.000**
	Teacher	110	4.17	0.86		
Q27	Student	390	4.81	0.48	110.114	0.000**
	Teacher	110	4.15	0.84		
Q28	Student	390	4.81	0.48	110.570	0.000**
	Teacher	110	4.15	0.81		
Q29	Student	390	4.81	0.48	104.896	0.000**
	Teacher	110	4.17	0.81		

*$p<0.05$ **$p<0.01$*

4.3. Hypothesis verification

4.3.1. Hypothesis verification of teacher-student interaction and music teaching atmosphere

This study uses quantitative empirical research methods to analyze the relationship between teacher-student interaction and music teaching atmosphere in the process of empirical research. In verifying the influence mechanism of teacher-student interaction and music classroom teaching atmosphere, the linear regression analysis method was used to analyze the interaction mechanism between the two. Before conducting empirical testing, this study used the "variable processing mechanism" in SPSS software. It unified the Q1-Q10 and Q11-Q19 questions using mean validation to obtain variable data on the "teacher-student interaction mechanism" and "teaching atmosphere." Subsequently, the study used the linear regression method to verify the interaction mechanism between teachers and students and the influence mechanism of the music classroom teaching atmosphere. **Table 12** shows the linear regression situation:

Table 12. Teacher-student interaction relationship and teaching atmosphere linear regression analysis results (n=500).

Items	**Regression coefficient**	**95% CI**	**Collinearity diagnosis**	
			VIF	**Tolerance**

Constant	2.795** (10.498)	2.273 ~ 3.317	-	-
Teacher-student interaction relationship	0.410** (7.573)	0.304 ~ 0.516	1.000	1.000
N		500		
R^2		0.103		
Adjust R^2		0.101		
F		F (1,498) =57.352, p=0.000		

Dependent variable: Teaching atmosphere

D-W: 1.268

From the above table, using the Teacher-student interaction relationship as the independent variable and Teaching atmosphere as the dependent variable for linear regression analysis, the model formula is Teaching atmosphere=2.795+0.410 * Teacher-student interaction relationship, with an R^2 value of 0.103, indicating that the Teacher-student interaction relationship can explain 10.3% of the changes in a Teaching atmosphere. When conducting an F-test on the model, it was found that it passed the F-test (F=57.352, p=0.000<0.05), indicating that the Teacher-student interaction relationship will impact the Teaching atmosphere. Finally, the specific analysis shows that:

The regression coefficient value of the Teacher-student interaction relationship is 0.410 (t=7.573, p=0.000<0.05), indicating that the relationship will significantly impact on the Teaching atmosphere.

Summary analysis shows that all teacher-student interaction relationships have a significant positive impact on the teaching atmosphere. The mechanism of the impact between the two is shown in **Figure 1**:

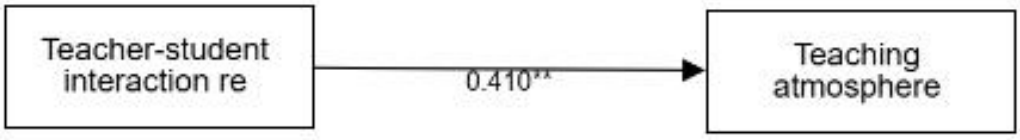

Figure 1. Schematic diagram of the influence of the mechanism of teacher-student interaction and teaching atmosphere.

4.3.2. Verification of the regulatory mechanism of family factors

Since verifying the main effect, the study has demonstrated a positive correlation between teacher-student interaction and music teaching atmosphere. On this basis, the study aims to analyze further and organize the factors influencing the mechanism of external influence. The study first validated the family factors. Before validation, the article processed the survey data of Q20-Q23 items with variables and used SPSS software "Variable Processing Mechanism" to obtain "Family Factors" variable data through mean validation. In conducting moderated variable analysis, the study must first centralize each variable. **Table 13** shows the variable processing situation.

Table 13. Explanation of study variable processing.

Type	Name	Data type	Data processing
Dependent variable	Teaching atmosphere	Ration	Not processed
Independent variable	Teacher-student interaction relationship	Ration	Centralization
Adjusting variables	Family factors	Ration	Centralization

From the above table, in this study, the treatment of the teacher-student interaction relationship and family factors was centralized, while the teaching atmosphere was not treated. Subsequently, the study validated the moderating effect of family factors, and **Table 14** shows the validation of moderating variables:

Table 14. The moderating effect of family factors (n=500).

Items	M1				M2				M3					
	B	SD	t	p	B	SD	t	t	B	SD	t	SD	B	SD	t
Constant	4.751	0.013	373.268	0.000**	-	4.751	0.006	772.022	0.000**	-	4.779	0.006	789.682	0.000**	-
Teacher-student interaction relationship	0.778	0.027	28.334	0.000**	0.786	0.429	0.016	27.069	0.000**	0.433	0.211	0.024	8.745	0.000**	0.213
Family factors						0.475	0.012	40.414	0.000**	0.646	0.461	0.011	43.479	0.000**	0.627
Teacher-student interaction relationship*Family factors											-0.178	0.016	-11.190	0.000**	-0.268
R^2	0.617				0.911				0.929						
Adjust R^2	0.616				0.910				0.928						
F	F (1,498) =802.800, p=0.000				F (2,497) = 2533.757, p=0.000				F (3,496) =2153.109, p=0.000						
$\triangle R^2$	0.617				0.294				0.018						
$\triangle F$	F (1,498) =802.800, p=0.000				F (1,497) =1633.326, p=0.000				F (1,496) =125.222, p=0.000						

Dependent variable: Teaching atmosphere

** p<0.05 ** p<0.01*

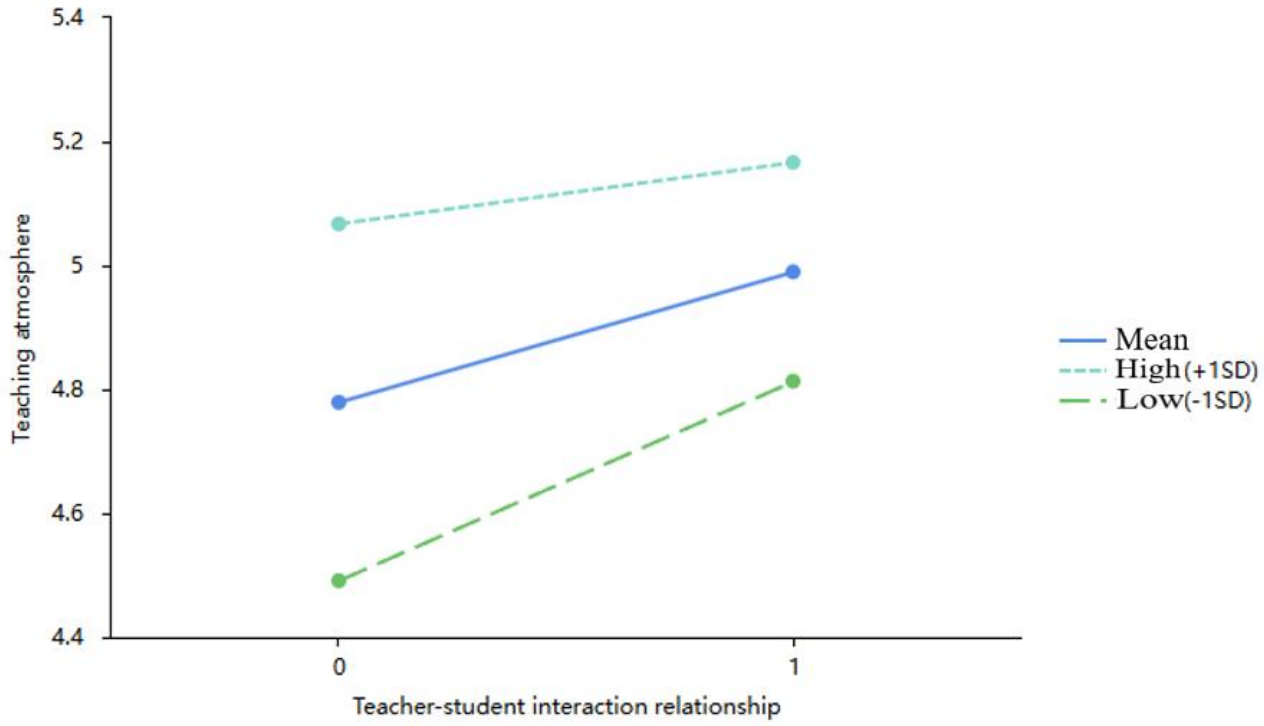

Figure 2. Slope plot of family factors moderating variables.

The regulatory effect is divided into three models from **Table 13**. Model 1 includes the independent variable (Teacher-student interaction relationship). Model 2 adds family factors to Model 1, while Model 3 adds interaction terms (product of independent and moderating variables) to Model 2. The purpose of Model

1 is to investigate the impact of the teacher-student interaction relationship on the teaching atmosphere without considering the interference of family factors. From the above table, the independent variable (Teacher-student interaction relationship) shows significance (t=28.334, p=0.000<0.05). This means that Teacher-student relationships will significantly impact on the teaching atmosphere. The regulatory effect can be viewed in two ways. The first examines the significance of the F-value change from Model 2 to Model 3. The second examines the significance of the interaction terms in Model 3 and, this time, analyzes the moderating effect using the second method. The interaction term between Teacher-student interaction relationship and Family factors shows significant differences (t=-11.190, p=0.000<0.05). This means that when the Teacher-student interaction relationship affects the Teaching atmosphere, the moderating variable (Family factors) has a significant impact at different levels, which can be viewed through the following simple slope chart, as shown in **Figure 2**. Family factors are important moderating variables in regulating the impact of teacher-student interaction on the educational atmosphere.

4.3.3. Verification of the regulatory mechanism of technical factors

Further, analyze and verify the impact of technological factors on the teaching atmosphere in the interaction between teachers and students. Before validation, the article also conducted variable processing on the survey data of Q24-Q26 projects and obtained variable data for "technical factors" through mean validation using SPSS software's "variable processing mechanism." In conducting moderate variable analysis, the research first needs to focus on each variable. **Table 15** shows the variable processing situation.

Table 15. Explanation of study variable processing.

Type	Name	Data type	Data processing
Dependent variable	Teaching atmosphere	Ration	Not processed
Independent variable	Teacher-student interaction relationship	Ration	Centralization
Adjusting variables	Technical factors	Ration	Centralization

From the above table, in this study, the treatment of the teacher-student interaction relationship and technical factors was centralized, while the teaching atmosphere was not treated. Subsequently, the study validated the moderating effect of technical factors, and **Table 16** shows the validation of moderating variables:

The regulatory effect is divided into three models from the above table. Model 1 includes the independent variable (teacher-student interaction relationship). Model 2 adds technical factors to Model 1, while Model 3 adds interaction terms (product of independent and moderate variables) to Model 2. The purpose of Model 1 is to investigate the impact of the teacher-student interaction relationship on the teaching atmosphere without considering the interference of technical factors. From the above table, the independent variable (Teacher-student interaction relationship) shows significance (t=28.334, p=0.000<0.05). This means that Teacher-student relationships will significantly impact on the teaching atmosphere. The regulatory effect can be viewed in two ways. The first examines the significance of the F-value change from Model 2 to Model 3. The second examines the significance of the interaction terms in Model 3 and, this time, analyzes the moderating effect using the second method. From the above table, the interaction term between the Teacher-student interaction relationship and technical factors shows significant differences (t=-11.088, p=0.000<0.05). This means that when the Teacher-student interaction relationship affects the Teaching atmosphere, the moderating variable (Technical factors) has a significant impact at different levels, which can be viewed through the following simple slope chart, as shown in **Figure 3**. Technical factors are

essential moderating variables in regulating the impact of teacher-student interaction on the educational atmosphere.

Table 16. The moderating effect of technical factors (n=500).

Items	M1			M2			M3								
	B	**SD**	**t**	**B**	**SD**	**t**	**B**	**SD**	**t**	**B**	**SD**	**t**	**B**	**SD**	**t**
Constant	4.751	0.013	373.268	0.000**	-	4.751	0.006	775.780	0.000**	-	4.780	0.006	786.428	0.000**	-
Teacher-student interaction relationship	0.778	0.027	28.334	0.000**	0.786	0.430	0.016	27.284	0.000**	0.434	0.205	0.025	8.299	0.000**	0.207
Technical factors						0.480	0.012	40.671	0.000**	0.647	0.467	0.011	43.950	0.000**	0.630
Teacher-student interaction relationship*Technical factors											-0.186	0.017	-11.088	0.000**	-0.271
R^2	0.617			0.912			0.929								
Adjust R^2	0.616			0.911			0.929								
F	F (1,498) =802.800, p=0.000			F (2,497) =2560.911, p=0.000			F (3,496) =2167.147, p=0.000								
△R^2	0.617			0.294			0.018								
△F	F (1,498) =802.800, p=0.000			F (1,497) =1654.117, p=0.000			F (1,496) =122.943, p=0.000								

Dependent variable: Teaching atmosphere

** p<0.05 ** p<0.01*

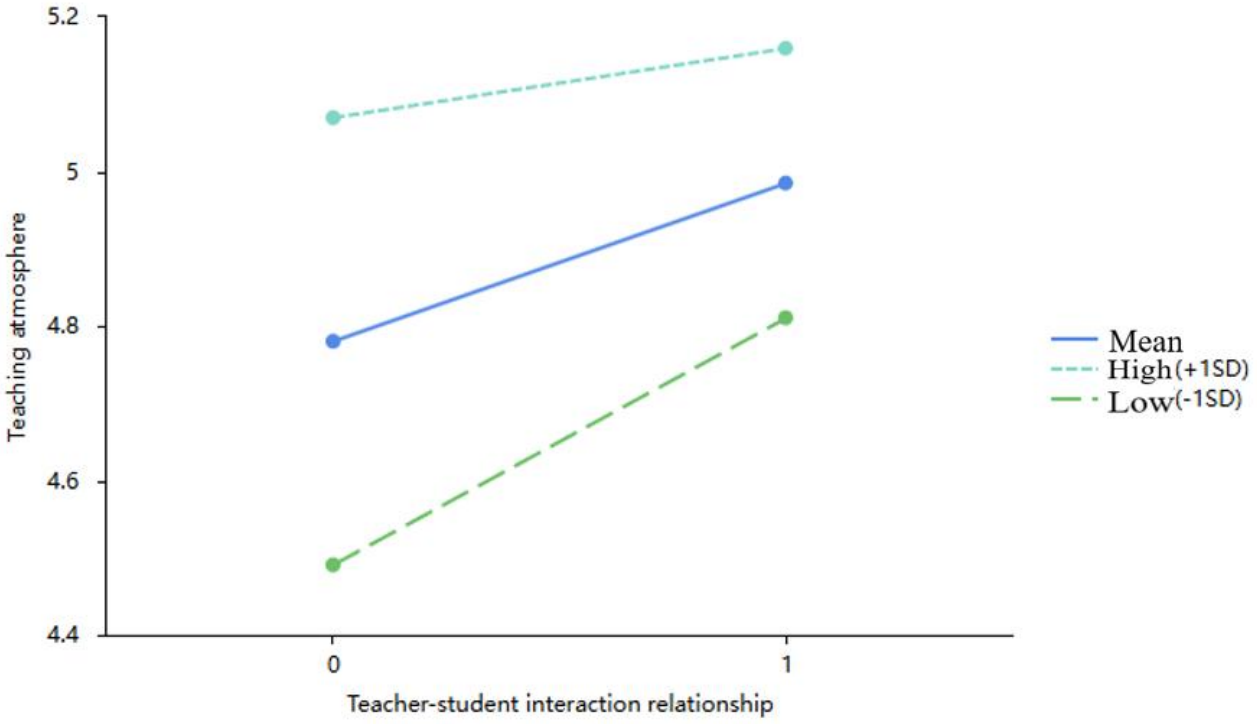

Figure 3. Slope plot of technical factors moderating variables.

4.3.4. Verification of the regulatory mechanism of school factors

Further, analyze and verify the impact of school factors on the teaching atmosphere in the interaction between teachers and students. Before validation, the article also conducted variable processing on the survey data of Q27-Q29 projects and obtained variable data for "school factors" through mean validation using SPSS software's "variable processing mechanism." In conducting moderate variable analysis, the research first needs to focus on each variable. **Table 17** shows the variable processing situation.

Table 17. Explanation of study variable processing.

Type	Name	Data type	Data processing
Dependent variable	Teaching atmosphere	Ration	Not processed
Independent variable	Teacher-student interaction relationship	Ration	Centralization
Adjusting variables	School factors	Ration	Centralization

From the above table, in this study, the treatment of the teacher-student interaction relationship and school factors was centralized, while the teaching atmosphere was not treated. Subsequently, the study validated the moderating effect of technical factors, and **Table 18** shows the validation of moderating variables:

Table 18. The moderating effect of School factors (n=500).

Items	M1			M2			M3								
	B	SD	t	B	SD	t	B	SD	t	B	SD	t	B	SD	t
Constant	4.751	0.013	373.268	0.000**	-	4.751	0.007	690.495	0.000**	-	4.782	0.007	703.854	0.000**	-
Teacher-student interaction relationship	0.778	0.027	28.334	0.000**	0.786	0.472	0.017	27.388	0.000**	0.477	0.231	0.027	8.602	0.000**	0.234
School factors						0.445	0.013	34.744	0.000**	0.605	0.432	0.012	37.407	0.000**	0.588

Teacher-student interaction relationship*School factors			-0.210 0.019 -10.980 0.000** -0.293
R^2	0.617	0.888	0.910
Adjust R^2	0.616	0.888	0.910
F	F (1,498) =802.800, p=0.000	F (2,497) =1977.163, p=0.000	F (3,496) =1675.386, p=0.000
△R^2	0.617	0.271	0.022
△F	F (1,498) =802.800, p=0.000	F (1,497) =1207.151, p=0.000	F (1,496) =120.561, p=0.000

Dependent variable: Teaching atmosphere

** p<0.05 ** p<0.01*

The regulatory effect is divided into three models from the above table. Model 1 includes the independent variable (teacher-student interaction relationship). Model 2 adds school factors to Model 1, while Model 3 adds interaction terms (product of independent and moderating variables) to Model 2. The purpose of Model 1 is to investigate the impact of the teacher-student interaction relationship on the teaching atmosphere without considering the interference of school factors. From the above table, the independent variable (Teacher-student interaction relationship) shows significance (t=28.334, p=0.000<0.05). This means that Teacher-student relationships will significantly impact on the teaching atmosphere. The regulatory effect can be viewed in two ways. The first examines the significance of the F-value change from Model 2 to Model 3. The second examines the significance of the interaction terms in Model 3 and, this time, analyzes the moderating effect using the second method. From the above table, the interaction term between Teacher-student interaction relationship and School factors shows significant differences (t=-10.980, p=0.000<0.05). This means that when the Teacher-student interaction relationship affects the Teaching atmosphere, the moderating variable (School factors) has a significant impact at different levels, which can be viewed through the following simple slope chart, as shown in **Figure 4**. School factors are essential moderating variables in regulating the impact of teacher-student interaction on the educational atmosphere.

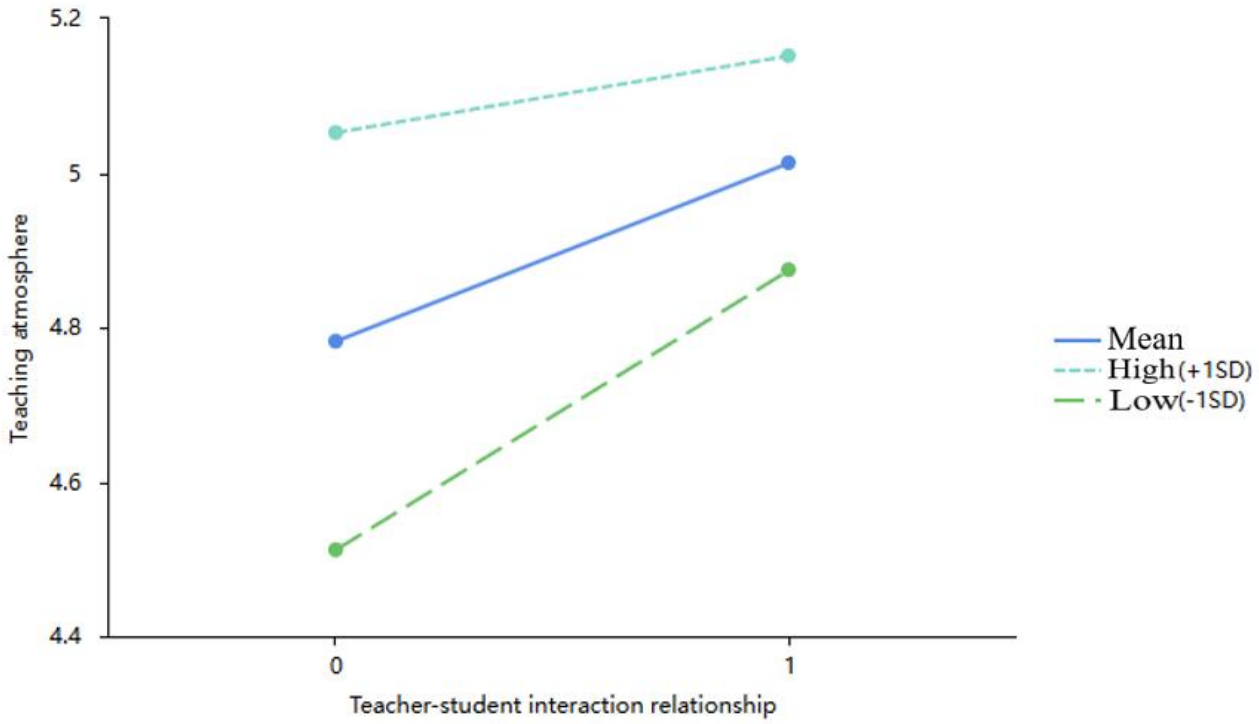

Figure 4. Slope plot of school factors moderating variables.

5. Discussion

This article uses empirical methods such as descriptive analysis, reliability and validity testing, linear regression, and moderation effect testing to verify the main effects of teacher-student interaction and teaching atmosphere in music teaching activities. It proves that teacher-student interaction significantly correlates positively with the teaching atmosphere. In sequence, the study analyzed the impact of three external factors: family, technology, and school. Based on the previous assumptions, the empirical conclusions summarized in the study are shown in **Table 19**.

Table 19. Summary of hypothesis validation.

Assumption number	hypothesis	Establishment status
H1	In music teaching activities, teacher-student interaction behavior will have a positive impact on the teaching atmosphere;	Established
H2	In the process of the influence of teacher-student interaction on the music teaching atmosphere, family factors will play a moderating role;	Established
H3	In the process of interaction between teachers and students affecting the music teaching atmosphere, technical factors will play a regulatory role in it;	Established
H4	In the process of the interaction between teachers and students affecting the music teaching atmosphere, school factors will play a moderating role in it;	Established

The article first proves the impact of teacher-student interaction on the music-teaching atmosphere in music-teaching activities and finds that teacher-student interaction has a significant positive correlation with the music-teaching atmosphere, consistent with previous research[43]. On this basis, the study analyzed the moderating effects of three external factors: family factors, technological factors, and school factors. Compared with previous literature, all three external factors have a moderating effect on the mechanism of the interaction between teachers and students and the music teaching atmosphere, which proves the theoretical speculation of previous scholars[44]. Therefore, research suggests that in the future development of music teaching in Chinese universities, it is necessary to simultaneously pay attention to the factors influencing family, school, and technology to establish an excellent teacher-student interaction relationship and build a free music teaching atmosphere. In addition, schools can provide professional development opportunities for teachers, such as training on educational technology and classroom management skills, to enhance their ability to control the teaching atmosphere[45]. Meanwhile, cooperative group projects or team activities can foster good student interaction and cooperation to enhance class cohesion and the overall learning atmosphere.

Specifically, in family education, teachers must pay attention to the preliminary assessment of students' music literacy, especially for university music students. Many students choose music as their academic major because of the family art atmosphere[46]. For this group of students, teachers should interact with them more to promote the construction of the overall artistic atmosphere in the classroom. They can also use their good music literacy skills to encourage other students to participate in classroom activities[47]. For another group of students who may lack a family-encouraging atmosphere, teachers need to use more encouraging teaching to give students the courage and confidence to participate in teacher-student interaction. In addition, schools can organize parent-schools and parent-child activities regularly to enhance parents' awareness of and support for education[48]. At the same time, more courses or lectures on education methods and child

development can be provided to parents to promote better parental involvement in their children's education process, thus enhancing positive family support for students' learning.

Secondly, in terms of technological factrs, the development of digital technology has provided new possibilities for art education, especially in constructing teacher-student interaction relationships. Through the development of digital technology, a new communication platform can be built for teacher-student interaction[49]. On the one hand, it is necessary to use digital technology to carry out a combination of online and offline classroom teaching methods and flexibly use educational technologies such as online courses and digital classrooms to expand teacher-student interaction channels; On the other hand, it is necessary to strengthen the integration of educational technology in music teaching activities, use more self-media channels in class and outside of class to enhance students' artistic perception ability, improve the quality of teacher-student interaction, and create a good atmosphere for teacher-student communication and music teaching[50]. In addition, more interactive online learning tools and platforms, such as virtual reality (VR) and augmented reality (AR) technologies, can be introduced to enhance student engagement and interest. At the same time, teachers should receive more comprehensive technology training to ensure that they are proficient in using various tools so that technology becomes an aid rather than a hindrance to teaching and learning.

Finally, in terms of school factors, the school factors proposed in this article include the school's hardware and software fields of school construction. Regarding hardware, schools should increase investment in constructing music classrooms, providing a better teaching platform for communication and interaction between teachers and students[51]. Regarding software, the school should organize diversified music and cultural exchange activities, such as music festivals and walls, to create a good artistic atmosphere on campus so students can spontaneously participate in music exchange. In addition, schools should invest more in teaching hardware facilities and teaching content[52]. The physical environment can be improved by introducing modern teaching equipment, such as upgrading audio and projection equipment, to make the music classroom livelier. At the same time, schools should pay attention to enhancing education concepts and teaching quality to ensure that the teaching content is up-to-date, and that students' creative and critical thinking is nurtured to realize their full potential in an excellent learning environment.

6. Conclusion

This study investigates the mechanisms of teacher-student interaction and the music teaching climate, highlighting how different social factors moderate these relationships. The findings reveal that teacher-student interaction significantly influences the music teaching climate, with a strong positive correlation between the quality of the teacher-student relationship and the classroom atmosphere. Additionally, social factors such as family support, technological integration, and school infrastructure were found to moderate the effects of teacher-student interaction on the learning environment, suggesting that these contextual elements play a pivotal role in shaping the overall teaching experience.

This research is significant because it deepens our understanding of the complex dynamics between teacher-student interaction and the music teaching climate. By examining the role of social factors as moderators, this study provides valuable insights into how external influences, such as family involvement and technological support, can enhance or hinder the effectiveness of teacher-student interactions in music education. These findings offer practical implications for educators, policymakers, and school administrators seeking to create a more supportive and engaging music teaching environment that fosters better outcomes.

However, this study is not without its limitations. First, the sample size, although significant, is limited to a specific cultural and educational context, which may limit the generalizability of the results. Additionally, the study primarily relies on self-reported data, which could introduce bias. Future research could explore the mechanisms identified in this study through longitudinal or experimental designs to establish causal relationships. Furthermore, future studies could expand the scope to include other social factors or different disciplines to validate the applicability of the findings across various educational settings.

Author contributions

Conceptualization, L.J. and S.I.T.; methodology, L.J.; software, L.J.; validation, L.J., S.I.T. and M.I.S.A.A.; formal analysis, L.J.; investigation, L.J.; resources, L.J.; data curation, L.J.; writing—original draft preparation, L.J.; writing—review and editing, L.J.; visualization, L.J.; supervision, S.I.T. and M.I.S.A.A.; project administration, S.I.T. and M.I.S.A.A. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare no conflict of interest.

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