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The Impact of Mathematics Teachers' Pedagogical Content Knowledge on the Classroom Learning Atmosphere

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Abstract: *Pedagogical content knowledge plays an indispensable role in teaching practice and has become an important category of research and practice for scholars and teachers. This article endeavors to delve into the influence of mathematics teachers' pedagogical content knowledge on the classroom learning atmosphere. Through the perspective of classroom recordings, it deeply analyzes the infectious effect of pedagogical content knowledge on students' learning experience and emotional engagement. This article employs qualitative analysis methods, utilizing encoded data, to dissect the application of teachers' pedagogical content knowledge, the status and feedback of students in mathematics classrooms, in order to unearth the relationship between the two. Research has found that the appropriate application of pedagogical content knowledge by mathematics teachers can have a positive impact on the learning atmosphere of students in the classroom. The artful use of humor by teachers has the power to visualize dull mathematical knowledge. It not only sparks students' interest and enthusiasm for learning but also contributes to the cultivation of high-quality classroom instruction. This precisely reflects the crucial role of teaching strategy knowledge in pedagogical content knowledge. The study reveals the mechanism by which mathematics teachers' pedagogical content knowledge plays a role in creating a positive learning atmosphere, providing beneficial insights for teaching practice.*

Keywords: classroom records, mathematics teachers, pedagogical content knowledge, learning atmosphere, impact

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1. Introduction

1.1 Research Background and Significance

In the field of modern basic education, countries seem to have reached a consensus that there is a general focus on teaching quality, student learning experience, and effectiveness. As the main educators, teachers play a key role in driving education forward. So, the quality and ability of teachers have become the core elements for education administrative departments and education experts to examine, and pedagogical content knowledge is the most important core element of teachers' quality and ability (Van Driel, Verloop, & De Vos, 1998). In addition, the learning atmosphere of students directly affects their learning interest, participation level, and learning experience. It is the main factor causing emotional fluctuations and changes in the classroom, and is an important cornerstone for mobilizing students' enthusiasm. Fostering a conducive learning atmosphere hinges on the foundation of teachers possessing robust pedagogical content knowledge. There has been many excellent literature on the relationship between pedagogical content knowledge and teaching effectiveness, but there is little in-depth exploration of how pedagogical content knowledge affects the learning atmosphere in the actual teaching process from the perspective of classroom records (Yang et al., 2021). Based on this background, this study analyzes the teaching records of mathematics classrooms, explores the impact of mathematics teachers' pedagogical content knowledge on students' learning atmosphere, and has important theoretical and practical value for improving teaching quality, optimizing teaching methods, and paying attention to students' learning experience effects.

From the perspective of teaching practice, clarifying the relationship between pedagogical content knowledge and student learning atmosphere can help teachers optimize classroom teaching, create a warm learning environment from the perspective of student subjectivity, alleviate students' psychological insecurity, and use scientific teaching methods to stimulate students' initiative. From the perspective of teacher professional development, it provides fundamental guidance for teachers to anchor improvement paths, laying the foundation for flexible response to real-time classroom teaching situations, and improving teachers' educational and teaching levels. From the perspective of student learning, it has long-term significance in cultivating students' stable initiative and enthusiasm.

In summary, this study aims to explore the impact of mathematics teachers' pedagogical content knowledge on students' learning atmosphere from the perspective of classroom recordings, providing new theoretical perspectives and practical insights for educational practice and the professional development of teacher.

1.2 Research problems

This study mainly addresses the following issues: what impact the pedagogical content knowledge of teachers have on the learning atmosphere in mathematics classrooms, and how it affects students' learning experience and participation. Specifically, it includes several sub questions: firstly, how does the subject knowledge of mathematics teachers be reflected in classroom teaching. The second is how students perceive the learning atmosphere and engage in emotions. The third is the mechanism by which pedagogical content knowledge affects the learning atmosphere.

The purpose of studying the above issues is to clarify how teachers' pedagogical content knowledge affects the learning atmosphere of students in the classroom, and to provide practical case guidance and inspiration for improving teachers' professional development and promoting students' academic progress.

2. Literature Review

2.1 Current Situation of Mathematics Teachers' pedagogical content knowledge

Marks focused on fifth-grade score teaching as the research subject (Marks, 1990). He conducted an analysis of the prevailing status of pedagogical content knowledge among eight mathematics teachers, examining it through four components: subject matter for instructional purposes, students' understanding of the subject matter, media for instruction in the subject matter, and instructional processes for the subject matter. Li, Ni and Xiao (2006) conducted a questionnaire survey involving expert mathematics teachers in primary schools, as well as regular teachers (p.60). The study revealed noteworthy disparities in their grasp of teaching strategies and comprehension of the learning environment, with the former demonstrating

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significantly superior proficiency compared to the latter. Bukova-Güzel (2010) employed a semi-structured interview approach to gather qualitative data, including teaching case videos and plans, focusing on the pedagogical content knowledge of pre-service mathematics teachers with a three-dimensional perspective (p.1875). Through qualitative analysis, it was discerned that these pre-service mathematics teachers demonstrated a strong grasp of subject knowledge and adeptness in utilizing diverse teaching representation methods. However, there appeared to be a deficiency in addressing the cognitive level of content among students. Effectively evaluating students' receptivity to knowledge and addressing practical challenges across multiple dimensions was also identified as an area that requires further attention. Akdoğan and Sağ (2015) discovered that pre-service mathematics teachers possess some knowledge of teaching strategies. However, they tend to exhibit a relative deficiency in understanding students' thought processes and actual cognitive abilities (p.222). In her study, Bao (2016) conducted interviews and administered questionnaire surveys to elementary school mathematics teachers. The findings indicated that among the diverse components of pedagogical content knowledge, teachers' content knowledge appeared to be the least robust (p.12). Furthermore, noteworthy disparities in the levels of pedagogical content knowledge were observed among teachers with varying years of teaching experience and educational backgrounds.

2.2 Construction and influencing factors of classroom student learning atmosphere

The learning atmosphere in the classroom plays a pivotal role in students' learning experience. Factors, whether singular or multifaceted, such as the teaching approach adopted by teachers and the overall classroom environment, can directly impact this atmosphere.

Yang et al. (2013) explored the perception of classroom environment through a questionnaire survey and found that teachers' emotional engagement and teaching attitude are positively correlated with the learning atmosphere (p.275). Positive emotions and attitudes of teachers are important prerequisites for shaping a good learning atmosphere. Yerdelen, and Sungur (2019) found that variables such as teacher beliefs and characteristics were directly related to students' self-regulation when studying the relationship between classroom learning environment and teacher efficacy, and regulated the relationship between learning environment and self-regulation variables (p.95). The good professional literacy of teachers can significantly affect the learning environment of students in the classroom, contributing to the establishment of a positive and conducive learning atmosphere. Cai et al. (2022) discovered that the learning atmosphere is intricately linked to factors like teachers' emotional support, the physical setup of the classroom, teacher-student interactions, and the design of the textbook (p.610). Active guidance, coupled with effective interaction from teachers, can ignite students' curiosity and enthusiasm for learning, ultimately fostering a conducive learning atmosphere.

2.3 The relationship between pedagogical content knowledge and student learning effectiveness of mathematics teachers

Baumert et al. (2010) employed a hierarchical linear model to investigate the influence of mathematics teachers' pedagogical content knowledge and subject expertise on both teaching quality and student learning outcomes (p.150). Their findings revealed that while teachers' subject knowledge exhibited a relatively modest predictive capacity for students' academic performance progress, pedagogical content knowledge emerged as a potent determinant of students' advancement in mathematical learning. Gess-Newsome et al. (2019) measured the potential changes in teacher knowledge and practice due to intervention (p.951). A tool was developed to measure pedagogical content knowledge (PCK), they explored the relationship between teacher variables, and tested the relationship between teacher professional knowledge and classroom practice on student performance. It is clear from the results that all variables have advantages for teachers.

Some scholars have used quantitative methods, and they employed quantitative research methods to investigate the connection between primary school mathematics teachers' pedagogical content knowledge and student performance. The study uncovered a noteworthy correlation between the comprehensive pedagogical content knowledge of teachers and controlled student performance. Furthermore, when individual student grades were regressed against various independent variables, it was observed that only mathematical knowledge demonstrated significant significance for effective teaching (Peters-George, 2021, p.125)

In conclusion, the pedagogical content knowledge as defined in this study refers to the manner in which teachers impart subject knowledge to students in a way that is easily comprehensible and accessible to them. The related research in this field is extensive, encompassing investigations into the content, current state, influencing factors, and developmental trajectories of pedagogical content knowledge, yielding a substantial body of research outcomes. However, existing research also has its limitations. While they emphasize the impact of pedagogical content knowledge on students' academic performance, they seldom mention its influence on the learning atmosphere. The learning atmosphere directly affects students' learning experiences, interests, and motivation, all of which play a crucial role in the long-term cultivation of students. Learning mathematics should not be a transient endeavor; instead, it necessitates the establishment of enduring incentive mechanisms that genuinely instill a love for exploring mathematics within students. This requires further exploration. Therefore, investigating the influence of mathematics teachers' pedagogical content knowledge on the learning atmosphere in the classroom is deemed highly significant. This also addresses the research question outlined in the preceding section of this paper: what are the impacts of teachers' pedagogical content knowledge on the learning atmosphere in mathematics classrooms, and how does it affect students' learning experiences and engagement levels.

3. Research Methods

3.1 Research subjects

This paper primarily relies on transcripts from mathematics classroom records, employing a case study approach to conduct in-depth observations of the utilization of various elements of pedagogical content knowledge by two secondary school mathematics teachers, as well as the states and feedback from students. The study sample consists of two teachers from a regular high school in Neijiang City, Sichuan Province, China, along with their respective parallel classes. These two teachers possess significantly divergent levels of teaching experience, with one having 5 years and the other 12 years of teaching experience. Their professional titles are intermediate and associate senior, respectively, coded as Teacher A and Teacher B. The corresponding class sizes are 37 and 41 students, respectively.

This article selects the second chapter "Equations and Inequalities" from the compulsory first year of senior high school in the People's Education Press. The reason is that first of all, the course is designed for students to enter high school shortly after, and the differences brought about by teachers' teaching experience cannot be significantly demonstrated, which can better control the variables of teacher experience. Furthermore, the newly revised course presents an equal test for teachers to change traditional teaching arrangements and better reflects their level of application of pedagogical content knowledge. Additionally, the selection of the first-year curriculum is grounded in the author's prior experience in teaching this particular mathematics course, thereby ensuring a familiarity with the content. Following the elucidation of the research intent, both teachers provided strong support for the study.

3.2 Research Design

This study primarily employed a non-participatory classroom observation method to gather pertinent information about both teachers and students in the classroom setting. Carefully capture the use of pedagogical content knowledge and corresponding student feedback details during the teacher's teaching process through recorded mathematics classes, identify a series of qualitative data such as the teacher's teaching situation, two-way interaction, and learning atmosphere. The data gathered from observing teachers and students were then coded, synthesized, and analyzed, thereby unveiling the relationship between pedagogical content knowledge and the learning atmosphere. Furthermore, supplementary textual materials such as textbooks and lesson plans were collected to assist the researcher in comprehending the teacher's instructional behavior and gaining further insights into the teacher's pedagogical designs and strategies. By directly observing and recording the classroom situation, it is possible to avoid the negative effects of subjective explanations from teachers and deliberate avoidance from students during interviews, ensure the authenticity and objectivity of research data and results, improve the credibility of conclusions, and provide strong support for practical teaching.

4. Analysis and Discussion

4.1 Evaluation of the level of reflection of teachers' pedagogical content knowledge

Due to the inherent advantages of non-participatory teaching video observation, which ensures complete independence between the observer and the observed, the observed teaching activities maximize their naturalness. Therefore, this article adopts the non-participatory observation method. The teaching behaviors of teachers and the students' responses during lectures were observed word by word and sentence by sentence, which are subsequently coded. Taking the three primary indicators of teaching, content, and students as a starting point, this study provides a detailed description and documentation of the six secondary indicators: teaching purpose knowledge, teaching strategy knowledge, subject content knowledge, content organization knowledge, student understanding knowledge, and effect feedback knowledge. These six secondary indicators comprise a total of twelve specific observation points, offering a comprehensive understanding of the Pedagogical Content Knowledge (PCK) classroom practices exhibited by mathematics teachers. This paper draws on the theoretical foundation of Pedagogical Content Knowledge (PCK) by Parker (Park, & Oliver, 2008). It borrows and modifies Shu's practical graph regarding the analysis scale of PCK (Shu, 2013). Furthermore, it adopts Grossman's theoretical framework, which categorizes PCK into six major classifications (Grossman, Schoenfeld, & Lee, 2005), to develop an evaluation framework table indicating the level of PCK expression in mathematics teachers (as shown in Table 1).

Table 1: PCK Level Evaluation Framework Table

Dimension	Primary indicators	Observation points (secondary indicators)
Content dimension	Subject Content Knowledge (SCK)	Basic knowledge and skill knowledge of mathematics (SCK1)
		Cross disciplinary knowledge of mathematics and other disciplines (SCK2)
	Content organization knowledge (COK)	Arrange teaching content and set up knowledge of teaching links (COK1)
		Knowledge of horizontal and vertical connections related to content (COK2)

Teaching dimension	Teaching purpose knowledge (TPK)	Knowledge of setting teaching objectives (TPK1)
		Knowledge of the relationship between overall objectives and sub objectives (TPK2)
	Teaching strategy knowledge (TSK)	Strategic knowledge for improving teaching ability and classroom effectiveness (TSK1)
		Assist students in correcting learning methods and establishing strategic knowledge of mathematical thinking (TSK2)
Student dimension	Students' understanding of knowledge (SUK)	Understand students' inherent cognitive level and knowledge of sequence cognition (SUK1)
		Understanding the reasons for students' confusion and new ideas (SUK2)
	Effect feedback knowledge (EFK)	Timely adjust teaching knowledge through students' questioning, answering, and interaction (EFK1)
		Supplement and optimize teaching knowledge through student exercises and tests (EFK2)

Based on the evaluation framework table assessing the Pedagogical Content Knowledge (PCK) expression of the mathematics teacher, a line-by-line analysis of the teacher's classroom instructional behavior is conducted, cross-referencing the twelve specified observation points. This process aims to provide a comprehensive assessment of the teacher's proficiency level (Bae et al., 2022). For the purpose of facilitating quantification, this study referred to Jie's MPCK measurement instrument and developed a specific measurement instrument tailored for this research. Each observation point is categorized into four levels: limited, basic, proficient, and outstanding. These levels are then assigned corresponding scores, ranging from a maximum of 10 points to a minimum of 0 points. Specifically, the limited score is 1-2 points, the basic score is 3-5 points, the proficient score is 6-8 points, and the outstanding score is 9-10 points. The highest score for each secondary indicator is 20 points, totaling 120 points (as shown in Table 2).

According to the score attribute in Table 4.2, if the overall PCK level score of mathematics teachers is between 0-24 partitions; It is at the "limited" level, and if the score is in the 25-60 range, it is at the "basic" level; If the score is in the range of 61-96, it is at the level of "proficiency"; If the score is in the range of 97-120, it is at the "outstanding" level. The grading criteria for individual dimensions and observation points are consistent with the overall grading method.

Table 2: PCK Gauge Analysis Scale for Mathematics Teachers

Primary indicators	**Observation points**	**Level and score**			
		Limited (0-2)	**Basic (3-5)**	**Skilled (6-8)**	**Outstanding(9-10)**
SCK	SCK1	Little is known	Ordinary	Good	Solid
	SCK2	Little is known	Ordinary	Good	Perfect
COK	COK1	Confusion	Ordinary	Reasonable	Scientific
	COK2	Unclear	Limited	Familiar	Perfect
TPK	TPK1	Unclear	Ordinary	Good	Very Clear
	TPK2	Unclear	Reluctantly	Good	Skilled
TSK	TSK1	Single and weak targeting	Ordinary	Appropriate	Efficient
	TSK2	Single and weak effectiveness	Ordinary	Appropriate	Scientific
SUK	SUK1	Little is known	Ordinary	Good	Accurate

	SUK2	Little is known	Ordinary	Good	Accurate
EFK	EFK1	Not timely enough	Ordinary	Good	Sharp and Timely
	EFK2	Almost none	Ordinary	Good	Skilled

Based on the evaluation framework table and the gauge analysis scale, by recording and observing the classroom teaching video of "Solution to Univariate Linear Inequality" for teachers A and B, and assisting in reviewing lesson plans, the pedagogical content knowledge level of the two teachers is evaluated and analyzed. The following results are obtained, as shown in Tables 3 and 4. ▲ represents the score of Teacher A, and ■ represents the score of Teacher B.

Table 3: PCK Level Analysis Scale for Teachers A and B

Observation points	Level										Score	
	Limited		Basic			Skilled			Outstanding		Total score of Teacher A	Total score of Teacher B
	1	2	3	4	5	6	7	8	9	10		
SCK1								▲■			13	15
SCK2					▲		■					
COK1						▲		■			12	15
COK2						▲	■					
TPK1							▲		■		12	16
TPK2					▲		■					
TSK1				▲				■			9	14
TSK2					▲	■						
SUK1					▲		■				10	13
SUK2					▲	■						
EFK1						▲	■				12	13
EFK2						▲■						
Total											68	86

From the above data, it can be seen that Teacher A's overall score for mathematical pedagogical content knowledge is 68 points, which is at the "proficient" level, close to the basic level and far from the outstanding level. Teacher A demonstrates relative proficiency in SCK1 and TPK1, displaying a solid foundation and clear teaching objectives. In terms of TSK1, there appears to be room for improvement, as the methods employed are somewhat limited, resulting in lower effectiveness. The scores for the remaining observation points fall within the 5-6 range, and moderate performance level is basically consistent with the situation where Teacher A has a relatively short teaching experience and is relatively inexperienced. The overall score of Teacher B's mathematics pedagogical content knowledge is 86 points, which is at the "proficient" level, far from the basic level and close to the outstanding level. Teacher B is relatively good at SCK1, COK1, TPK1, and TSK1, and possessing an overall sound grasp of pedagogical content knowledge. The other observation points are all in the range of 6-7 points, and the higher scores are basically consistent with the situation of Teacher B with longer teaching experience, extensive expertise, and higher professional titles.

The average scores of teachers A and B in the 12 observation points of mathematics pedagogical content knowledge are 5.67 and 7.17 respectively, the standard deviations are 1.07 and 0.94, and the standard errors are 0.31 and 0.27, respectively. Due to the normal distribution of teaching knowledge scores of teachers A and B in mathematics, independent sample t-tests were conducted on their scores, and the following results were obtained, as shown in Table 4.

Table 4: Independent sample t-test results

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Scores	Equal variances assumed	.211	.651	-3.647	22	.001	-1.50000	.41133	-2.35305	-.64695
	Equal variances not assumed			-3.647	21.610	.001	-1.50000	.41133	-2.35394	-.64606

The independent sample t-test results of the average scores of the observation points of the two teachers showed that the homogeneity of variance test was not significant ($p>0.05$), indicating that the variances of the two groups were homogeneous. There is a significant difference between the two sets of data ($t=-3.647$, $df=22$, $p<0.05$), therefore, Teacher B's overall mathematics pedagogical content knowledge is better than Teacher A.

4.2 Evaluation of students' response level to the learning atmosphere in the classroom

Based on the observation and analysis of classroom recorded videos, this article divides the teaching process of the two teachers into seven parts, namely situational introduction (SI), guiding self-learning (GSL), teacher teaching (TT), teacher-student interaction (TSI), cooperative exploration (CE), practice consolidation (PC), and Summary and Reflection (SR). The various elements of teachers' subject teaching knowledge were paired with the teaching process, and observations were conducted on the classroom responses of students corresponding to each stage (Barrett et al., 2015). This encompassed, but was not limited to, assigning scores based on elements such as frequency, intensity, and other relevant factors. This article has developed an analysis scale for students' classroom response level based on actual classroom teaching situations (as shown in Table 5). Divide each observation point of students into four levels: limited, average, good atmosphere, and very harmonious, and assign a score of up to 10 points and down to 0 points. If the overall response score of the student is between 0-24 zones; It is at the "limited" level, and if the score is in the 25-60 range, it is at the "average" level; If the score is in the range of 61-96, it is at the level of "good atmosphere"; If the score is in the range of 97-120, it is at the level of "very harmonious".

Table 5: Analysis scale of students' classroom reaction level scale

Teaching Process	PCK Observation Points	Student Reaction Observation Points	Student's reaction level and scores
SI	SCK2	Students' interest in the situation introduced by the teacher	Limited：1-2
	COK1		
GSL	COK1	The degree to which students are clear about what the teacher is leading	ordinary：3-5
	SCK1		
	TPK1	How clear students are about their learning goals	
TT	SCK1	Students concentrate on listening to lectures	Good atmosphere：6-8
	COK2		

	TSK2	Students comprehend the teacher's error correction method	
TSI	SUK1 EFK1	The situation where students receive teacher's questions and raise reasonable questions	Very harmonious : 9-10
	SUK2	The situation where students actively propose reasonable new ideas	
CE	COK1 TSK1	The situation where students gain Corresponding knowledge from exploration	
PC	EFK2	Students reshaped their knowledge structure and consolidated their learning through practice	
SR	COK2	The students sorted out the knowledge structure under the guidance of the teacher	
	TPK2	Students' understanding of the role of connecting the past and the future in this lesson	
	TSK2	The situation where students establish their own mathematical thinking	

Based on the analysis scale of students' classroom reaction level, observation of recorded classroom teaching videos was conducted to investigate and analyze the classroom atmosphere of students in two classes. The following results were obtained, as shown in Table 6. For the convenience of tabulation, the student response observation points are sequentially coded as 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12. It should be noted that the grading of students in this article is based on the overall classroom atmosphere of the class, and no specific grading is given to individuals.

Table 6: Student Reaction Level Analysis Scale

Student Reactions	Student's Reaction Level										Scores	
	Limited		Ordinary			Good Atmosphere			Very Harmonious		Class A	Class B
	1	2	3	4	5	6	7	8	9	10		
1								▲	■		8	9
2							▲■				7	7
3						▲		■			6	8
4							▲	■			7	8
5					▲		■				5	7
6						▲	■				6	7
7					▲	■					5	6
8					▲	■					5	6
9						▲	■				6	7
10				▲		■					4	6
11				▲	■						4	5
12			▲		■						3	5
Total											66	81

From the above data, it can be seen that the overall classroom reaction score of Teacher A's class is 66 points, which is at the level of "good atmosphere", close to the average level and far from the "very harmonious" level. Students showed a higher level of interest in the real-life situations introduced by the teacher, resulting in the highest scores. Conversely, they demonstrated the lowest level of engagement in experiencing and appreciating mathematical concepts. Overall, the classroom atmosphere in Class A is positive. The first half of the class exhibits a more favorable environment compared to the latter half. Some students display a limited level of engagement in exploration and interaction. The majority of students demonstrate low initiative in providing answers, while a small minority engage in behaviors such as playing with erasers, looking through the outside, and being in a daze. The overall score of Class B's classroom reaction is 81 points, which is at the level of "good atmosphere", far from the average level, and close to the "very harmonious" level. The majority of observation points received scores at or above the "good atmosphere" level, indicating an overall conducive learning environment in the classroom. When adverse phenomena begin to appear in the second half of the classroom, such as some students bowing their heads and wandering their minds, teachers can intervene and adjust in a timely manner. Group discussions showed high levels of enthusiasm, even extending invitations to the teacher for feedback and guidance. A few students displayed lower levels of initiative, occasionally engaging in activities like playing and daydreaming.

The average scores of the 12 observation points for classroom reactions of Class A and Class B students were 5.5 and 6.75, respectively, with standard deviations of 1.45 and 1,22, and standard errors of 0.42 and 0.35. Since the scores of each observation point for classroom reactions of Class A and B students follow a normal distribution, independent sample t-tests were conducted on their scores, and the following results were obtained, as shown in table 7.

Table 7: Independent sample t-test results

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
scores	Equal variances assumed	.482	.495	-2.292	22	.032	-1.25000	.54530	-2.38088	-.11912
	Equal variances not assumed			-2.292	21.368	.032	-1.25000	.54530	-2.38282	-.11718

The independent sample t-test results of the average scores of the observation points for students in two classes showed that the homogeneity of variance test was not significant ($p>0.05$), indicating that the variances of the two groups were homogeneous. There is a significant difference between the two sets of data ($t=-2.292$, $df=22$, $p<0.05$), therefore, the overall classroom atmosphere of Class B is better than that of Class A.

4.3 Evaluation of the auxiliary level of teaching plan text materials

This paper collected textual materials of daily teaching plans from two teachers and qualitatively compared the similarities and differences between them. The commonality is first reflected in the teaching foundation design of both, which can closely adhere to teaching objectives and provide detailed explanations of the requirements for knowledge and skills to be achieved. Furthermore, they are able to integrate teaching content with daily life, which helps guide students to form correct emotional attitudes and values (Explanation, 2013). Furthermore, their teaching focuses and difficulties are relatively clear, all aimed at cultivating students' ability to calculate inequalities and their thinking of attribution and transformation. The difference is first reflected in Teacher A's relatively limited teaching design to the content itself, and their handling of open activities is not natural enough and not smooth enough. But Teacher B can clarify the coherence of knowledge, use the old to bring the new, making the presentation of knowledge more systematic and complete, progressive layer by layer, and in line with the cognitive logic of students. Secondly, in cultivating students to apply knowledge to solve practical problems, Teacher B is more able to concretize and contextualize knowledge than Teacher A, helping students better output knowledge.

Summing up the aforementioned points, we have grounds to arrive at the conclusion that the mathematical pedagogical content knowledge of Teacher B surpasses that of Teacher A, and the classroom learning environment in Class B excels in comparison to that of Class A. From this, it can be inferred that there is a positive correlation between a mathematics teacher's pedagogical content knowledge and the classroom learning atmosphere, the solid and versatile reservoir of pedagogical content knowledge in mathematics enables teachers to foster students' interests, enthusiasm for learning, and the development of proficient mathematical thinking.

5. Conclusion and Inspiration

This study aims to explore the impact of pedagogical content knowledge of mathematics teachers on the classroom learning atmosphere of students. It examines the PCK of two mathematics teachers with different teaching experience, as well as the classroom learning environment of their respective classes. The results indicate that a mathematics teacher's pedagogical content knowledge significantly influences the classroom learning environment, showing a positive correlation, which is basically consistent with the conclusions of other scholars' research (Park & Oliver, 2008). The reasonable display of mathematics teachers' pedagogical content knowledge can promote the formation of a good learning atmosphere, which not only ignites students' passion for learning mathematics but also activates their mathematical cognition, Consequently, it is conducive to improving teachers' professional level and students' learning effectiveness (Bao & Kong, 2014).

While this article provides useful insights into teaching practice and teacher professional development, which emphasizes the accumulation, integration, and application of pedagogical content knowledge in teaching career. But after all, it is a case study with a small sample size, which lacks representativeness and statistical significance (Şimşek, & Boz, 2016). Moreover, given that the subjects under examination are human beings, their psychological states, cultural backgrounds, and individual attributes exhibit significant variability, resulting in challenges associated with replicability of the process. Consequently, the generalizability and applicability of findings are subject to certain limitations. Furthermore, despite our best efforts to align the application of teachers' pedagogical content knowledge with student feedback, there inevitably exists a degree of empiricism that cannot guarantee with absolute certainty that the feedback from students is solely attributable to the impartation of teachers' pedagogical content knowledge (Küçükaydin, 2019). Therefore, future research should primarily focus on reasonably expansion of sample size to enhance the effectiveness of the samples and reduce the errors caused by data randomness (Jacob, John, & Gwany, 2020). Moreover, Future research should also obtain data from interviews with teachers and students to compensate for some of the speculative nature of classroom recordings (Bakar, Maat, & Rosli, 2020). For example, students' quiet thinking transitions may be mistaken for being in a daze, and for some students' responses may merely reflect agreement with their peers, lacking substantial individual reflection. Last but not least, the dimensions of the study should take into account both horizontal and vertical comparisons. Horizontal comparison involves assessing whether different levels of pedagogical knowledge in mathematical subjects lead to noticeable differences in the learning atmosphere among parallel classrooms. Vertical comparison, on the other hand, examines whether the dynamic development of a teacher's pedagogical knowledge in mathematical subjects over time results in significant changes in the learning environment for students. Only in this way can we more comprehensively obtain real data and comprehensively understand the mechanism by which pedagogical content knowledge affects the classroom learning atmosphere (Campbell et al., 2014).

Based on research findings, there are several insights to be provided for mathematics teachers' instruction. First, it is imperative to bolster teachers' own mathematical knowledge, ensuring a solid command of various definitions, concepts, theorems, as well as their implications and extensions, thereby avoiding ambiguity. A profound grasp of the historical backdrop of mathematical culture is indispensable, ensuring the attainment of rigor, precision, and systematicity in the realm of mathematical ontology. This can lay a robust foundation for teachers' professional development and instructional effectiveness (Watt-Douglas & George, 2021); Second, diversifying teaching strategies is crucial. This may involve employing engaging and relatable real-life scenarios, incorporating suitable multimedia technologies, and utilizing heuristic and scaffolding approaches to maximize students' zone of proximal development. These efforts aim to enhance student engagement, stimulate interest in learning, cater to individualized needs, and establish a relaxed and democratic teacher-student relationship, thereby preparing the ground for an optimal classroom atmosphere. Third, a rich emotional investment in teaching is recommended, fostering empathetic connections and discerning subtle shifts in students' emotions. It is crucial to value seemingly incomprehensible student ideas, allowing students to experience the teacher's attentiveness and care (Taherdoost, 2017). Students can accept knowledge from the bottom of their hearts and actively try to express their feelings and experiences, which improves their expression, perception, willpower, and other aspects, ultimately culminating in a resonance between teacher and student. Creating a conducive learning atmosphere not only promotes comprehensive student development but also enhances educational effectiveness and teaching quality.

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Conflict of Interest Statement
The authors declare that there is no conflict of interest regarding the publication of this study.

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