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An Empirical Study of The Impact of Mathematics Learning Engagement on Academic Performance in Sixth Grade Primary School Students

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ABSTRACT

This study aimed to explore the relationship between primary school students' mathematics learning engagement (including the three dimensions of vigor, dedication, and absorption) and their mathematics academic performance, and to analyze the differences in mathematics learning engagement among students of different genders, classes, and academic levels. The Chinese version of the Utrecht Work Engagement Scale for Students (UWES-S). was used to conduct a questionnaire survey among 96 students from two sixth-grade classes in a central primary school in a town. Data were analyzed using SPSS 24.0 for reliability analysis, correlation analysis, and independent samples t-test. Conclusion: Academic performance is a key factor influencing primary school students' mathematics learning engagement, the classroom environment may have a potential influence but did not reach statistical significance, and gender showed no significant effect. This study suggests that educators should seek to improve students' academic outcomes by enhancing their learning engagement.

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INTRODUCTION

In the global wave of 21st-century key competency education, educational goals have shifted from mere knowledge transmission to promoting students' comprehensive and sustainable development. Mathematics, as a key discipline for cultivating students' logical reasoning, innovative thinking, and problem-solving abilities, is of paramount importance to educational quality. However, traditional educational evaluation systems have long been trapped in the "score-only" mindset, over-relying on academic achievement as the ultimate indicator of educational quality (Liu et al., 2020). This evaluation approach neglects students' psychological states and emotional experiences during the learning process, failing to comprehensively reflect the true effectiveness of education. Consequently, a growing number of researchers and

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educational practitioners recognize that revealing the process variables influencing academic achievement is more instructive for deeply understanding learning mechanisms and implementing effective teaching interventions (Fredricks, Blumenfeld, & Paris, 2004).

Against this backdrop, "learning engagement" has garnered widespread attention as a core process variable. It goes beyond traditional behavioral participation, encompassing the emotional, cognitive, and behavioral energy students invest in learning activities (Fredricks, Blumenfeld, & Paris, 2004). The importance of this concept has been supported by empirical evidence. For instance, results from the Programme for International Student Assessment (PISA) 2015 conducted by the Organisation for Economic Co-operation and Development (OECD) showed that while students from Beijing-Shanghai-Jiangsu-Guangdong (China) ranked tenth globally in scientific literacy, they reported longer learning hours and relatively lower learning efficiency. This finding suggests that despite high time investment, there may be an imbalance in students' emotional experiences and cognitive engagement during the learning process (OECD, 2016).

Among various models, the three-dimensional model of "vigor-dedication-absorption" (Schaufeli, Salanova, González-Romá, & Bakker, 2002) conceptualizes learning engagement as a positive, fulfilling state of mind, providing a solid theoretical framework for empirical research. This model posits that vigor manifests as high energy and mental resilience during learning; dedication reflects a strong sense of significance, enthusiasm, inspiration, and challenge in learning; and absorption is a pleasant state of full concentration characterized by immersion and the feeling that time passes quickly.

The Utrecht Work Engagement Scale for Students (UWES-S) was developed based on the three-dimensional model of learning engagement (vigor, dedication, absorption) proposed by Schaufeli et al. (2002). The development process of this scale was rigorous: Schaufeli and his colleagues first collected descriptive materials about engagement states through in-depth interviews with university students and young workers; subsequently, they combined these materials with items from the Utrecht Work Engagement Scale (UWES) to develop a preliminary student version; after multiple rounds of exploratory and confirmatory factor analyses, a three-dimensional structure comprising 17 items was ultimately established (Schaufeli et al., 2002). The scale was later revised by Fang, Shi, and Zhang (2008) to suit Chinese student populations. After testing with Chinese university student samples, they conducted item analysis and reliability and validity tests, confirming that the Chinese version of UWES-S possesses sound psychometric properties within the Chinese cultural context. The scale has been validated for good reliability and validity in multiple contexts worldwide (Fang, Shi, & Zhang, 2008).

Although research on learning engagement is increasingly abundant, the existing literature has two main shortcomings. First, most studies focus on secondary or university levels, while exploration targeting the upper primary grades—a critical period for cognitive and affective development—is relatively limited, despite evidence suggesting the crucial importance of engagement during this stage for subsequent development (Wang & Degol, 2014). Second, many studies investigate general learning engagement, while research situating engagement within specific subject contexts (such as mathematics), though called for by scholars (Wang, Fredricks, Ye, Hofkens, & Linn, 2016), remains to be deepened. Furthermore, despite the recognized importance of learning engagement, the current state of primary school students' mathematics learning engagement is not optimistic. Preliminary classroom observations and teacher interviews revealed that some sixth-grade students exhibit inattention, low interest in learning, and a tendency to give up when encountering difficulties during mathematics classes. These

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phenomena suggest potential deficiencies in their learning engagement, particularly in the dimensions of vigor (e.g., learning energy) and absorption (e.g., immersive experience).

The upper primary grades are a crucial period for the formation of students' mathematical interest, confidence, and learning habits. However, existing research presents two gaps: first, studies predominantly target secondary or university students, with limited exploration of the upper elementary level—a critical stage for cognitive and emotional development (Wang & Degol, 2014); second, most research examines general learning engagement, while subject-specific investigations (particularly in mathematics), despite scholarly calls (Wang, Fredricks, Ye, Hofkens, & Linn, 2016), require further deepening. This study possesses distinct novelty: it represents the first application of the UWES-S scale to specifically investigate mathematics learning engagement among sixth-grade students in Chinese township areas. Beyond examining the relationship between learning engagement and academic performance, it also analyzes the influence of variables such as gender and class, thereby offering more nuanced references for classroom teaching interventions. Therefore, investigating the characteristics of mathematics learning engagement and its relationship with academic performance during this stage holds unique theoretical value and practical significance for diagnosing current issues in primary mathematics instruction, enriching the disciplinary research on learning engagement, and providing teachers with targeted recommendations for teaching improvement.

Therefore, this study aims to fill the aforementioned research gaps. Using Schaufeli's three-dimensional model of "vigor-dedication-absorption" as the theoretical framework and the Chinese version of the UWES-S scale, this research investigates the mathematics learning engagement of sixth-grade primary school students. The specific objectives of this study are as follows:

1) To examine whether significant differences exist in mathematics learning engagement among student groups based on gender, class, and academic performance.
2) To explore the relationship between mathematics learning engagement and academic performance.

The findings of this study will provide an empirical basis for understanding the mathematics learning process of primary school students and offer targeted insights for teachers and schools on how to improve academic outcomes by enhancing student learning engagement.

LITERATURE REVIEW AND RESEARCH HYPOTHESES

2.1 The Concept and Measurement of Mathematics Learning Engagement

Learning engagement is a multidimensional construct. This study adopts the definition proposed by Schaufeli et al. (Schaufeli, Salanova, González-Romá, & Bakker, 2002), which views learning engagement as a positive, fulfilling state of mind associated with learning, characterized by: Vigor refers to having high levels of energy and mental resilience while learning, the willingness to invest effort in one's work, and persistence even in the face of difficulties; Dedication refers to being strongly involved in one's learning and experiencing a sense of significance, enthusiasm, inspiration, pride, and challenge; Absorption refers to being fully concentrated and happily engrossed in one's learning, whereby time passes quickly and one has difficulty detaching from the learning activity.

This three-dimensional model is widely accepted and applied internationally (Fredricks & McColskey, 2012). In terms of measurement, Fang Laitan, Shi Kan, and Zhang Fenghua (Fang, Shi, & Zhang, 2008) revised the Utrecht Work Engagement Scale (UWES) developed by

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Schaufeli et al., resulting in the Chinese version of the UWES-S suitable for student populations. This scale has demonstrated good reliability and validity among Chinese student groups, providing a reliable measurement tool for this study.

Although the UWES-S was initially developed as a general scale to measure engagement in general learning contexts, its core psychological constructs (vigor, dedication, absorption) have been proven equally applicable to specific subject learning contexts (Wang, Fredricks, Ye, Hofkens, & Linn, 2016). Regarding the discipline of mathematics, researchers have begun to explore the specific manifestations of these three dimensions in mathematics learning. For instance, studies at the secondary level indicate that students' vigor in mathematics classrooms manifests as persistence when facing difficult problems, dedication manifests as a sense of 认同感 towards the value of mathematics, and absorption manifests as immersive experiences during problem-solving (Ma, Fan, & Sun, 2015). Concerning the primary level, although relevant research is relatively limited, scholars have noted that mathematics learning engagement among upper primary students can also be effectively measured through these three dimensions, as students at this stage possess basic metacognitive abilities and emotional expression capabilities, enabling them to self-report their psychological states during the learning process (Wei et al., 2014). Therefore, applying the UWES-S to the primary mathematics context has both theoretical and empirical foundations. Based on this, the present study employs this scale to measure sixth-grade students' engagement levels during the mathematics learning process.

2.2 The Relationship Between Learning Engagement and Academic Performance

Substantial research indicates that learning engagement is an important predictor of academic performance (Fredricks, Blumenfeld, & Paris, 2004). Schaufeli et al. found that university students' level of learning engagement positively predicted their academic achievement (Schaufeli, Martínez, Pinto, Salanova, & Bakker, 2002). This relationship is also significant in basic education. Research by Ma Leidi et al. showed that learning engagement significantly influenced junior high school students' mathematics performance (Ma, Fan, & Sun, 2015).

The reason why students with high learning engagement demonstrate greater willingness to exert effort, employ effective learning strategies, and maintain positive learning attitudes involves the interplay of multiple psychological factors. According to Self-Determination Theory (Ryan & Deci, 2000), when students' three basic psychological needs—autonomy, competence, and relatedness—are satisfied during the learning process, they exhibit higher levels of learning engagement. Specifically within mathematics learning contexts, research indicates that students' interest in mathematical tasks and their perception of task value stimulate cognitive and emotional engagement (Wigfield & Eccles, 2000). Simultaneously, students' mathematics self-efficacy—their belief in their ability to successfully accomplish specific mathematical tasks—directly influences their persistence when facing difficulties (i.e., the vigor dimension) and their overall engagement level (Bandura, 1997). Furthermore, students with mastery goal orientations, who focus on ability improvement and task mastery, demonstrate deeper cognitive engagement and higher levels of concentration (Pintrich, 2000). These factors collectively contribute to the tendency of highly engaged students to exert more effort, use effective strategies, and maintain positive attitudes during learning, ultimately promoting improved academic performance (Linnenbrink-Garcia & Pekrun, 2011).

RESEARCH METHOD

3.1 Research Design

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This study employed a quantitative research design utilizing the survey research method, collecting data through questionnaires to investigate the relationship between primary school students' mathematics learning engagement and academic performance, as well as its differences across gender, class, and academic achievement levels.

3.2 Research Hypotheses

Based on the literature review presented in the previous section, this study proposes the following hypotheses:

H1: There are no significant differences in the total score and dimensions of mathematics learning engagement among primary school students of different genders.

H2: There are significant differences in the total score and dimensions of mathematics learning engagement among primary school students from different classes.

H3: There are significant differences in the total score and dimensions of mathematics learning engagement among primary school students with different levels of academic performance.

3.3 Participants

A cluster sampling method was employed in this study, and all students from two intact sixth-grade classes of a central primary school in a town were selected. These classes were naturally formed through the school's routine administrative process, with comparable teaching schedules and equivalent teacher qualifications, thus providing a representative sample of the school's sixth-grade population. A total of 102 questionnaires were distributed during regular class sessions. Following data screening procedures that eliminated incomplete and pattern-response questionnaires, 96 valid responses were retained, yielding an effective response rate of 94.1%.

Demographic information of participants was collected to serve as grouping variables for examining differences in mathematics learning engagement across various student populations. Specifically: Gender (male/female) was used to test H1; Class (Class 1/Class 2) was used to test H2; and Academic Performance (high/low performance group) was used to test H3, with academic performance groups categorized based on the most recent school-wide mathematics examination results—students scoring in the top 50% (n = 48) were classified as the high academic performance group, while those in the bottom 50% (n = 48) comprised the low academic performance group. The demographic characteristics of the final sample are presented in Table 3.1

Table 3.1. Demographic Information of Participants (N=96)

Variable	Name of courses	Number	Percent %
Gender	Male	54	56.25
	Female	42	43.75
Class	Class 1	47	48.96
	Class 2	49	51.04
Academic	High Performance Group	48	50.00
Performance	Low Performance Group	48	50.00

3.4 Research Instrument

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This study employed the Chinese version of the Utrecht Work Engagement Scale for Students (UWES-S), which was linguistically and culturally adapted and validated for Chinese student populations by Fang, Shi, and Zhang (2008). The scale comprises 17 items distributed across three dimensions: Vigor (6 items), Dedication (5 items), and Absorption (6 items). Participants responded to all items on a 7-point Likert-type scale ranging from 1 (never) to 7 (always), with higher composite scores reflecting greater levels of learning engagement. All items were positively worded and scored.

This study employed Cronbach's α coefficient to assess the internal consistency reliability of the scale. According to widely accepted criteria in the field, α coefficients greater than 0.9 indicate excellent reliability, 0.8-0.9 indicate good reliability, 0.7-0.8 indicate acceptable reliability, and values below 0.7 suggest unacceptable reliability (DeVellis, 2017; Nunnally & Bernstein, 1994). As shown in Table 3.2, the Cronbach's α coefficients for the vigor, dedication, and absorption dimensions were 0.880, 0.882, and 0.844, respectively, all falling within the good range (0.8-0.9); the total scale achieved an α coefficient of 0.942, reaching the excellent level. These results demonstrate that the Chinese version of the UWES-S possesses excellent internal consistency reliability within this study sample and is suitable for measuring primary school students' mathematics learning engagement. Previous validation studies have established satisfactory content and construct validity for this instrument within Chinese educational contexts.

Table 3.2. Reliability Analysis of the Mathematics Learning Engagement Scale

Dimension	Number of Items	Cronbach's α
Vigor	6	0.880
Dedicaton	5	0.882
Absorption	6	0.844
Total Scale	17	

3.5 Research Procedure and Data Analysis

The questionnaire was administered in group settings during regular class sessions. A trained head teacher provided standardized instructions to ensure consistent understanding across all participants, after which students completed the measure independently within a 15-minute period.

Prior to the implementation of the questionnaire survey, this study strictly adhered to the ethical norms for educational research involving human participants. Given that the research employed an anonymous questionnaire to collect non-sensitive data (focusing solely on students' mathematics learning engagement and academic performance without involving personal privacy or potential psychological harm), and in line with the common criteria for ethical exemption in non-invasive educational survey research (consistent with local educational research ethics guidelines), this study was granted an exemption from formal ethical review by the academic affairs office of a primary school in a town. No formal approval number was assigned as the exemption falls under routine educational research oversight.

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Informed consent forms detailing the study's purpose, data usage scope, anonymity guarantee, and voluntary participation principle were distributed to the guardians of all participating students, and written consent was obtained from each guardian prior to data collection. Additionally, students were verbally informed of their right to withdraw from the survey at any time without penalty and to skip any questions they were unwilling to answer. All collected data were processed and stored anonymously using password-protected devices to ensure the privacy and rights of participants were fully safeguarded.

Prior to statistical analysis, the collected data underwent comprehensive screening and cleaning procedures to identify and remove incomplete or patterned responses. All valid data were then analyzed using SPSS version 24.0. The statistical significance level for this study was set at $\alpha = 0.05$, meaning that results with p-values less than 0.05 were considered statistically significant (Field, 2018). For independent samples t-tests, in addition to reporting p-values, Cohen's d was calculated as a measure of effect size to quantify the magnitude of group differences. According to Cohen's (1988) criteria, $d = 0.2$ represents a small effect, $d = 0.5$ represents a medium effect, and $d = 0.8$ represents a large effect. The analytical procedure consisted of two main phases: first, descriptive statistics and correlation analyses were conducted to examine variable distributions and relationships; second, independent-samples t-tests were performed to investigate group differences in learning engagement based on gender, class membership, and academic performance level.

RESULTS

4.1 Descriptive Statistics and Correlation Analysis

Descriptive statistics and correlation analyses were conducted for all primary variables in this study, with detailed results presented in Table 4.1. Students' overall mathematics learning engagement demonstrated a mean score of 4.15 (SD = 1.18). Correlation analyses revealed statistically significant positive relationships between academic performance and all measures of learning engagement, including the total score and individual dimension scores (all $p < 0.01$).

Notably, among all correlations, the strongest association emerged between academic performance and the total engagement score ($r = 0.489$, $p < 0.01$). According to the interpretation standards for correlation coefficients in social science research proposed by Plonsky and Oswald (2014), r values between 0.40 and 0.59 are considered moderate correlations. Therefore, $r = 0.489$ indicates a moderate positive correlation between primary school students' overall mathematics learning engagement and their academic performance. This finding suggests that higher levels of student learning engagement tend to be associated with better mathematics academic outcomes, and vice versa. Among the three dimensions, dedication ($r = 0.468$) and vigor ($r = 0.463$) showed similar correlation strengths with academic performance, both slightly higher than absorption ($r = 0.417$). Nevertheless, all three dimensions reached statistical significance ($p < 0.01$), indicating that each aspect of learning engagement is closely related to academic performance.

Table 4.1. Descriptive Statistics and Correlation Analysis Results (N=96)

Variables	M	SD	1	2	3	4
Vigor	3.77	1.21				
Dedicaton	4.40	1.37	0.809			
Absorption	4.28	1.29	0.815	0.842		
Total Engagement	4.15	1.18	0.932	0.931	0.943	

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Academic Performance	-	-	0.463	0.468	0.417	0.489

M=Mean, SD=Standard Deviation, p<0.01

4.2 Tests of Differences in Mathematics Learning Engagement Among Different Groups

To test the research hypotheses, independent samples t-tests were used to compare differences in mathematics learning engagement across groups based on gender, class, and academic performance. The results are shown in Table 4.2, with the main findings summarized as follows:
Gender Differences: Male students scored slightly higher than female students on the vigor, absorption dimensions, and total score. However, independent samples t-test results showed that all p-values for dimensions and total score were greater than 0.05, and effect sizes (Cohen's d = 0.13-0.20) were all small effects according to Cohen's (1988) criteria. This indicates no significant differences in mathematics learning engagement between male and female primary school students, thus supporting research hypothesis H1.

Class Differences: Class 1 students scored higher than Class 2 students on all dimensions and the total score. Independent samples t-test results showed that p-values for all dimensions and total score ranged from 0.055 to 0.125, none reaching the 0.05 significance level. However, the p-values for the absorption dimension (p = 0.055) and total score (p = 0.062) approached the critical threshold, with effect sizes reaching small to medium effects (d = 0.38-0.40). These findings suggest that although there are no statistically significant differences in mathematics learning engagement between the two classes, certain trending differences exist. Therefore, research hypothesis H2 is not supported.

Academic Performance Differences: The high academic performance group scored significantly higher than the low academic performance group on all dimensions and the total score. Independent samples t-test results showed that all p-values for dimensions and total score were less than 0.001, reaching highly significant levels, with effect sizes (Cohen's d = 0.77-0.88) all reaching large effects according to Cohen's (1988) criteria. This indicates that students with high academic performance demonstrate significantly higher levels of mathematics learning engagement than those with low academic performance, providing strong support for research hypothesis H3.

Table 4.2. Comparison of Differences in Mathematics Learning Engagement Among Different Groups (M±SD)

Grouping Variable	Group	No.	Vigor	Dedication	Absorption	Total Score
Gender	Male	54	3.88±1.19	4.38±1.39	4.38±1.17	4.21±1.13
	Female	42	3.64±1.23	4.39±1.35	4.16±1.43	4.06±1.26
	t	-	0.97	-0.03	0.84	0.62
	p	-	0.335	0.975	0.404	0.537
	Cohen's d	-	0.20	-0.01	0.17	0.13
Class	Class 1	47	3.99±1.25	4.60±1.42	4.54±1.52	4.38±1.31
	Class 2	49	3.57±1.13	4.18±1.29	4.03±0.97	3.93±1.01
	t	-	1.73	1.55	1.95	1.89
	p	-	0.087	0.125	0.055	0.062

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Academic Performance	Cohen's d	-	0.35	0.32	0.40	0.38
	High Group	48	4.22±1.23	4.92±1.29	4.75±1.21	4.63±1.14
	Low Group	48	3.33±1.01	3.85±1.24	3.82±1.20	3.67±1.03
	t	-	3.87	4.12	3.76	4.33
	p	-	< 0.001	< 0.001	< 0.001	< 0.001
	Cohen's d	-	0.79	0.84	0.77	0.88

DISCUSSION

The results of this study indicate that academic performance is a key factor influencing primary school students' mathematics learning engagement, while the influence of the classroom environment did not reach statistical significance, and no significant gender differences were observed.

First, the significant positive correlation between academic performance and learning engagement validates the "input-output" model. High engagement typically leads to high achievement, while successful academic experiences may, in turn, enhance students' vigor, dedication, and absorption, forming a virtuous cycle (Schaufeli, Martínez, Pinto, Salanova, & Bakker, 2002; Wang & Fredricks, 2014). In this study, there were significant differences between the high and low performance groups across all dimensions and the total score ($p < 0.001$), with large effect sizes (Cohen's $d > 0.77$). This finding is consistent with previous research. For instance, Schaufeli et al. (2002) found that university students' level of learning engagement positively predicted their academic achievement; Ma Leidi et al. (2015) also demonstrated that mathematics learning engagement significantly influenced junior high school students' mathematics performance. The present study extends this relationship to sixth-grade primary school students, confirming that a significant positive correlation between learning engagement and academic performance also exists at the upper primary level. Compared with studies conducted at secondary and university levels, the correlation coefficient in this study ($r = 0.489$) is moderate, slightly lower than those reported in some secondary school studies (e.g., Ma et al., 2015, $r = 0.52$-0.58). This discrepancy may stem from the limitations of primary school students' metacognitive abilities and self-reporting capacity. Nevertheless, the effect sizes ($d > 0.77$) reached large levels, indicating that the association between learning engagement and academic performance holds important practical significance in actual educational contexts. Therefore, this study not only validates the applicability of the learning engagement-academic performance relationship at the primary level but also suggests that educators should prioritize the cultivation of mathematics learning engagement among upper primary students.

Second, although the differences between classes did not reach statistical significance, Class 1 scored higher than Class 2 on the total score and all dimensions, with differences in the absorption dimension ($p = 0.055$) and total score ($p = 0.062$) approaching significance and demonstrating small to medium effect sizes ($d = 0.38$–0.40). This trend may stem from differences in environmental factors: for example, Class 1's teacher might adopt more interactive teaching methods (e.g., group problem-solving activities) that enhance students' immersive learning (thus increasing absorption scores), or Class 1 has a more positive peer learning climate that encourages mutual support in mathematics learning. This pattern aligns with existing

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research documenting that learning environments characterized by teacher support and peer collaboration positively influence student engagement (Linnenbrink-Garcia & Pekrun, 2011).

Finally, the three-dimensional model of "vigor-dedication-absorption" employed in this study demonstrates unique application value in the context of primary mathematics education. Specifically: the vigor dimension effectively captures primary school students' persistence and energy investment when facing difficulties in mathematics learning, which is crucial for cultivating mathematical resilience; the dedication dimension reflects students' sense of meaning and enthusiasm toward the mathematics discipline, contributing to understanding the formation mechanisms of mathematical interest; the absorption dimension embodies students' immersive experiences during mathematical activities, closely associated with deep learning qualities. These three dimensions portray the complete process of primary mathematics learning from different perspectives, providing teachers with multi-dimensional observation lenses for instructional practice. For instance, when students score low on the vigor dimension, teachers can design appropriately challenging tasks; when dedication dimension scores are insufficient, teachers can strengthen connections between mathematics and real life to enhance students' sense of value identification. Thus, introducing the three-dimensional engagement model into primary mathematics education research not only enriches the theoretical connotations of learning engagement but also provides operable diagnostic tools for classroom teaching practice.

Furthermore, the absence of significant gender differences represents a noteworthy finding worthy of deeper consideration. This may reflect the advancement of gender equality in education in recent years, suggesting that at the primary school level, boys and girls are becoming more similar in their cognitive and emotional investment in mathematics learning (Wang & Degol, 2014). This finding carries important implications for educational practice: This research suggests the need for educators to move beyond traditional stereotypes that "boys are better at mathematics than girls," and instead focus on individual differences rather than gender differences, providing equal mathematics learning support for all students. Additionally, the findings suggest the need to further explore deeper factors influencing learning engagement, such as environmental variables including classroom climate, teacher-student interactions, and family support, rather than focusing solely on students' demographic characteristics.

CONCLUSION

5.1 Research Conclusions

Based on a questionnaire survey of 96 sixth-grade primary school students, this study draws the following main conclusions:

First, the Chinese version of the UWES-S scale demonstrated sound psychometric properties in the context of this study. The Cronbach's α coefficient for the total scale was 0.942, and the coefficients for the vigor, dedication, and absorption dimensions were 0.880, 0.882, and 0.844, respectively, all reaching good or excellent levels. This indicates that the scale is suitable for measuring the mathematics learning engagement of Chinese primary school students.

Second, there is a significant positive correlation between primary school students' mathematics learning engagement and their mathematics academic performance. Correlation analysis showed that the correlation coefficients between the total engagement score and dimension scores with academic performance ranged from 0.417 to 0.489 ($p < 0.01$), with the dedication dimension ($r = 0.468$) and vigor dimension ($r = 0.463$) showing slightly higher

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correlations than the absorption dimension (r = 0.417). This finding suggests that higher levels of student learning engagement tend to be associated with better mathematics academic outcomes.

Third, students with different demographic characteristics exhibited different patterns of differences in mathematics learning engagement. Gender difference analysis revealed no significant differences between male and female students in the total engagement score or any dimension scores ($p > 0.05$), indicating that gender is not a key factor influencing primary school students' mathematics learning engagement. Class difference analysis showed that although Class 1 scored higher than Class 2 on all dimensions, the differences did not reach statistical significance ($p > 0.05$). However, the differences in the absorption dimension ($p = 0.055$) and total score ($p = 0.062$) approached significance, with effect sizes reaching small to medium levels ($d = 0.38$-0.40), suggesting that the classroom environment may have a potential influence on learning engagement. Academic performance difference analysis demonstrated that the high academic performance group scored significantly higher than the low academic performance group on the total engagement score and all dimensions ($p < 0.001$), with effect sizes reaching large levels ($d = 0.77$-0.88), indicating that academic performance is a key factor influencing primary school students' mathematics learning engagement.

5.2 Educational Recommendations

Based on the above conclusions, the following educational recommendations are proposed:

Teacher Level: Given the strong association between learning engagement and academic performance, teachers should focus on creating a positive and supportive mathematics learning atmosphere. This can be achieved by designing tasks with appropriate challenge levels to enhance students' vigor; integrating the history of mathematics and real-life application cases to strengthen students' sense of dedication; and guiding students to experience immersive learning to cultivate absorption. These strategies can systematically enhance student learning engagement.

School Level: Schools should encourage experience sharing among teachers and pay attention to the balanced development of learning atmospheres across different classes. Additionally, schools should consider using learning engagement as a reference indicator in process evaluation, enabling early identification of and intervention for student groups with low engagement levels.

5.3 Research Limitations and Future Directions

This study has two main limitations that need to be noted. First, the sample was recruited exclusively from two sixth-grade classes of a central primary school in a town with a relatively small size ($n = 96$). This not only limits the generalizability of results to students in urban or rural primary schools with different socioeconomic backgrounds but may also reduce the statistical power to detect subtle differences (e.g., the near-significant class differences in absorption, $p = 0.055$). Second, the cross-sectional research design only captures the simultaneous state of mathematics learning engagement and academic performance at a specific time point, making it impossible to confirm the causal direction between the two variables. It remains unclear whether high learning engagement leads to better academic performance or whether good academic performance promotes higher learning engagement.

Future research could expand the sampling scope (e.g., including multiple schools across urban and rural areas) and increase sample size, while employing longitudinal tracking designs to more deeply reveal the dynamic interaction mechanisms between mathematics learning

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engagement and academic performance. Furthermore, in light of the finding that class differences approached but did not reach statistical significance, future research could employ qualitative methods such as classroom observations and teacher interviews to explore the specific reasons behind this trend, including the mechanisms of environmental factors such as teacher teaching styles, classroom interaction patterns, and peer learning climates. Through the combination of quantitative and qualitative research approaches, a more comprehensive understanding of the formation mechanisms of primary school mathematics learning engagement and its dynamic relationship with academic performance can be achieved.

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