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Exploring the relationship between teachers' perceived workload, challenge-hindrance stress, and work engagement: a person-centered approach

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Abstract

Purpose This study explored the effects of teachers' perceived workload on their work engagement in Chinese primary and secondary schools using a person-centered approach. The aim was to investigate the relationship and the mediating roles of challenge and hindrance stress.

Methods A total of 40,712 primary and secondary school teachers from China participated in this study. Participants were asked to rate their perceived workload across five major educational and teaching tasks. To assess their work engagement and challenge-hindrance stress, the Utrecht Work Engagement Scale and the Challenge-Hindrance Stressors Scale were employed. Latent Class Analysis (LCA) was conducted to classify the distinct workload categories. Subsequently, relative mediation analysis was performed to examine the relationships between perceived workload, work engagement, and the mediating roles of challenge and hindrance stress. The data analysis was carried out using Mplus 8.3, SPSS 26.0, and the PROCESS macro (version 3.3).

Results The LCA identified five different classes of workload: low, relatively low, average, relatively high, and high, corresponding to different levels of teachers' perceived workload. There was a negative correlation between perceived workload and work engagement. Challenge stress positively mediated this relationship by increasing teachers' work engagement, whereas hindrance stress negatively mediated the relationship by decreasing work engagement.

Conclusion The study reveals a complex interplay between teachers' perceived workload and work engagement, with challenge and hindrance stress acting as mediators. These findings offer insights for developing targeted intervention strategies to improve teacher well-being and performance.

Keywords Perceived workload, Teachers' work engagement, Challenge stress, Hindrance stress, Latent class analysis

Introduction

Work engagement is a positive, work-related psychological state that manifested as employees' enthusiasm, dedication, and focus on their work [1, 2]. In recent years, from the perspective of positive psychology, work engagement in the unique occupational field of teaching has garnered significant attention as a positive aspect of occupational psychology. High levels of work engagement are of great significance to educational outcomes

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and organizational efficiency. Not only do they help teachers implement teaching activities more effectively and enhance students' learning achievements [3, 4], but they are also inversely related to issues such as teacher burnout, thereby improving the overall quality of education [5–7]. Teacher work engagement not only reflects their passion for education and professional commitment but is also an important indicator of their mental health and professional development [7–9].

Existing research mainly focuses on the outcome variables of work engagement, while relatively fewer studies investigate the antecedent variables that affect teachers' work engagement, especially the relationship between perceived workload and work engagement. Moreover, research on workload has predominantly emphasized objective indicators, such as working hours [10, 11], rather than examining it from the perspective of teachers' subjective perceptions. With increasing societal demands for educational quality, especially in the context of China's "Double Reduction" policy, primary and secondary school teachers (including elementary, middle, and high school teachers) are facing increasingly heavy and diverse workloads, leading to a continual increase in their perceived workload [12]. Excessive workload may negatively impact teachers' psychological states, thereby reducing their level of work engagement [13]. Existing studies often fail to investigate workload based on different work contents, overlooking the impacts that specific work tasks may have on teachers' psychology and behavior. Therefore, an in-depth exploration of the mechanisms by which perceived workload affects teachers' work engagement is of crucial importance for promoting teachers' professional development and mental health.

To gain a deeper understanding of this phenomenon, this study draws on Conservation of Resources Theory (COR) as its theoretical framework. The COR theory posits that individuals have the motivation to acquire, maintain, and protect their own resources. Excessive work demands can deplete personal resources, resulting in stress and burnout, which reducing work engagement [14]. In the work context, teachers regard time, energy, emotional resources, and so on as "important resources." High workloads accelerate the depletion of these resources, causing teachers to experience a sense of resource loss, increasing stress, and thus reducing their work engagement [15]. However, an individual's cognitive appraisal of workload determines their stress response [14]. Applied to the teaching context, individuals may appraise workload as either challenges or threats, thereby affecting their emotional and behavioral responses. Empirical studies have shown that when teachers perceive high workloads as challenge stress, it may stimulate their intrinsic motivation and promote work engagement; conversely, if they perceive it as hindrance stress, it may lead to negative emotions and reduce work engagement [16]. However, current research is still insufficient in revealing the internal link between perceived workload and teachers' work engagement. Particularly, how the nature of stress resulting from teachers' perceived workload (i.e., challenge stress or hindrance stress) affects their work engagement—the mechanism of this effect—has yet to be fully validated and explained [17, 18].

In the context of Asian culture, primary and secondary education generally adopts a collective teaching model, and families have high expectations for education. This requires teachers not only to cope with heavy teaching tasks but also to handle a large number of administrative and interpersonal communication matters [19]. Especially under China's "Double Reduction" policy, societal expectations for the quality of compulsory education continue to rise, and the workload and stress faced by primary and secondary school teachers are continually increasing [20], providing a rich practical basis for this study. In such a high-stress environment, teachers' work engagement may be affected, thereby influencing their mental health and the quality of education and teaching.

Based on this, the present study aims to thoroughly explore the pathways through which primary and secondary school teachers' perceived workload affects their work engagement, with particular attention to the mediating roles of challenge and hindrance stress. Specifically, this study will examine the direct relationship between perceived workload and work engagement, as well as the mediating effects of challenge stress and hindrance stress between them, with the aim of providing a theoretical basis for enhancing teachers' occupational mental health, stabilizing the teaching workforce, and promoting the sustainable development of education. The research findings will not only help to reveal common issues and patterns among teachers in the basic education stage—holding significant practical implications for the Chinese education system—but also offer broad insights for other educational contexts. Regardless of the educational environment, understanding the interrelationship between workload and teachers' work engagement is of great importance for administrators in formulating effective educational management strategies and enhancing teachers' professional motivation, thereby improving education quality and safeguarding teachers' well-being.

Literature review

Theoretical foundation

This study is grounded in Conservation of Resources Theory (COR) and the Cognitive Appraisal Theory of stress [15]. According to COR theory, individuals have an

intrinsic motivation to acquire, retain, and protect their valued resources, which include personal characteristics, energy, time, and supportive relationships [15]. Among these principles, the primacy of resource loss principle states that resource loss has a greater impact on individuals than resource gain. That is, individuals are more sensitive to actual resource loss or potential threats, which can trigger greater stress and negative reactions [15, 21]. Within this theoretical framework, teachers need not only physical and emotional resources to cope with daily work but also psychological resources to maintain a positive attitude and sustained engagement in their work. Excessive workload may lead to overconsumption of teachers' emotional, cognitive, and physical resources [22], and is therefore regarded as a potential depletion and threat to their resources. If teachers do not have the opportunity to recover resources from heavy work, or cannot obtain sufficient resources to compensate for the resource depletion caused by workload, they may enter a vicious cycle of continuous resource loss, thereby reducing work engagement [23].

According to the Cognitive Appraisal Theory of stress [14], teachers' subjective evaluation of workload plays a critical role in stress responses and work motivation. When workload exceeds an individual's capacity or resources, it becomes a stressor that affects teachers' experience of stress and subsequent behavioral responses. Specifically, when facing workload, teachers determine the significance of these stressors and their coping ability through primary and secondary appraisals. Primary appraisal is the cognitive judgment about whether the workload constitutes a challenge or a threat; secondary appraisal is the evaluation of one's own resources and abilities, leading to varying levels of stress. Building upon this theory, Cavanaugh et al. introduced the challenge-hindrance framework to classify how individuals appraise stressors as either challenges or hindrances [24]. When individuals believe they have the capability to cope with the stressor, and that the coping process may bring growth and benefits, they are more inclined to perceive it as challenge stress, leading to positive behavioral outcomes. Conversely, if individuals believe the stressor is difficult to manage and may threaten personal growth and gains, they tend to perceive it as hindrance stress, resulting in negative consequences.

By integrating the above two theories, it can be inferred that teachers' perceived workload determines their cognition of the nature of work-related stress, thereby influencing their work engagement. When perceived workload causes teachers to experience challenge stress, they tend to actively mobilize resources, enhance the sense of meaning and accomplishment in their work, and thus increase work engagement [25, 26]. Conversely, if the perceived workload generates hindrance stress, it may result in resource depletion, stress accumulation, and even job burnout, thereby reducing work engagement [27]. By deeply understanding this theoretical framework, we can more effectively formulate and implement strategies to optimize teachers' work tasks, further promote the rational utilization of resources, alleviate teachers' stress perceptions, and thus significantly enhance their work engagement and professional well-being.

The effect of perceived workload on teachers' work engagement

Perceived workload, as a subjective experience, is considered a key factor affecting individual occupational health and work performance [28, 29]. It refers to an individual's subjective evaluation of the work tasks they undertake, involving the perceived relationship between the effort required to complete the tasks and their own resources. When teachers perceive that the demands of work tasks exceed their existing abilities or resources, this subjective cognition becomes a stressor, potentially leading to a reduction in work engagement and even long-term mental health problems [24]. Therefore, exploring the impact of teachers' perceived workload on their work engagement is of great significance for understanding and promoting their professional well-being.

However, previous studies have tended to equate teachers' workload with time-related stressors, focusing on analyzing the impact of working hours on teachers' work status [10, 11]. This measurement approach overlooks the role of teachers' subjective perception of the demands of work tasks relative to their own resources—that is, the importance of teachers' subjective experience in work performance. With the evolution of educational policy reforms and teaching requirements, the tasks faced by teachers have become increasingly complex and diverse. Measuring workload solely by working hours is no longer sufficient to fully reflect teachers' work intensity. According to the survey results of TALIS across more than 60 education systems, the sources of workload for primary and secondary school teachers mainly include teaching responsibilities, students' performance in the classroom, administrative work, and managerial duties [30, 31]. Considering the Chinese educational context, in this study, teachers' perceived workload primarily refers to their core work content, namely, lesson preparation, homework grading, classroom teaching, classroom management, and parent-teacher communication.

Workload is typically associated with reductions in work performance and willingness, as well as harm to workers' well-being and health [32]. However, the rapid development of information technology, innovations in teaching methods, and the diversification of student

needs have all increased the breadth and depth of teachers' work. The recent implementation of the "Double Reduction" policy in China, although aimed at alleviating students' burdens, has imposed new requirements on teachers to adjust teaching content, improve teaching methods, and strengthen the management of after-school services, which may intensify teachers' perceived workload and thus affect their work engagement.

Based on the primacy of resource loss principle of the Conservation of Resources (COR) theory, when teachers perceive excessive workload, they may experience actual depletion of personal resources (such as time, energy, and emotions) or face the threat of further resource consumption. This resource loss or the threat of loss can trigger stress responses, causing teachers to focus more on conserving their remaining resources. To avoid further resource exhaustion, teachers may proactively reduce their enthusiasm and effort invested in their work [23]. Although this strategic resource conservation behavior may alleviate stress in the short term, it can lead to a decrease in work engagement. Empirical studies have consistently shown a negative correlation between perceived workload and work engagement [33]. When employees perceive a higher workload, it leads to increased emotional exhaustion, which, in turn, reduces their level of work engagement [34]. In the field of education, surveys have found that Asian high school teachers perceive greater workload, including longer working hours and higher levels of challenges in workload management, which is manifested in reduced job satisfaction and work engagement [35, 36]. Moreover, the impact of workload on the work engagement of primary and secondary school teachers also depends on factors such as psychological resilience, psychological stress, and cognitive appraisal of stressors [4, 37, 38]. Therefore, based on theoretical analysis and empirical research, this study proposes the following hypothesis:

H1: Teachers' perceived workload is negatively correlated with their work engagement; the higher the level of perceived workload, the lower the level of work engagement. Furthermore, perceived workload negatively predicts teachers' work engagement.

The mediating effect of challenge-hindrance stress

In delving deeper into the relationship between teachers' perceived workload and their work engagement, stress emerges as a core concept that plays a pivotal connecting role. Research indicates that individuals' subjective appraisal of stressors determines the nature of their responses (i.e., stress) [14], as well as the coping strategies they employ and their level of work engagement [39–41].

Within this framework, work stress can be categorized into challenge stress and hindrance stress based on its nature [14, 24, 26]. Challenge stress is a positive stress response that can stimulate motivation, enhance focus, and improve performance. In contrast, hindrance stress is a negative stress response that may lead to anxiety, job burnout, and decreased performance [42, 43]. With rising societal expectations regarding teachers' professional capabilities, the work content faced by primary and secondary school teachers has become more diverse and in-depth. They are expected to provide high-quality education, promote student success, address mental health issues, and maintain effective communication with parents and guardians. The overlapping roles and continually increasing responsibilities expose teachers to both challenge stress and hindrance stress simultaneously, exerting a complex impact on their work engagement.

Specifically, there is a close relationship between teachers' perceived workload and challenge-hindrance stress. When teachers perceive that the workload they bear—though accompanied by resource depletion—has the potential to promote personal growth and development, they may experience challenge stress. This type of stress is associated with factors such as the significance of job responsibilities and a broad scope of work [44]. Conversely, when teachers believe that workload hinders personal growth and impedes goal attainment, they may experience hindrance stress, which relates to factors such as organizational politics, role conflict, and job insecurity [45]. Studies have shown that individuals' cognitive appraisal of workload significantly influences the type and intensity of their stress experiences [46–48]. Empirical research has demonstrated the coexistence of challenge stress and hindrance stress within teachers' work environments [49, 50]. For example, the study by Stiglbauer et al. indicates that society's high demands on teachers and the management of student misbehavior led teachers to experience significant hindrance stress, while the expansion of their work scope makes them perceive their work as challenging [43].

Secondly, challenge and hindrance stress have different effects on teachers' work engagement. A substantial body of research has shown that challenge stress is typically associated with positive work outcomes [51]. When teachers face challenge stress, it can stimulate their intrinsic motivation and positive emotions, making them more likely to perceive their work as meaningful and valuable. This, in turn, encourages them to invest extra effort to overcome challenges and achieve professional growth [49, 52]. For example, teachers may actively engage in educational research and seek new teaching methods to enhance classroom effectiveness [53]. In contrast, hindrance stress may impede individual work performance and negatively affect work motivation and outcomes [54, 55]. Hindrance stress can cause teachers to develop

negative attitudes toward their work, such as emotional exhaustion and depersonalization, thereby reducing work engagement and teaching effectiveness [16, 17, 56]. Studies have shown that prolonged hindrance stress leads to teacher burnout, increases turnover intentions, and negatively impacts educational quality [57].

Furthermore, challenge and hindrance stress may serve as mediators between perceived workload and teachers' work engagement. The meta-analytic study by Crawford et al. supports the existence of this mediating role, indicating that challenge stress positively mediates the relationship between job demands and positive work outcomes, while hindrance stress negatively mediates the relationship between job demands and negative work outcomes [25]. Therefore, perceived workload may be a "double-edged sword." If teachers believe that their work tasks can enhance their professional competencies and career development opportunities, and they have confidence in their ability to cope, then a high workload is perceived as challenge stress, which can motivate positive responses and strengthen work engagement. Conversely, if teachers perceive that work tasks exceed their capabilities and may lead to failure or punishment, then a high workload is perceived as hindrance stress, reducing work engagement [39–41, 58]. Despite previous research demonstrating that work stress can have both negative and positive predictive effects on work engagement [16–18, 20], there remains a significant lack of studies exploring how challenge and hindrance stress specifically affect teachers as a distinct group. Moreover, the process by which workload influences teachers' work engagement through the induction of challenge and hindrance stress may play a crucial role. Therefore, this study proposes the following hypotheses:

H2: Workload is positively correlated with challenge stress and negatively correlated with hindrance stress; challenge stress is positively correlated with work engagement, while hindrance stress is negatively correlated with work engagement.

H3: Challenge and hindrance stress function as parallel mediators between perceived workload and teachers' work engagement. Perceived workload positively predicts teachers' work engagement through challenge stress and negatively predicts it through hindrance stress.

Person-centered approach and latent class analysis

In the field of research on teachers' perceived workload, the traditional variable-centered approach (VCA) has long been dominant. This method focuses on the correlations and overall trends among variables, unveiling common patterns within the overall sample through quantitative analysis [59]. Although VCA holds significant value in understanding relationships between variables, it may overlook heterogeneity among individuals and fail to capture the subtle differences in teachers' perceptions of workload.

In contrast, the person-centered approach (PCA) emphasizes individual differences, focusing on the unique combinations and patterns that individuals exhibit across multiple variables [60]. By identifying groups with similar characteristics, PCA delves deeply into how individual traits influence research questions, thereby revealing heterogeneity within groups and providing a new perspective for understanding the diversity of teachers' perceived workload [60, 61].

Latent Class Analysis (LCA) is a commonly used statistical technique within PCA. It identifies latent classes or types based on individuals' responses to a series of categorical variables [62]. In the field of educational psychology, LCA has been widely utilized to deeply analyze the psychological traits and behavioral patterns of teachers and students in large samples. The advantage of this method lies in its ability to process substantial datasets, uncovering the diverse psychological characteristics and behavior patterns within groups. For example, Korpershoek employed LCA to identify different types of student learning motivation, providing empirical support for the development of differentiated teaching strategies [63].

Applying LCA to classify teachers' perceived workload aids in gaining a deeper understanding of the differences in workload perception among various groups of teachers. This method not only offers statistically significant insights at the individual level but also allows a comprehensive examination of how teachers perceive workload across various tasks [17, 64]. Compared to VCA, PCA provides a more comprehensive, systematic, and integrated perspective, allowing for a more precise reflection of the diversity within the teacher population [65].

The current study

Given these considerations, the present study adopts a person-centered approach and utilizes Latent Class Analysis (LCA) to identify and classify latent classes of teachers' perceived workload. The aim is to explore the different latent classes among teachers' perceived workload and to reveal the heterogeneity within the teacher population. Based on this, and drawing from the Conservation of Resources Theory and the Cognitive Appraisal Theory of Stress, we further investigate the impact of these workload classes on teachers' work engagement and their underlying mechanisms. Specifically, we analyze the differences in work engagement among teachers belonging to different workload classes, clarifying the direct effects of perceived workload on work engagement. Additionally, this study examines the mediating

roles of challenge stress and hindrance stress between the workload classes and teachers' work engagement. This research design helps to unveil the internal structure of teachers' perceived workload and provides a deeper understanding of its pathways influencing work engagement.

Method

Procedure and participants

This study began in May 2022. To ensure the representativeness of the sample, various factors were comprehensively considered, including the economic and educational development levels of each province, urban–rural disparities, regional differences between eastern and western China, and variations in the educational stages taught by teachers. This research utilized a stratified sampling method to conduct a survey of primary and secondary school teachers across all 34 provinces in China over a 25-day period.

As part of a research project supported by the Ministry of Education of China, and following communication between our university and the education bureaus, online questionnaires were distributed to primary and secondary school teachers through official school channels using the Wenjuanxing platform. Teachers participating in the survey were required to complete all items before they could submit the questionnaire. The data collection period for the questionnaire was two weeks. Based on data provided by the schools, the expected number of participating teachers was 48,874. In actuality, 41,910 questionnaires were returned, yielding a participation rate of 85.75%. Since the questionnaires were completed online, there were no issues with missing data. Therefore, we excluded invalid questionnaires based on factors such as incorrect responses to validity check items and the time teachers took to complete the questionnaire, resulting in 40,712 valid responses, with a validity rate of 97.14%. Among the participants, there were 30,378 females (74.62%) and 10,334 males (25.38%). Detailed background characteristics of the participants are provided in Table 1.

Table 1 Background information of the participants

Characteristic	Frequency	Percentage (%)
Gender		
Male	10,334	25.38
Female	30,378	74.62
Age		
21- 30 years	7,090	17.42
31- 40 years	11,114	27.30
41- 50 years	13,481	33.11
50 years above	9,027	22.17
Teaching tenure		
0 –10 years	13,149	32.30
11—20 years	7,873	19.34
21—30 years	12,736	31.28
Over 30 years	6,954	17.08
Educational attainment		
Associate degree and below	6,650	16.35
Bachelor's degree	31,248	76.75
Graduate or professional degree	2,814	6.91
Professional title		
Junior	4,551	11.17
Intermediate	9,203	22.61
Senior	16,558	40.67
Advanced	10,400	25.55
Instructional level		
Primary school (Grades 1–6)	25,060	61.56
Middle school (Grades 7–9)	11,865	29.14
High school (Grades 10–12)	3,787	9.30

Measures

Teachers' perceived workload

To accurately assess the perceived workload of primary and secondary school teachers across regions, official guidelines on teachers' workload for compulsory education schools were referred to. These guidelines were issued by various regions after the implementation of the "Double Reduction" policy, based on directives from the national government issued in 2021. Additionally, discussions were held with experts in the fields of education and psychology to synthesize these guidelines, resulting in the identification of five core components of teachers' workload in primary and secondary schools: lesson preparation, homework grading, classroom teaching, classroom management, and parent-teacher communication. The questionnaire includes 5 items, each corresponding to a core work content, such as "How do you perceive the workload of correcting homework?" The questionnaire uses a 5-point Likert scale (1 = "Very Little"; 5 = "Very Much"), with higher scores reflecting a heavier workload perceived by teachers on the respective task.

Teachers' work engagement

Teachers' work engagement was evaluated using the Utrecht Work Engagement Scale [66], with questionnaire items modified to correspond with the discourse appropriate for the teaching demographic. The questionnaire consists of 17 items distributed across three dimensions: vigor (e.g., "At my work, I feel bursting with energy"), dedication (e.g., "I am enthusiastic about my job"), and absorption (e.g., "Time flies when I'm working"). Responses are recorded on a 5-point Likert scale (1 = "Never"; 5 = "Always"), with higher scores indicating

higher levels of work engagement. In the present study, the Cronbach's α coefficients were 0.865.

Challenge-hindrance stress

To assess the stress conditions experienced by the teachers, this study employed the Challenge-Hindrance Stressors Scale (HSS) [67]. The scale is divided into two sections, challenge stressor and hindrance stressor, with a total of eight items. The challenge stressor scale assessed the sense of time urgency, job complexity, job difficulty, and job responsibilities, with questions such as "My job requires me to put in a lot of effort." The hindrance stressor scale assessed perceived levels of red tape, role ambiguity, role conflict, and hassles, with questions such as "I receive conflicting requests from two or more people." All items were assessed using a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). The Cronbach's alpha coefficient was 0.730 for the challenge stressor scale and 0.735 for the hindrance stressor scale.

Statistical analysis

The questionnaires were distributed online to primary and secondary school teachers and were coordinated by their respective schools; therefore, there were no missing data in the final sample. Before proceeding with person-centered analysis, the data were first examined for common method bias. Subsequently, latent class analysis (LCA) was conducted using Mplus 8.3 software to identify distinct levels of teachers' perceived workload (including lesson preparation, homework grading, classroom teaching, classroom management, and parent-teacher communication). Models with 2 to 6 classes were extracted and compared, and the optimal latent class model was selected based on the corresponding fit indices. Then, variance analysis was performed using Hayes's SPSS 22.0 to confirm the differences between latent classes in the model [68]. Following this, relative mediation analysis was conducted using the PROCESS macro to test the mediating effects of challenge stress and hindrance stress as mediator variables. The bias-corrected percentile Bootstrap method was employed, extracting 5000 samples to estimate the 95% confidence intervals for the mediation effects.

Results

Common method bias test

Due to inherent constraints, this study exclusively utilized self-reported approaches for data collection, which may have introduced common method variation (CMV). To mitigate potential biases, procedural control measures, including anonymous measurement and the inclusion of reversed questions on selected items, were implemented in accordance with recommendations [69]. During data processing, Harman's single-factor test for CMV was executed. Each item across the four scales underwent individual exploratory factor analysis (EFA), resulting in the extraction of 6 factors with eigenvalues surpassing 1. The cumulative variance explained by the primary factor amounted to 25.80%, falling below the critical threshold of 40%, signifying the absence of significant CMV [69].

Demographic characteristics in relation to teachers' work engagement

The results of t-test and one-way ANOVA indicated significant variations in the teachers' work engagement concerning demographic variables, including gender, age, educational attainment, teaching tenure, professional titles, and the instructional level at which they were engaged. Specifically, a noteworthy gender difference in teachers' work engagement was observed ($t = -4.93$, $p < 0.001$), with male teachers showing significantly lower engagement ($M = 61.16$, $SD = 9.05$) compared to their female counterparts ($M = 61.67$, $SD = 8.62$). Analysis of variance results further indicated significant differences in teachers' work engagement based on age ($F_{(3,40709)} = 168.41$, $p < 0.001$), educational attainment ($F_{(2,40710)} = 104.00$, $p < 0.001$), teaching tenure ($F_{(3,40709)} = 143.00$, $p < 0.001$), professional title ($F_{(3,40709)} = 123.48$, $p < 0.001$), and instructional level ($F_{(2,40710)} = 12.07$, $p < 0.001$).

Teachers aged 51 and above manifested the highest level of work engagement ($M = 63.18$, $SD = 8.57$), while those within the 21–30 age cohort demonstrated comparatively lower work engagement ($M = 60.30$, $SD = 8.72$).

Teachers with graduate or professional degrees ($M = 59.89$, $SD = 8.74$) exhibited significantly lower work engagement than those holding a bachelor's degree ($M = 61.44$, $SD = 8.69$) and those with an associate degree or below ($M = 62.68$, $SD = 8.78$).

Teachers with teaching tenure longer than 30 years reported the highest work engagement ($M = 63.38$, $SD = 8.57$), followed by those with 21–30 years of experience ($M = 61.57$, $SD = 8.73$). Those with 0–10 years of teaching tenure reported the lowest work engagement ($M = 60.82$, $SD = 8.66$).

In terms of professional titles, advanced-level teachers exhibited the highest level of work engagement ($M = 62.76$, $SD = 8.50$). Intermediate-level teachers reported the lowest work engagement ($M = 60.41$, $SD = 8.82$), which was significantly lower than that of junior-level ($M = 61.67$, $SD = 8.77$), senior-level ($M = 61.36$, $SD = 8.73$), and advanced-level teachers.

Regarding the instructional levels, primary school teachers ($M = 61.65$, $SD = 8.80$) demonstrated the highest work engagement High school teachers exhibited the lowest work engagement ($M = 60.90$, $SD = 8.53$).

There was no significant difference in work engagement between primary school teachers and middle school teachers ($M = 61.52$, $SD = 8.65$).

In addition, to mitigate the potential impact of the demographic variables on the research findings, these variables were considered control variables in the subsequent relative mediation effect analysis.

Descriptive analysis of perceived workload, challenge-hindrance stress, and teacher work engagement

Table 2 presents the means, standard deviations, and correlation coefficients for each variable. Significant correlations were found between the total score of perceived workload, challenge stress, hindrance stress, and teacher work engagement. Consistent with the hypotheses, the total score of perceived workload was positively correlated with challenge stress and negatively correlated with hindrance stress and work engagement. Furthermore, challenge stress was positively correlated with teachers' work engagement, whereas hindrance stress was negatively correlated with teachers' work engagement.

Latent class analysis of perceived workload

To explore latent classes in teachers' perception of workload, this study conducted Latent Class Analysis (LCA) based on teachers' perceived workload associated with different work tasks. The present study extracted 2–6 classes for model comparison. Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC), and sample-size-adjusted BIC (SSA-BIC) indices decrease with the number of classes, indicating improved model fit. Entropy, reflecting classification accuracy with values between 0 and 1, suggests higher precision with increased values, enhancing the utility of the latent class model [70]. Significance in both LMRT and BLRT values denotes that a model with k latent classes significantly outperforms the k-1 model [70].

As indicated by Table 3, the LMRT was significant for the 5-class model but not for the 6-class model, suggesting a preference for the 5-class model. The 5-class model included all classes from 2, 3, and 4, with an additional class representing the lowest perceived workload across five tasks. Despite increased complexity, the 6-class model exhibited lower Entropy. Considering

Table 2 Means, standard deviations, and correlation coefficients of variables

	M ± SD	Correlation matrix								
		1	2	3	4	5	6	7	8	9
1. Lesson preparation	2.88 ± 1.34	1								
2. Assignment grading	2.25 ± 1.20	.47**	1							
3. Classroom instruction	3.33 ± 1.04	.05**	.09**	1						
4. Class management	3.01 ± 1.33	.19**	.36**	.15**	1					
5. Parent-teacher communication	2.76 ± 1.09	.23**	.44**	.09**	.72**	1				
6. Perceived Workload	2.84 ± 0.78	.62**	.73**	.39**	.74**	.76**	1			
7. Challenge stress	16.24 ± 2.54	.14**	.13**	.08**	.10**	.10**	.17**	1		
8. Hindrance stress	12.61 ± 3.40	.09**	.16**	.09**	.16**	.18**	.20**	-.02**	1	
9. Work engagement	61.54 ± 8.73	.08**	.01	-.07**	-.04**	-.02*	-.04**	.54**	-.32**	1

Note: N = 40,712

* $p < .05$

** $p < .01$

Table 3 Comparison of LCA model fit indices

No. of classes	fp	likelihood	AIC	BIC	SSA-BIC	Entropy	LMRT	BLRT	Relative frequency of the classes
1	20	−297,803.15	595,646.30	595,818.58	595,755.02				
2	41	−283,092.29	566,266.58	566,619.76	566,489.46	0.76	< 0.001	< 0.001	.59/.41
3	62	−277,604.54	555,333.09	555,867.17	555,670.14	0.77	< 0.001	< 0.001	.15/.44/.41
4	83	−275,070.15	550,306.31	551,021.29	550,757.52	0.78	< 0.001	< 0.001	.11/.12/.41/.36
5	104	−273,214.63	546,637.27	547,533.15	547,202.64	0.78	< 0.001	< 0.001	.32/.12/.09/.11/.36
6	125	−271,884.10	544,018.98	545,094.98	544,697.73	0.76	0.735	< 0.001	.29/.12/.34/.07/.08/.10

Note: fp free parameters, *AIC* Akaike's Information Criterion, *BIC* Bayesian Information Criterion, *SSA-BIC* Sample-size-adjusted Bayesian Information Criterion, *LMRT* Lo–Mendell–Rubin Likelihood Ratio Test, *BLRT* Bootstrapped Likelihood Ratio Test

non-significant LMRT and various factors, the 5-class model was deemed optimal. Therefore, the LCA led to the identification of five teachers' perceived workload classes: (1) *low workload*, (2) *medium–low workload*, (3) *medium workload,* (4) *medium–high workload*, and (5) *high workload*.

As shown in Fig. 1, within the *low workload* class (C1; 10.81%), teachers exhibited the lowest perceived workload across five work domains, including lesson preparation, homework grading, classroom instruction, classroom management, and parent-teacher communication, with average scores of 2.55, 1.54, 3.03, 1.32, and 1.38, respectively. The *medium–low workload* class (C2; 35.64%) comprised most teachers, exhibited relatively lower perceived workload in homework grading (1.80), classroom management (2.22), and parent-teacher communication (2.02) while demonstrating a medium level of workload in lesson preparation (2.78) and classroom instruction (3.23). Teachers in the *medium workload* class (C3; 32.27%) scored at a medium level across lesson preparation, homework grading, classroom management, and parent-teacher communication, with average scores of 2.72, 2.22, 3.41, and 2.97, respectively, and higher perceived workload in classroom instruction (3.47). In the *medium–high workload* class (C4; 12.51%), teachers reported a moderately elevated perceived workload in lesson preparation (2.89), homework grading (2.41), and classroom instruction (3.47) while indicating significantly high perceived workloads in classroom management (4.59) and parent-teacher communication (4.28). Within the *high workload* class (C5; 8.77%), teachers reported the overall highest perceived workload, with notably higher scores in lesson preparation (4.91), homework grading (4.70), classroom instruction (3.55), and parent-teacher communication (4.38) compared to C1 through C4. However, their average score in classroom management (4.42) was slightly lower than in C4.

Group differences in challenge stress, hindrance stress, and teachers' work engagement

To examine the validity of the perceived workload classification and investigate the differences in challenge stress, hindrance stress, and work engagement among teachers with different perceived workload categories, a multivariate analysis of variance (MANOVA) was conducted. The five latent classes of perceived workload were set as independent variables, with challenge stress, hindrance stress, and work engagement as dependent variables. Gender, age, teaching tenure, educational attainment, professional title, and instructional level were used as covariates.

Statistically significant differences were observed in challenge stress, hindrance stress, and work engagement scores among primary and secondary school teachers with different perceived workload classes (classified as C1 through C5; $p < 0.001$). Table 4 illustrates the discrepancies between the five latent classes in regard to challenge stress, hindrance stress, and work engagement. Notably, the correlation between perceived workload classes and

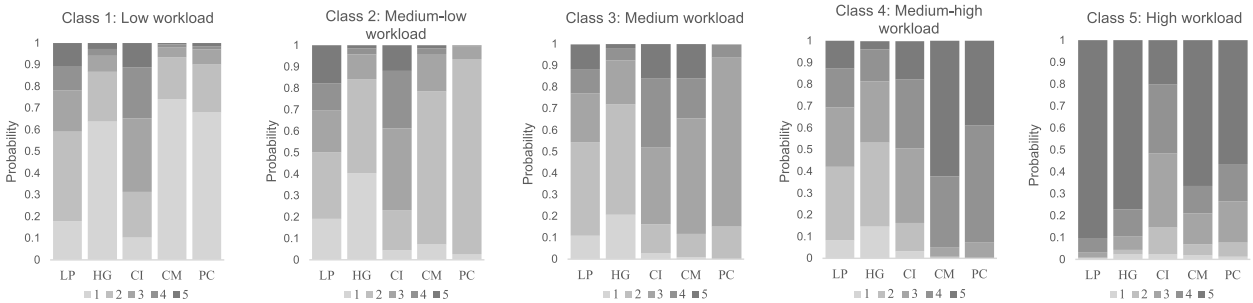

Fig. 1 Five class latent class analysis model depicting teachers' perceived workload patterns by class. *Note*:LP = Lesson preparation; HG = Homework grading; CI = Classroom instruction; CM = Classroom management; and PC = Parent-teacher communication

Table 4 Variance in challenge stress, hindrance stress, and work engagement among teachers

	C1	C2	C3	C4	C5	F	Post hoc	η^2
Challenge stress	15.76 (2.47)	16.08 (2.45)	16.29 (2.53)	16.35 (2.64)	17.15 (2.63)	148.48***	C1 < C2 < C3/C4 < C5	0.16
Hindrance stress	11.80 (3.28)	12.19 (3.28)	12.66 (3.27)	13.35 (3.41)	14.11 (3.75)	145.26***	C1 < C2 < C3 < C4 < C5	0.13
Work engagement	62.09 (8.50)	61.67 (8.30)	61.28 (8.63)	60.55 (9.31)	62.68 (9.98)	81.48***	C4 < C3 < C2 < C1/C5	0.06

Note: The values in the table are expressed as M (SD)

*** $p < .001$

challenge stress was the most pronounced, followed by hindrance stress and work engagement.

The analysis also yielded significant results for all covariates ($p < 0.05$), yet the effect sizes for each covariate on the dependent variables were negligible ($\eta^2 \leq 0.003$). This indicates that although the influences of these covariates on the dependent variables are statistically significant, their contributions to the overall model variance are minimal.

These findings substantiate the reliability of the latent classes of teachers' perceived workload and establish a foundation for subsequent mediation analysis.

Mediating roles of challenge stress and hindrance stress

Based on the results of the latent class analysis, this study further explored the mediating role of challenge stress and hindrance stress between different categories of perceived workload among primary and secondary school teachers and their work engagement. Previous research has indicated that when the independent variable is categorical, and both the mediator and dependent variables are continuous, especially when the independent variable includes multiple categories, stepwise regression analysis is not suitable for evaluating mediation effects [71]. Therefore, this study adopted relative mediation and composite mediation methods to align with current methodological standards [72]. In the analysis of mediation effects with a multi-categorical independent variable, if the overall mediation effect is not significant, it indicates that all relative mediation effects are zero, and the analysis concludes at this point. If the overall mediation effect is significant but all relative mediation effects are not significant, the analysis also ends; otherwise, the significance of the corresponding relative direct effect tests will be reported. Considering the characteristics of each category of perceived workload, this study selected the low workload class (C1), which has the lowest level of perceived workload, as a reference to compare with the other four classes. Demographic variables such as gender, age, teaching tenure, educational attainment, professional title, and instructional level were used as covariates in the analysis.

This study used the SPSS 22.0 PROCESS macro developed by Hayes and evaluated the mediation effects of the multi-categorical variable of perceived workload through the bootstrap method [68]. The results of the omnibus test showed significant differences between teachers' perceived workload of different classes and work engagement ($F(4, 40{,}697) = 35.1$, $p < 0.001$), indicating that perceived workload has a significant impact on work engagement. Further analysis of the direct effects revealed that the direct effects were also significant ($F(4, 40{,}695) = 33.66$, $p < 0.001$), supporting Hypothesis 1. In the four classes with higher perceived workload, both the direct effects and total effects were significant, suggesting that perceived workload may indirectly affect work engagement through other variables, highlighting the necessity to further test the mediation effects.

The results of the multiple regression analysis showed that each perceived workload class (C2–C5), compared to the reference group (C1), positively predicted challenge stress and negatively predicted hindrance stress (Fig. 2). Challenge stress positively predicted work engagement, while hindrance stress negatively predicted teachers' work engagement, supporting Hypothesis 2. The results of the relative mediation analysis indicated that, except for the direct path of the highest perceived workload class (C5), the direct and indirect paths of the other classes (C2, C3, C4) relative to the reference class (C1) significantly predicted work engagement. This suggests that, compared to teachers with the lowest perceived workload, the impact of perceived workload on work engagement in these classes includes not only direct effects but also indirect effects through challenge stress and hindrance stress. The parallel mediation effect of challenge and hindrance stress is established, supporting Hypothesis 3. The results of the mediation effects are presented in Table 5. Specifically, in the highest perceived workload class (C5), the influence of perceived workload on teachers' work engagement was mainly realized through the indirect effects of challenge stress and hindrance stress; the direct effect was not significant, accounting for only 6.62% of the total effect. This suggests that when teachers perceive their workload to be at the highest level, the mediating variables of challenge stress and hindrance stress play a dominant role in influencing work engagement.

Furthermore, a comparison of the relative sizes of the mediation effects revealed that the mediating effect of challenge stress ($\beta = 0.54$, $p < 0.001$) was significantly greater than that of hindrance stress ($\beta = -0.31$, $p < 0.001$). This indicates that although hindrance stress weakens teachers' work engagement, challenge stress more significantly enhances the positive impact of perceived workload on work engagement.

In summary, the research findings demonstrate that teachers' perceived workload has a significant impact on work engagement through challenge stress and hindrance stress, with these two forms of stress playing parallel mediating roles. Among them, challenge stress has a positive facilitating effect on work engagement, while hindrance stress exerts a negative influence.

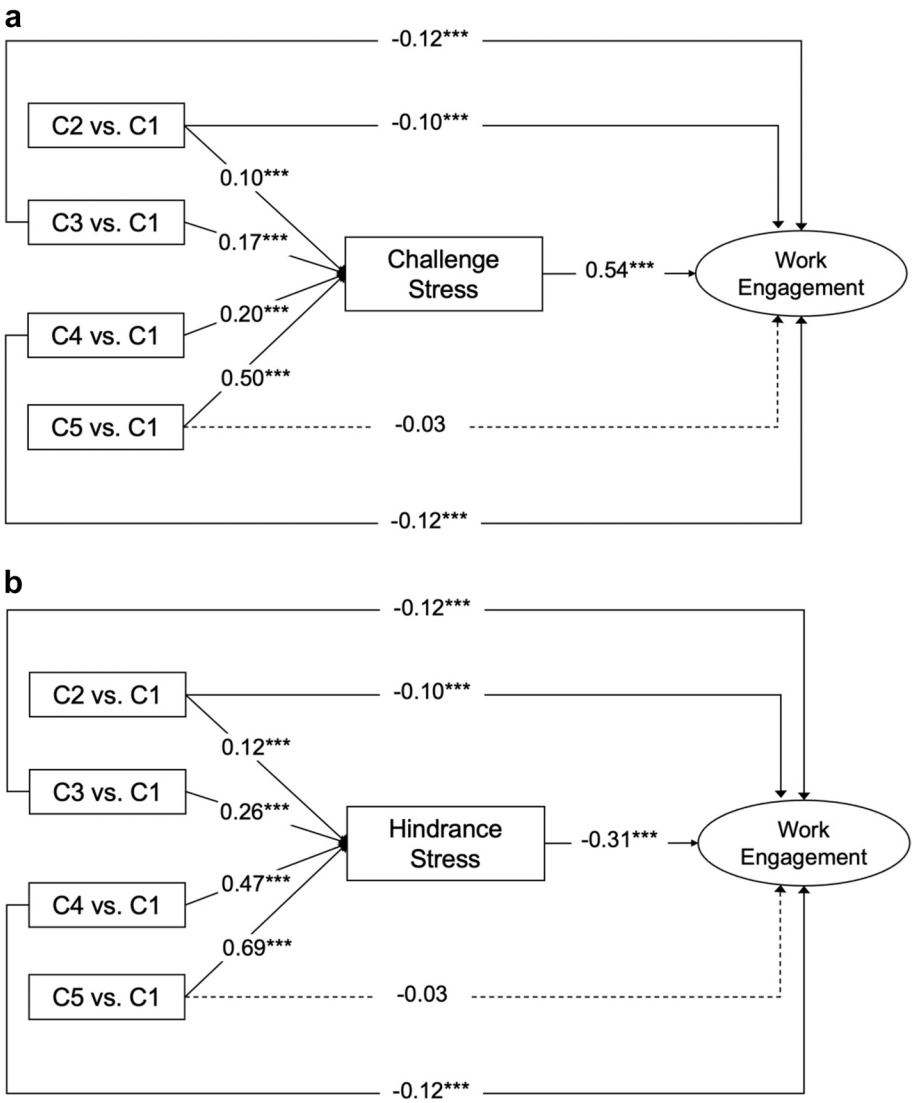

Fig. 2 **a** The relative mediation model of challenge stress. ***$p < .001$. **b** The relative mediation model of hindrance stress. ***$p < .001$

Discussion

Demographic variations in teachers' work engagement

Through a large-scale survey, this study found that teachers' work engagement exhibits significant differences across several key demographic dimensions, including gender, age, educational level, years of teaching experience, professional title, and instructional levels. This phenomenon highlights the diversity and complexity of work engagement in the field of education.

Regarding gender, the research found that female teachers generally have higher levels of work engagement than male teachers, a trend that aligns with existing studies [73, 74]. However, some studies have proposed different viewpoints, suggesting that gender is not a critical factor influencing teachers' work engagement, and that male teachers may even demonstrate higher levels of engagement in certain contexts [75, 76]. This discrepancy may stem from differences in research subjects, data sources, and cultural backgrounds. For instance, university teachers and primary and secondary school teachers differ in job responsibilities and career development [75], and societal and cultural expectations of gender roles may also lead to different research outcomes [76]. In many socio-cultural contexts, the teaching profession is perceived as more congruent with female gender role expectations. This social perception may enhance female teachers' professional identity and job satisfaction, making them more inclined to invest additional energy into their teaching work [73, 74].

Table 5 Bootstrap analysis of mediation effects

Path		Standardized effect size	Percentage of Total Effect	95% Confidence interval		*p*
				Upper limit	Lower limit	
C2 vs. C1	C2 vs. C1 – C STRESS – Work engagement	(0.10)* (0.54) = 0.05	28.45%	0.035	0.070	< 0.001
	C2 vs. C1 – H STRESS – Work engagement	(0.17)* (−0.31) = −0.04	19.57%	−0.407	−0.227	< 0.001
	C2 vs. C1 Relative direct effect	−0.10	51.98%	−1.066	−0.609	< 0.001
C3 vs. C1	C3 vs. C1 – C STRESS – Work engagement	(0.17)* (0.54) = 0.10	37.45%	0.660	0.975	< 0.001
	C3 vs. C1 – H STRESS – Work engagement	(0.26)* (−0.31) = −0.08	14.48%	−0.816	−0.629	< 0.001
	C3 vs. C1 Relative direct effect	−0.12	48.07%	−1.279	−0.814	< 0.001
C4 vs. C1	C4 vs. C1 – C STRESS – Work engagement	(0.20)* (0.54) = 0.11	28.71%	0.087	0.131	< 0.001
	C4 vs. C1 – H STRESS – Work engagement	(0.47)* (−0.31) = −0.15	38.77%	−0.159	−0.133	< 0.001
	C4 vs. C1 Relative direct effect	−0.12	32.52%	−1.752	−1.053	< 0.001
C5 vs. C1	C5 vs. C1 – C STRESS – Work engagement	(0.50)* (0.54) = 0.27	51.61%	0.244	0.293	< 0.001
	C5 vs. C1 – H STRESS – Work engagement	(0.69)*(−0.31) = −0.22	41.77%	−0.232	−0.202	< 0.001
	C5 vs. C1 Relative direct effect	0.03	6.62%	−0.274	0.334	0.194

Note: *C STRESS* Challenge stress, *H STRESS* Hindrance stress

Secondly, age and years of teaching experience are positively correlated with work engagement, a trend consistent with previous research findings [77]. Older and more experienced teachers exhibit higher levels of engagement when facing work challenges, which may be related to their accumulated organizational experience, established interpersonal networks, and flexible strategies for coping with work situations. Moreover, as years of teaching increase, the bond between teachers and schools becomes stronger, and the increased cost of leaving further reinforces their work engagement [78, 79].

This study also found an association between teachers' educational level and work engagement. Teachers with postgraduate or PhD degrees exhibited lower levels of work engagement. This may be because these highly educated teachers participating in the study were mostly young teachers with shorter teaching experience. Additionally, the salary expectations associated with higher educational qualifications may not align with the actual complexity and demands of the job [79], potentially leading to reduced psychological satisfaction and affecting work engagement [80, 81].

Professional titles also have a significant impact on work engagement. Teachers with senior and junior professional titles demonstrate higher levels of work engagement. Professional titles not only serve as recognition of teachers' professional achievements and abilities but also act as effective motivational mechanisms, enhancing teachers' job satisfaction and enthusiasm for work [82, 83].

Finally, as the teaching level increases, teachers' work engagement decreases instead. Primary school teachers exhibit higher levels of work engagement compared to secondary school teachers, which may be related to their frequent opportunities for interaction with students and the positive influence of students' learning engagement [84, 85]. High school teachers' level of engagement is significantly lower than that of primary and middle school teachers, possibly due to the increased complexity of teaching tasks they face, heightened pressure of college entrance examinations, and greater challenges in student management and home-school communication [86, 87].

These findings not only enrich the research on the relationship between teachers' demographic characteristics and work engagement but also, through a detailed examination of teachers' backgrounds, this study effectively identifies and controls potential confounding factors that may influence core variables. This provides a more nuanced perspective for in-depth analysis of the relationships among variables, thereby helping to uncover the deep mechanisms underlying these complex associations.

Latent classes of perceived workload

This study employed a person-centered latent class analysis to identify five levels of teachers' perceived workload: low, medium–low, medium, medium–high, and high. Over half (53.55%) of the teachers were classified into the medium and above workload classes. This data distribution reveals that although not all teachers face extreme work overload, a considerable proportion regularly endures a certain level of work-related stress. This finding aligns with the conclusions of existing literature on teachers' workload [20], further emphasizing the urgency of addressing teachers' workload issues.

The study found that teachers across different latent classes perceived similar levels of workload in lesson preparation and classroom instruction. However, significant differences existed in the workload related to homework grading, classroom management, and parent-teacher communication among these classes. Traditionally, society expects teachers to provide high-quality instruction and maintain optimal learning environments. Core tasks such as lesson preparation, homework grading, and classroom instruction constitute teachers' essential work content and basic responsibilities, affording them a certain degree of autonomy to adjust their workload according to classroom dynamics and personal circumstances [88]. Therefore, teachers can proactively manage their perceived workload within a stable and acceptable range.

However, with the evolution of educational philosophies and the intensification of social competition, teachers' non-teaching workload has been continuously increasing. In the Chinese cultural context, parents' intense focus on education and eager expectations for their children's achievements, coupled with the implementation of the "Double Reduction" policy, have led parents to shift more attention to school education. This not only increases the demands for after-school assignments, adding to the pressure on teachers to grade work, but also expects teachers to assume responsibility for cultivating students' life habits, interests, and social skills, further augmenting teachers' workloads [89]. While fulfilling teaching duties, teachers also have to cope with a significant amount of home-school communication and student management, which are interpersonal interaction tasks. These complex duties often result in teachers facing excessive physical and mental burdens [86, 90].

Overall, the latent class model of teachers' perceived workload constructed in this study expands the perspectives of existing research [30, 91], providing a more detailed classification framework for teachers' workload. This model accurately captures teachers' subjective experiences of workload across diverse work tasks, avoiding biases that may be introduced by simple categorization or reliance on average data. Additionally, it underscores the challenges teachers encounter in interpersonal interactions and psychological dimensions.

The relationship between teachers' perceived workload and work engagement

This study explored the mechanism by which perceived workload affects work engagement among primary and secondary school teachers. The results showed that teachers' perceived workload is significantly negatively correlated with work engagement, confirming Hypothesis 1 and aligning with previous research [35, 92].

Despite the Chinese government's increased investment in education and the enhancement of teachers' social status and benefits, many teachers still bear a substantial workload. They often face issues such as excessively long working hours, insufficient personal time, and unequal distribution of teaching tasks [12], which exacerbate their workload and psychological pressure, thereby impeding their work engagement [17, 20]. In the context of social progress and educational reform, the tasks undertaken by teachers have become increasingly burdensome, with numerous "invisible tasks" and responsibilities consuming their time and energy. Based on the Conservation of Resources Theory, an excessive workload may negatively impact teachers' ability to conserve and acquire resources, leading them to reduce their work engagement to prevent further resource depletion [93].

Another intriguing finding is that for teachers with an extremely high perceived workload, the predictive effect of perceived workload on work engagement is not significant. Results indicate that more than half of the teachers in the high workload class rated their perceived workload for all work content, except classroom instruction, at the highest level (5/5), forming a significant contrast with other classes. Previous research suggests that some teachers, driven by a strong sense of professional ethics and a pursuit of intrinsic values, are willing to take on more work responsibilities [31, 94, 95]. These dedicated teachers, despite facing excessive workloads and resource constraints, strive to maintain a positive work attitude and high performance [96, 97]. Furthermore, the attitudes and behaviors of others in the work environment may have an assimilation effect on individuals, weakening the negative correlation between perceived workload and work engagement [98]. In collectivist societies, changes in the external environment may interact with individuals' internal factors, positively influencing teachers' work engagement [99]. Therefore, from an individual perspective, it is necessary to conduct more detailed research on the impact of perceived workload on teachers' work engagement, exploring the unique roles of factors such as personal traits [100, 101].

The mediating effects of challenge-hindrance stress between teachers' perceived workload and work engagement

The results of this study indicate that challenge-hindrance stress plays a parallel mediating role between perceived workload and teachers' work engagement. This finding aligns with the perspectives of the cognitive appraisal theory of stress and previous research outcomes, suggesting that teachers' evaluations of their workload influence their stress responses to work tasks and subsequent coping strategies [102, 103].

Specifically, the study found that perceived workload is positively correlated with challenge stress and negatively correlated with hindrance stress, confirming Hypothesis 2. Teachers possess a relative degree of autonomy in teaching tasks, exhibit flexibility in non-teaching work methods, have a broad scope of work, and hold a strong sense of responsibility towards students, making them more prone to experiencing challenge stress [43]. On the other hand, the complexity and irregularity of teaching tasks may lead to hindrance stress. Workloads related to communication with parents and student behavior management are considered sources of hindrance stress [104]. Factors such as classroom discipline issues, poor family education practices, excessive parental expectations, or distrust towards teachers may lead teachers to negatively evaluate their work tasks and work environment, thereby generating hindrance stress [54, 57].

Moreover, challenge stress is positively correlated with work engagement, while hindrance stress is negatively correlated with work engagement, supporting Hypothesis 2. Challenge stress contributes to enhancing teachers' work flexibility and boosting their sense of self-affirmation [105], deepening their identification with their organization [106], and consequently exerting a positive impact on work engagement and overall job satisfaction [107]. In contrast, excessive hindrance stress can lead to psychological imbalance and a perfunctory approach to work, manifested as reduced work engagement [108].

Through relative mediation analysis, this study found that challenge stress and hindrance stress play parallel mediating roles between perceived workload and teachers' work engagement, supporting Hypothesis 3. Specifically, when teachers perceive a high workload and view task completion as an opportunity for professional development, they generate more challenge stress [109, 110]. This type of stress drives them to invest more energy and enthusiasm into their work, thereby enhancing work engagement [42, 107]. On the other hand, if teachers facing a high workload believe it exceeds their capabilities, they tend to perceive it as a threat to their personal resources, leading to increased hindrance stress. This, in turn, diminishes their enthusiasm for work and lowers work engagement [9, 105, 106].

It is worth noting that the impact of perceived workload on challenge stress predicts teachers' work engagement more significantly than hindrance stress. This may be related to the unique characteristics of the teaching profession. Teachers in high workload environments may be more inclined to view problems at work as opportunities for growth and self-realization rather than obstacles [111]. Furthermore, their professional sense of mission and responsibility toward students may make them more willing to accept work challenges, thereby reducing their perception of hindrance stress [31, 94]. This finding not only enriches the theoretical framework of challenge-hindrance job demands but also provides practical strategies for optimizing teachers' work environments and improving the quality of education [49].

Theoretical implications

The findings of this study have significant theoretical implications. Firstly, employing a large-sample, person-centered approach, we conducted an in-depth exploration of the types of teachers' perceived workload using Latent Class Analysis (LCA). Through this method, we considered individual differences and classified teachers' perceived workload into five levels, enriching the theoretical classification system of perceived workload. This provides a new perspective for understanding the intrinsic structure and variations of teachers' workload, filling the gap in previous research regarding detailed classifications.

Secondly, this study investigated the mechanism by which perceived workload affects teachers' work engagement by constructing a model with challenge stress and hindrance stress as mediators. The results further validated the facilitating effect of challenge stress on work engagement and the diminishing effect of hindrance stress on work engagement. This finding supports the challenge–hindrance framework proposed based on the cognitive appraisal theory of stress, emphasizing the differential roles of different types of stress in influencing work behavior and psychological processes, and providing new empirical support for theoretical research on the relationship between stress and work engagement.

In summary, through innovative research methods and an in-depth exploration of influencing mechanisms, this study expands the theoretical understanding of the relationships among perceived workload, challenge–hindrance stress, and work engagement, contributing to the theoretical development in the field of teachers' psychological health.

Practical implications

Through in-depth analysis, this study reveals how primary and secondary school teachers' perceived workload affects work engagement via challenge and hindrance stress. These insights hold profound practical value for educational administrators, school leaders, and teachers themselves, offering feasible strategies to optimize the teaching environment and enhance educational quality.

Firstly, based on a large-scale survey of primary and secondary school teachers across various provinces in China, this study uncovers the current state of teachers' workload and its impact on work engagement. Amid the implementation of the "Double Reduction" policy,

teachers' work and environments are undergoing new changes, highlighting imbalances in the allocation of work resources. Such imbalances negatively affect teachers' work engagement. Therefore, it is recommended that supervisory departments closely monitor teachers' workload, optimize their job responsibilities, provide efficient teaching resources and professional training for primary and secondary schools, and alleviate the pressure of lesson preparation. This can fundamentally reduce or help solve the additional burdens caused by adjustments in teaching content. For example, schools could establish dedicated specialized platforms for home-school communication and assign professional staff to assist teachers in handling parental affairs.

Secondly, while perceived workload is positively correlated with both challenge stress and hindrance stress, these two types of stress have entirely different effects on work engagement: challenge stress can stimulate teachers' motivation and sense of involvement, thereby promoting work engagement, whereas hindrance stress diminishes teachers' work enthusiasm, exerting a negative impact on work engagement. Therefore, schools should adopt comprehensive strategies. Firstly, they should encourage teachers to view their workload as a positive challenge by setting clear career goals, providing opportunities for professional growth, and hosting activities like teaching competitions to enhance their sense of achievement. Secondly, schools should identify and eliminate hindering factors in the work environment, such as excessive non-teaching tasks, unreasonable regulations, and cumbersome procedures. For example, by actively collaborating with parents at the school level to develop effective student and parent management strategies, schools can prevent teachers from independently shouldering excessive responsibilities in these areas. By enhancing the positive effects of challenge stress and mitigating the negative impacts of hindrance stress simultaneously, schools can comprehensively improve teachers' work engagement.

Finally, the study underscores the necessity of enhancing stress management training for teachers. This study finds that, among teachers with the highest perceived workload, the impact of workload on work engagement is primarily mediated through the indirect effects of challenge stress and hindrance stress. Therefore, schools should pay particular attention to this specific group, helping teachers correctly understand and cope with work stress, and strengthening their ability to perceive stressors as constructive challenges. By improving teachers' skills in identifying and managing stressors, Teachers can effectively transform work stress into positive challenges while reducing the impact of hindrance stress. Educational authorities and schools should regularly provide stress management and mental health training to enhance teachers' self-regulation and emotional management abilities, thereby creating a healthier and more positive work environment.

Limitations and future directions

Although this study employs a person-centered analytical approach and contributes to understanding the internal mechanisms between primary and secondary school teachers' perceived workload and their work engagement, several limitations remain. First, the measurement in this study focused on the core teaching tasks, yet in reality, teachers may experience additional workloads due to non-teaching tasks (such as school administrative work, meetings, etc.). Future research could consider incorporating a more diverse range of work tasks to provide a more comprehensive and systematic definition of the concept of teachers' perceived workload. This would allow for a more comprehensive, clear, and precise definition of teachers' perceived workload. Additionally, while our study reveals the overall mechanism of workload through systematic pattern classification, we acknowledge that measurement constraints limited our ability to examine the specific impacts of each core work dimension. Future research can integrate mixed methods to further explore the independent effects of each workload dimension and their interactions with overall perception patterns, aiming to establish a more comprehensive and detailed theoretical framework.

In terms of model construction, this study, based on the Conservation of Resources Theory and the Cognitive Appraisal Theory of Stress, established a mediation model linking teachers' perceived workload, work stress, and work engagement. However, the model did not account for potential influences from factors such as personality traits. Future research could explore these influencing factors more comprehensively, considering both teachers' personal characteristics and external environmental factors. For example, personal factors could include stable personality traits and teachers' variable educational beliefs, while external factors might encompass the school environment, school type, teachers' family context, and changes in national policies.

As this study is cross-sectional, there are limitations in establishing causal relationships. Future research could employ longitudinal methods, combined with a person-centered perspective, using approaches such as Latent Transition Analysis (LTA) to examine changes in teachers' perceived workload and its causal relationship with work engagement. This would provide insights into whether these relationships evolve with increases in teachers' tenure and age, offering educational

administrators valuable information for developing strategies to enhance teachers' work engagement.

Conclusion

This study employed a person-centered analytical approach to classify teachers' perceived workload and explore the relationship between perceived workload and teachers' work engagement, as well as the roles of challenge stress and hindrance stress in this relationship. The findings revealed that teachers' perceived workload comprises five levels: low, medium–low, medium, medium–high, and high. Moreover, perceived workload indirectly predicts teachers' work engagement through the mediating effects of both challenge stress and hindrance stress. Specifically, teachers' perceived workload enhances work engagement through challenge stress, but may reduce it through hindrance stress. Comparatively, while both mediators are significant, the influence of challenge stress is stronger.

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Authors' contributions
Conceptualization: H.W. and Y.S.; Data curation: H.L. and W.W.; Formal analysis: Y.S.; Investigation: H.L.; Methodology: Y.S.; Project administration: H.W. and H.L.; Resources: H.L.; Software: Y.S. and W.W.; Supervision: H.W.; Validation: W.W.; Visualization: Y.S.; Writing – original draft: Y.S.; Writing – review & editing: H.W. and W.W. All authors have read and agreed to the published version of the manuscript.

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study has been conducted in accordance with of the Ethical Principles of Psychologists and Code of Conduct by the American Psychological Association (APA). The Ethics Committee of Northeast Normal University reviewed and approved this study (code 2022034). The participants provided their written informed consent to participate in this study, with the additional signature of their guardians when applicable. This research complies with the Declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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