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Variable- and person-centered approaches to teacher support and learning satisfaction in blended English learning: the role of SDT motivation and learning engagement

Xuan Yang[1], Lynn Ling Li[1*], Jingjing Jiang[1] and Jianfen Ying[1]

Abstract

Background With blended learning boosting explosively, learning satisfaction is confronted with challenges. Aiming at its enhancement, teacher support, an essential element of instruction, was investigated.

Methods To pinpoint the dynamics between teacher support and learning satisfaction, 376 university students who participated in blended English learning were involved in self-report questionnaires. A variable-centered approach for data analysis was employed to examine the chain mediation model, and a person-centered one was utilized for exploring more personalized learning patterns of the samples.

Results The variable-centered investigation validated the hypothesized chain mediation model. SDT motivation and learning engagement were two successful mediators, and they also formed an effective chain mediator between teacher support and learning satisfaction. The person-centered study analyzed teacher support and learning satisfaction reported, and identified three latent profiles: below-average-both, average-both, and high-both profile. Learners in different profiles were spotted with disparate traits, with those in high-both profile presenting the most favorable results.

Conclusion This study addresses the gap in research on the four variables from a blended learning perspective, and innovatively combines variable-centered and person-centered analytical approaches, providing customized enlightenments into fostering students' progress. Pedagogical implications are part of discussion.

Keywords Blended English learning, Teacher support, SDT motivation, Learning engagement, Learning satisfaction, Variable- and person-centered approaches

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Introduction

Learning satisfaction is the result of internal assessments on whether individuals are content with their study activities [1]. Empirical evidence indicates its contribution to academic performance, experience, and learning effectiveness [2]. Hence, by enhancing learning satisfaction, educators can pursue higher qualities and more satisfying outcomes in English education. Learning motivation in our study is an autonomous sort of regulation making students act for inherent pleasure [3]. Self-Determination theory (SDT) suggests that it derives from satisfying individuals' innate needs for autonomy, competence and relatedness [4]. Correspondingly, studies showed that teachers bolster these needs by providing autonomous choices, structured knowledge to build competence, and peer interactions, and thereby enhance learning satisfaction [5–7]. Concurrently, students' learning experience is enriched by teacher support for increasing engagement [2, 8], which means students' active involvement in learning [9]. Moreover, the significant contribution of SDT motivation to learning engagement is well-documented by Ryan and Deci [10, 11]. According to the various relationships stated above, and due to the lack of the structural analysis involving those four variables, the intrinsic mechanism still needs to be discovered.

Furthermore, as an integration of online and offline learning, blended learning is under scrutiny due to some negative issues brought about by the online part. Potential shortcomings have been designated, inclusive of insufficient real-time connections [12], questionable learning engagement, and reduced student satisfaction [13] due to digital proficiency gaps and accessibility hurdles [14]. These challenges underscore the need for profound explorations into blended learning concerning the intrinsic mechanism of teacher support, SDT motivation, learning engagement, and satisfaction.

The current study employs a dual analytical lens, combining variable- and person-centered methods to offer a relatively new and comprehensive understanding of learning satisfaction. The approaches diverge from the predominant literature relying merely on variable-centered techniques, for example, structural equation modeling (SEM) and regression. Person-centered approaches are crucial for recognizing the heterogeneity of students and providing tailored educational guidance, which caters to subgroups with distinct features. Hence, by integrating the two approaches, our study validated a chain mediation model from a variable-centered standpoint and applied latent profile analysis (LPA) from a person-centered angle, offering a more holistic and nuanced view into the relationships among teacher support, SDT motivation, learning engagement, and learning satisfaction.

Teacher support and learning satisfaction

Teacher support is a vital form of social support [15] encompassing both intellectual and psychological assistance for learners, to optimize their learning experiences and meet their needs [6, 16, 17]. Teacher support therefore possesses a crucial role across various educational environments [18–20]. Learning satisfaction refers to the feelings and attitudes of learners toward the learning process and outcomes, which is considered conducive to learning quality [2] in aspects of variety, confidence, respect, caring, clarity [21, 22], and academic psychological capital [23]. The magnitude of the significance of learning satisfaction is underscored by its role as a predictor or measurement of course quality [24, 25].

Significant correlations have been revealed between teacher support and some positive emotions [16, 17] including learning satisfaction [26–28]. It is shown that learning satisfaction essentially relies on learner-teacher interactions [29], but pertinent explanation concerning the interplay between teacher support and learning satisfaction still lacks, which is indeed momentous in educational practice. Furthermore, the blending of online and offline learning adds to the complexity of the intricate correlations and the imminence of its exploration. Studies have discovered that teacher support is better conveyed offline than online [12, 13], and if problems of blended learning such as lack of conceptual understanding [30] and digital literacy [14] remain unresolved, students would be less satisfied. In view of the unclarity of the dynamics of teacher support and learning satisfaction in blended English learning, Hypothesis 1 was developed for further elaboration.

Hypothesis 1 (H1) Teacher support significantly and positively contributes to learning satisfaction in blended English learning.

SDT motivation between teacher support and learning satisfaction

Learning motivation is enhanced by social support, which includes teacher support [31]. Teachers' supportive behaviors and attitudes can nourish the aspects of learning motivation [11, 32, 33], and there exists a trilateral correlation that learners sensing themselves being more supported by teachers are better motivated in learning, and will thereby bear a more satisfied attitude towards learning [34, 35]. Nonetheless, due to the rapid regeneration led by blended learning, more studies are needed to validate the effect of learning motivation on learning satisfaction, as well as the mediation role of learning motivation between teacher support and learning satisfaction in the context of blended English education.

Numerous motivational theories such as Hierarchy of Needs [36] and Self-Determination Theory [37] have

provided theoretical foundations for learning motivation, with the latter posing that basic psychological need satisfaction comprises three aspects, namely autonomy, competence, and relatedness, and that it derives intrinsic motivation, which is a desirable catalyst for learning. The current study adopted SDT Theory as the theoretical lens for its compatibility with classroom context evidenced by a vast array of investigations: learning satisfaction is influenced by teachers' facilitating students' free choices, course contents, and classroom interaction [5–7], aligning respectively with the three aspects of learning motivation. Besides, interests in SDT motivation are widely distributed in various educational contexts, not only offline but also online [38–40], laying the rationale for us to apply it in blended learning. Furthermore, teacher support can also be measured according to the three sub-dimensions in line with SDT [41, 42], which confirms the intimate relationships intrinsically. As a result, SDT framework was utilized in exploring the dynamics, Hypotheses 2, 3, 4 were formulated.

Hypothesis 2 (H2) Teacher support positively and significantly affects SDT motivation in blended English learning.

Hypothesis 3 (H3) SDT motivation positively and significantly affects learning satisfaction in blended English learning.

Hypothesis 4 (H4) SDT motivation positively and significantly mediates the correlation between teacher support and learning satisfaction in blended English learning.

Learning engagement between teacher support and learning satisfaction

Learning engagement is a set of factors involved in learning process [43], contributing to learning achievements [44]. Originally, it was a multidimensional construct consisting behavioral, emotional and cognitive engagement, and it was later expanded for the introduction of agentic engagement [9].

Previous research has reported that the perception of ample teacher support is related with more active learning engagement in high school [17, 45] and higher education [19, 35, 46]. Researchers have discovered a significant association between lecturer support and the interactive effects of study engagement [47]. Meanwhile, a study highlights that learners' cognitive, emotional and behavioral engagement contribute significantly to student satisfaction [48]. Specifically, students with higher levels of perceived teacher support have been found to be more engaged [47] and also more satisfied with their study experience [24, 49]. Therefore, learning engagement is probably both a critical outcome affected by the learning

environment [50], and a crucial contributor to students' learning satisfaction [2]. Consequently, Hypothesis 5 to 7 were developed, in order that the impact and mediation role of learning engagement between teacher support and learning satisfaction could be corroborated.

Hypothesis 5 (H5) Teacher support significantly and positively relates to learning engagement in blended English learning.

Hypothesis 6 (H6) Learning engagement significantly and positively relates to learning satisfaction in blended English learning.

Hypothesis 7 (H7) Learning engagement positively and significantly mediates the association between teacher support and learning satisfaction in blended English learning.

SDT motivation and learning engagement

Research highlights the psychological and behavioral impacts of students' motivation [51], prerequisite for mental development, internalization, and psychological well-being [11]. It is well-documented that learning engagement has a variety of predictors, including self-efficacy, need satisfaction, and instructional strategies [26, 32, 50]. Empirical studies have demonstrated that SDT motivation, whether elevated independently or in tandem with other factors, can enhance academic performance and engagement [33, 52, 53].

In a Chinese study with 648 samples, researchers observed a positive correlation between triggering SDT motivation and work engagement [54]. 366 Korean high school students' increasing engagement was closely tied to perceived autonomy support from the instructors [55]. According to Malaysian research, satisfying the competence need was demonstrated to be a predictor of undergraduate student engagement [56]. However, some researchers hold that no significant correlation existed between SDT motivation and learning engagement [57, 58] and autonomy satisfaction also varies depending on the culture of collectivism or individualism [59]. Therefore, the interplay between SDT motivation and learning engagement still requires further investigation. Hypothesis 8 and 9 were developed.

Hypothesis 8 (H8) SDT motivation has a significant positive correlation with learning engagement in blended English learning.

Hypothesis 9 (H9) SDT motivation and learning engagement play a significant and positive chain mediation role in the relationship between teacher support and learning satisfaction in blended English learning.

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Variable- and person-centered approaches to teacher support, SDT motivation, learning engagement, and learning satisfaction

Conventionally, a majority of studies concerning teacher support and learning satisfaction adopted merely variable-centered approaches such as the linear regression or SEM, calculating various correlation effects and validating structured models [8, 16, 17, 19, 34]. But this approach emphasizing commonalities across samples can limit research findings due to overlooked subgroups with unique learning traits. In contrast, the person-centered approach recognizes population heterogeneity [60], and can enrich the findings when combined with variable-centered methods with a more comprehensive and fine-grained view. Noticing these merits, some most recent studies have employed person-centered approaches like LPA and attempted explorations into psychological and educational contexts, such as student teacher development [61], teachers' well-being [62], and also teacher support on students' digital reading literacy [63], occupation satisfaction [64], and self-efficacy [65]. However, the practice of person-centered methods or the amalgamation of both approaches is exceedingly limited concerning teacher support for learning satisfaction. But nurturing learning satisfaction matters for it is students' internal pleasure [1], and it is closely interwoven with various teaching objectives including learning performance, experience, and effectiveness [2].

Built on the indeterminate nature of teacher support and learning satisfaction in blended English learning, and the intricate dynamics lying between as reviewed, this study aims at delineating distinct profiles with different learning patterns, and discovering methods to better supply teacher support to boost students' learning satisfaction. LPA in the current case enables the researchers to understand learners' characteristics of their ways of perceiving teacher support and achieving learning satisfaction. Aiming at understanding the intrinsic dynamics between teacher support and learning satisfaction, this research would resort to students' diverse feedbacks regarding teacher support and learning satisfaction, categorize the samples into three to six profiles as suggested in previous studies [63, 64], generalize the features of each group, and report differences in SDT motivation and learning engagement across profiles. Since previous research remains scant concerning exactly teacher support and reported learning satisfaction, and the roles of SDT motivation and learning engagement in between, no specific latent profiles were hypothesized.

Methods

Participants

Randomized cluster sampling method adopted, 496 students between the ages of 17 and 22 (121 male students, 375 female students) enrolled in English courses in Z University in East China were involved in this study. Of the total respondents, 376 samples (76 males, 300 females) were valid, yielding a 75.8% response for further analysis. Required by the overall arrangement of the curriculum of the university, those participants were either learning English as their major, or as a mandatory minor course in the first two semesters. Noticeably, Z University has been conducting blended learning since 2016, thus making such method involved maturely in many courses including English ones. Participants in this study were recruited based on learning experience of blended English for at least 1 semester.

Besides the long-term effort to implement blended learning, due to the barriers in teaching and learning set by COVID-19 pandemic from 2019 to 2022, blended methods have been universal in Z University, for which the participants' experiences are sustainable for examining the mediation model and offering concrete pedagogical implications. The blended English courses aim to not only enhance English linguistic proficiency and practical skills of college students on the cusp of societal integration, but also foster their sense of global awareness and cross-cultural competencies. It seeks to cultivate an understanding of the world, particularly the cultures of English-speaking nations. The overall forms and features of blended learning in this study distinguished from other learning modes could be summarized into four aspects: multimodality, pre-recorded serials, handy interactions, and portion of final score. Actual implementations are effectuated through diverse channels like websites or software applications, depending on the curriculum settings. Online lessons are formalized with pre-recorded videos and relative tasks serving as a supplement and consolidation for offline courses. The courses are generally offered in two formats: half-semester and full-semester lengths. The shortest allowable duration for a single class session is 40 min, with students generally enrolling in sessions comprising either 2 or 3 such units per attendance. Each weekly offline class is accompanied by corresponding online activities, where learners can conveniently fetch their teachers and peers and launch notes or discussions, in forms of chat groups for classes or comments sections for course videos. In most cases, the online learning performance would be converted and counted proportionately into the total course score according to certain rubrics, mainly concerning the duration of course video playback, the frequency of launching notes and discussions, and the correctness of assignments and quizzes.

Research design

To establish a more holistic model of the four variables, and furnish the results with an individualized

perspective, the research was conducted in two steps: a variable-centered study validating the chain mediation model with SPSS 26.0 and PROCESS 3.4.1, then a person-centered study employing LPA of Mplus 7.0 and ANOVA of SPSS 26.0.

The composite questionnaire, which comprises four questionnaires concerning teacher support, SDT motivation, learning engagement, and learning satisfaction, has been consolidated into a single online hyperlink to ensure the accessibility. Participants were made aware of the research objectives and the anonymity, and were encouraged to partake voluntarily. Consent was obtained from all participants beforehand.

Measures

Teacher support, SDT motivation, and learning engagement were assessed by 7-point Likert scales ranging from 1 (strongly disagree) to 7 (strongly agree). Learning satisfaction was measured by a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Higher scores for each item indicate greater perception of the corresponding variable.

Teacher support

The teacher support questionnaire was adopted from related previous studies [41, 42]. It contains three aspects of the variable, namely teacher autonomy support (5 items, e.g., I feel that the English teacher provides me with choices), teacher competence support (4 items, e.g., The English teacher helps us to improve), and relatedness support (5 items, e.g., The English teacher supports us). The scale has been practiced in a similar context of blended learning in Hong Kong, China [45]. Cronbach's α coefficient for this study was 0.923.

SDT motivation

The SDT motivation questionnaire was adopted from SDT motivation and Frustration Scale developed by Ghent University [66] and a study concerning learning motivation [67]. The survey consists of three sections: autonomy satisfaction (4 items, e.g., I feel a sense of choice and freedom in my English study), competence satisfaction (4 items, e.g., I feel confident that I can learn English well) and relatedness satisfaction (3 items, e.g., I feel accepted by the English learning group.). The whole scale was grounded on and derived from Basic Psychological Needs Theory, a sub-theory of SDT [3, 68]. The reliability and validity have been validated in research using samples from university students of Belgian, Peru, and the United States, and especially from China [69]. In this investigation, Cronbach's α coefficient was 0.922.

Learning engagement

The learning engagement questionnaire, regarding four aspects of the variable, namely behavioral engagement (3 items, e.g., When I'm in this class, I listen very carefully), agentic engagement (5 items, e.g., I let my teacher know what I need and want), cognitive engagement (3 items, e.g., When I study for this class, I try to connect what I am learning with my own experiences), and emotional engagement (5 items, e.g., When we work on something in this class, I feel interested), was adopted from a study on motivationally supportive learning environments of students [9, 55]. The measurement has been practiced and validated in a previous study involving Chinese L3 learners [44]. Cronbach's α coefficient in the current study was 0.933.

Learning satisfaction

The learning satisfaction questionnaire was adopted from a study on student satisfaction, learning outcomes and cognitive loads [70], consisting of nine items (e.g., The resources I need are readily available through blended learning). The scale has been practiced in blended learning modes of computer assisted learning in China with Chinese university students. Scale reliability and validity have been validated. Cronbach's α coefficient in the present study was 0.945.

Method of data analysis

In the variable-centered study, a preliminary analysis was conducted using descriptive statistics and Pearson correlations to assess the feasibility of further analysis with SPSS 26.0. Afterwards, the mediation model was evaluated, with the simple linear regression and pathways examination among the four variables with PROCESS 3.4.1, which is designed for analyzing various models including mediation ones [71]. And previous research has also practiced on establishing mediation models with PROCESS [19, 35]. The person-centered study employed Mplus 7.0 to conduct a latent profile analysis (LPA), in which teacher support and learning satisfaction were observed as independent variables while SDT motivation and learning engagement as outcome variables, to identify potential classes of students for delving into the dynamics in between. Afterwards, a series of one-way ANOVAs were implemented with SPSS 26.0 to inspect the differences among profiles.

Results

Variable-centered study

Preliminary analysis

Mean scores per item for each variable and Pearson correlations are displayed in Table 1. The mean of teacher support was 5.61 (SD = 0.77), of SDT motivation was 5.24 (SD = 0.93), of learning engagement was 5.29 (SD = 0.80),

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Table 1 Descriptive statistics and pearson correlations (N = 376)

		M	SD	1	2	3	4
1	TS	5.61	0.77	1			
2	SM	5.24	0.93	0.646**	1		
3	LE	5.29	0.80	0.650**	0.733**	1	
4	LS	3.84	0.64	0.571**	0.644**	0.730**	1

TS means teacher support, SM means SDT motivation, LE means learning engagement, LS means learning satisfaction. **$p < 0.001$

Table 2 Model results (N = 376)

DV	IV	R	R^2	β	t
SM	TS	0.646	0.417	0.776	16.351**
LE	TS	0.769	0.591	0.313	6.986**
	SM			0.462	12.395**
LS	TS	0.751	0.565	0.090	2.296*
	SM			0.134	3.668**
	LE			0.412	9.639**

TS means teacher support, SM means SDT motivation, LE means learning engagement, LS means learning satisfaction. *$p < 0.05$, **$p < 0.001$

and of learning satisfaction was 3.84 (SD = 0.64). Significant and positive correlations were evidenced between teacher support and SDT motivation ($r = 0.646$, $p < 0.001$), teacher support and learning engagement ($r = 0.650$, $p < 0.001$), teacher support and learning satisfaction ($r = 0.571$, $p < 0.001$), SDT motivation and learning engagement ($r = 0.733$, $p < 0.001$), SDT motivation and learning satisfaction ($r = 0.644$, $p < 0.001$), as well as between learning engagement and learning satisfaction ($r = 0.730$, $p < 0.001$). By most criteria, the correlation

value between 0.3 and 0.7 can be regarded as moderate, and it doesn't reach a strong relationship until the size turns 0.75 [72]. And the strength should be interpreted in comparison with other investigations in the same field [73]. Since there have been some studies presenting similar correlation sizes on teacher support, learning engagement and satisfaction [28, 46], the Pearson correlations in this study can be accepted as of medium intensity, thus avoiding the risk of multi-collinearity. Hence, the preliminary evidence supported Hypothesis 1 and laid the foundation for further analysis.

Linear regression in the hypothesized model

Results indicating the effects between the variables generated from a simple linear regression analysis are presented in Tables 2 and 3; Fig. 1. Hypotheses 2 to 9 were examined in this part. It was shown that teacher support had a significant and positive effect on SDT motivation (β = 0.776, $p < 0.001$), learning engagement (β = 0.313, $p < 0.001$), and learning satisfaction (β = 0.090, $p = 0.022$).

Table 3 Test of pathways of mediation model (N = 376)

	Effect	Boot SE	BootLLCI	BootULCI	%
Total TS → LS	0.471	0.035	0.4024	0.5403	100.00%
Direct TS → LS	0.090	0.039	0.0130	0.1678	19.11%
Total indirect	0.381	0.035	0.3144	0.4522	80.89%
Ind1 TS → SM → LS	0.104	0.036	0.0336	0.1726	22.08%
Ind2 TS → LE → LS	0.129	0.028	0.0777	0.1865	27.39%
Ind3 TS → SM → LE → LS	0.148	0.027	0.1010	0.2067	31.42%

TS means teacher support, SM means SDT motivation, LE means learning engagement, LS means learning satisfaction. SE means stand error, LLCI means lower limit of the confidence interval, ULCI means upper limit of the confidence interval. Bootstrap sample size = 5,000
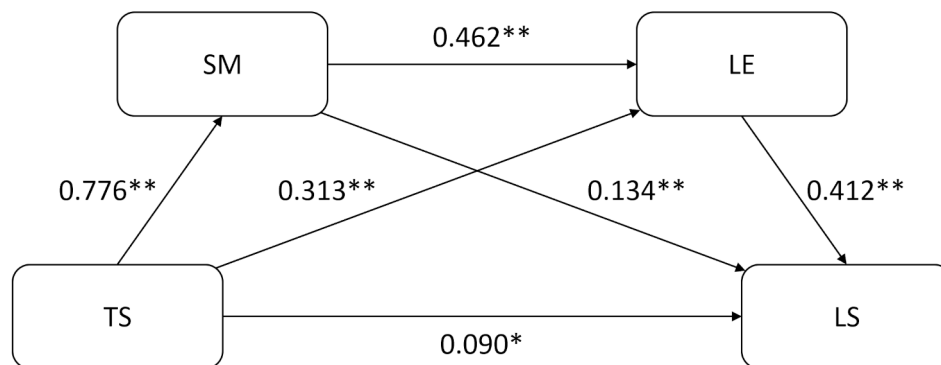
Fig. 1 Chain mediation model
TS means teacher support, SM means SDT motivation, LE means learning engagement, LS means learning satisfaction. *$p < 0.05$, **$p < 0.001$

Moreover, SDT motivation significantly and positively predicted learning engagement ($\beta = 0.462$, $p < 0.001$), and learning satisfaction ($\beta = 0.134$, $p < 0.001$). Furthermore, learning engagement appears to be a positive and significant predictor of learning satisfaction ($\beta = 0.412$, $p < 0.001$). As a result, the outcomings were consistent with Hypotheses 2, 3, 5, 6, and 8.

The total effect of teacher support on learning satisfaction ($\beta = 0.471$, SE = 0.035, t = 13.439, $p < 0.001$, 95% CI, 0.4024 LLCI & 0.5403 ULCI) and the direct effect of teacher support on learning satisfaction ($\beta = 0.090$, SE = 0.039, t = 2.296, $p = 0.0222$, 95% CI, 0.0130 LLCI & 0.1678 ULCI) were evidenced to be significant and positive. In addition, the total indirect effect was significant and positive ($\beta = 0.381$, SE = 0.035, 95% CI, 0.3144 LLCL & 0.4522 ULCL), accounting for 80.89% of the total effect.

SDT motivation had a mediation effect between teacher support and learning satisfaction ($\beta = 0.104$, SE = 0.036, 95% CI, 0.0336 LLCI & 0.1726 ULCI), explaining 22.08% of the total effect. Consequently, Hypothesis 4 was confirmed by the findings – SDT motivation significantly and positively mediated between teacher support and learning satisfaction in blended English learning.

Moreover, learning engagement as a mediator was revealed to be positive and significant ($\beta = 0.129$, SE = 0.028, 95% CI, 0.0777 LLCI & 0.1865 ULCI), contributing to 27.39% of the total effect. This meant that Hypothesis 7 – learning engagement can play a significant and positive mediation role between teacher support and learning satisfaction in blended English learning – was valid.

Furthermore, the chain mediator formed by SDT motivation and learning engagement was significant and positive ($\beta = 0.148$, SE = 0.027, 95% CI, 0.1010 LLCI & 0.2067 ULCI), explaining 31.42% of the total effect. The success of the chain mediator indicated that Hypothesis 9 was verified, and that SDT motivation and learning engagement, functioning together, significantly and positively mediated the correlation between teacher support and learning satisfaction.

Person-centered study
Latent profile identification
The LPA results are presented in Table 4, which indicates a solution of 3 profiles is appropriate compared with other solutions, with lower AIC and BIC than 1 or 2 profiles. When the number of classes reached 4, though the profile showed lower AIC, BIC, aBIC, a higher entropy, and was statistically significant, the smallest cluster consisted only 9 students, accounting for merely 2.4% (less than 5%) of the total sample size, for which the solution of 4 profiles was excluded for its spurious memberships. Moreover, the L-M-R indicated that the 5-profile solution did not outperform the 4- profile solution significantly. Hence, the 3-profile model was chosen for its finer-grained classes and better interpretability.

Afterwards, the means for the 3 profiles were calculated, and ANOVAs were conducted respectively to examine the inter-profile differences. Results are presented in Fig. 2; Table 5. In Class 1, students presented means slightly lower than the overall means of teacher support and learning satisfaction, so it was named as "below-average-both profile" ($N = 104$, 27.7%). Moreover, students of Class 2 reported approximately average means on teacher support and learning satisfaction, so it was referred to as "average-both profile" ($N = 207$, 55.1%). The other profile was "high-both profile" ($N = 65$, 17.3%), since the students had the highest perception of teacher support and learning satisfaction. Significant distinctions were evidenced between the profiles.

Latent profile comparison
The three profiles selected were hypothesized to be distinct statistically from each other. As a result, ANOVAs were conducted to verify and compare the differences [60] in SDT motivation and learning engagement and their subscales across profiles of teacher support and learning satisfaction. The statistics were demonstrated in Table 5. Furthermore, in an attempt to do an inter-variable and inter-profile comparison, z-scores of subscales of SDT motivation and learning engagement across profiles were also calculated, with outcomes presented in Fig. 3.

The hypothesis regarding the between-profile distinctions received support from the results of ANOVAs.

Table 4 Indices for LPA fit

Number of classes	AIC	BIC	aBIC	Entropy	L-M-R LRT (p)	BLRT (p)	Smallest cluster frequency
1	1605.821	1621.539	1608.848	-	-	-	376 (100%)
2	1451.302	1478.809	1456.600	0.824	0.0000	0.0000	95 (25.3%)
3*	1371.668	1410.964	1379.237	0.899	0.0001	0.0000	65 (17.3%)
4	1353.047	1404.132	1362.886	0.922	0.0098	0.0000	9 (2.4%)
5	1338.737	1401.608	1350.844	0.849	0.4103	0.0000	28 (7.5%)

AIC means Akaike Information Criterion. BIC means Bayesian Information Criterion. aBIC means Ample-size adjusted BIC. L-M-R LRT means Lo-Mendell-Rubin Likelihood Ratio Test. BLRT means Bootstrap Likelihood Ratio Test
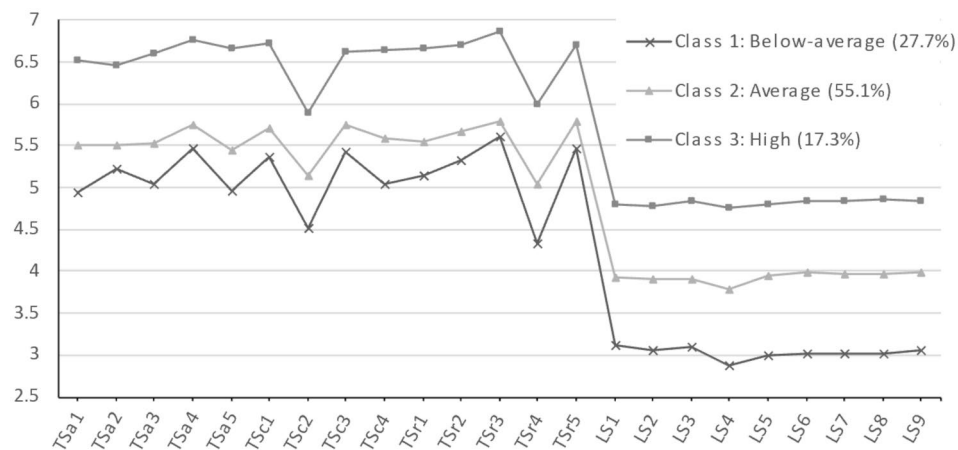
Fig. 2 Teacher support and learning satisfaction of different profiles
TSa means teacher support for autonomy. TSc means teacher support for competence. TSr means teacher support for relatedness

Table 5 Means of variables and ANOVA across profiles of teacher support and learning satisfaction

	Below-average $n = 104$	Average $n = 207$	High $n = 65$	F	Partial η^2	
Variables	M (SD)	M (SD)	M (SD)	-	-	-
TS	5.13 (0.70)	5.56 (0.60)	6.56 (0.50)	110.241**	0.372	3 > 2 > 1
LS	3.03 (0.25)	3.93 (0.22)	4.82 (0.22)	1278.194**	0.873	3 > 2 > 1
SM	4.50 (0.97)	5.29 (0.61)	6.23 (0.67)	112.629**	0.377	3 > 2 > 1
Autonomy	4.49 (1.26)	5.29 (0.80)	6.45 (0.78)	86.584**	0.317	3 > 2 > 1
Competence	4.47 (1.27)	5.26 (0.77)	6.11 (0.81)	61.939**	0.249	3 > 2 > 1
Relatedness	4.55 (0.96)	5.34 (0.68)	6.11 (0.92)	76.212**	0.290	3 > 2 > 1
LE	4.39 (0.61)	5.17 (0.45)	6.08 (0.56)	216.662**	0.537	3 > 2 > 1
Behavioral	4.63 (0.86)	5.32 (0.67)	6.04 (0.95)	67.494**	0.266	3 > 2 > 1
Agentic	4.23 (0.84)	5.19 (0.73)	6.00 (0.92)	104.057**	0.358	3 > 2 > 1
Cognitive	4.83 (0.90)	5.47 (0.67)	6.37 (0.87)	79.963**	0.300	3 > 2 > 1
Emotional	4.75 (0.78)	5.45 (0.62)	6.57 (0.68)	143.876**	0.435	3 > 2 > 1

TS means teacher support, SM means SDT motivation, LE means learning engagement, LS means learning satisfaction. **$p < 0.001$
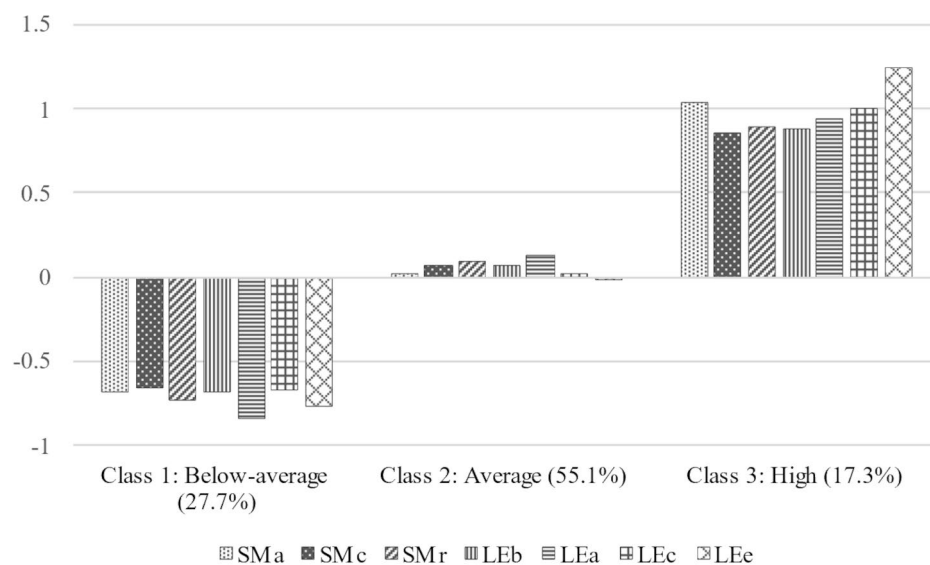
Fig. 3 Z-Score comparisons of subscales of SDT motivation and learning engagement across profiles
SMa means SDT motivation of autonomy. SMc means SDT motivation of competence. SMr means SDT motivation of relatedness. LEb means behavioral learning engagement. LEa means agentic learning engagement. LEc means cognitive learning engagement. LEe means emotional learning engagement

As is shown in Table 4, the between-profile distinctions in SDT motivation (F = 112.629, $p < 0.001$) and learning engagement (F = 216.662, $p < 0.001$) were statistically significant. Additionally, significance in differences was also vindicated in subscales of SDT motivation and learning engagement, namely SDT motivation of autonomy (F = 86.584, $p < 0.001$), of competence (F = 61.939, $p < 0.001$), of relatedness (F = 76.212, $p < 0.001$), behavioral learning engagement (F = 67.494, $p < 0.001$), agentic learning engagement (F = 104.057, $p < 0.001$), cognitive learning engagement (F = 79.963, $p < 0.001$), and emotional learning engagement (F = 143.876, $p < 0.001$). Post-hoc test results furtherly indicated that students perceiving high teacher support and learning satisfaction ranked highest in all SDT motivation and learning engagement subdimensions, followed by those in average profile, while that students in below-average profile scored the lowest.

Z-scores in Fig. 3 demonstrated students' distinct perceptions and performances of subdimensions of SDT motivation and learning engagement within and across 3 profiles. Students in below-average profile perceived a higher SDT motivation of competence than that of autonomy, and they perceived a relatively lowest SDT motivation of relatedness. As for the learners of average teacher support and learning satisfaction profile, the need in relatedness was best satisfied, with competence taking the second place, while that for autonomy was comparatively less satisfied. But for students of the profile of high teacher support and learning satisfaction, SDT motivation of autonomy was realized most extensively, with relatedness being the second, and competence the third. As for learning engagement, students with below-average teacher support and learning satisfaction tended to engage in learning in a way which was more cognitive or behavioral than emotional or agentic. Learners in average teacher support and learning satisfaction profile reported a favor for an agentic or a behavioral manner compared with a cognitive or an emotional one when engaging in language learning. Contrarily, students who perceived high teacher support and learning satisfaction were in preference for emotional or cognitive learning engagement, more than agentic or behavioral learning engagement. Hence, 3 profiles with different traits were identified for developing pedagogical strategies.

Discussion

This research investigated the intrinsic connection between perceived teacher support, SDT motivation, learning engagement, and learning satisfaction among Chinese university students in blended English learning using both variable- and person-oriented analyses. The variable-oriented study confirmed 9 hypotheses. A chain mediation model was established since results indicate that teacher support positively and significantly correlated with learning satisfaction, either in a direct way or mediated ways. The person-centered study identified 3 profiles, each with unique traits in blended English leaning.

Variable-centered study: interrelationships among teacher support, SDT motivation, learning engagement, and learning satisfaction

A significant relationship was corroborated that teacher support related positively to learning satisfaction (H1, $\beta = 0.501$, $p < 0.001$), aligning with earlier discoveries across different educational settings [17, 47]. Existing studies have criticized online learning because of insufficient virtual engagement, significant dissatisfaction [13] and lack of real interactions [12]. Reasons might be that online lectures are usually realized through pre-recorded videos, which are comparatively fixed and one-size-fits-all. Fortunately, the correlation and effect size of teacher support on learning satisfaction in this study is higher than those of online teaching experience [27, 28], indicating blended learning is a more favorable mode, with online and offline parts complementing reciprocally, providing a more facilitated channel for teachers' supportive actions.

The correlation between teacher support and SDT motivation (H2, $\beta = 0.641$, $p < 0.001$) was vindicated, aligning with the previous research among Chinese left-behind rural children [31], Chinese middle school students [17], and Chinese non-English major EFL students [16], indicating that teachers are expected to express care, support, understanding, and offer feedback timely and positively, students would feel affirmed and supported, which contributes to learning motivation.

The results unveiled that SDT motivation related positively to learning satisfaction (H3, $\beta = 0.633$, $p < 0.001$), concurring with extensive studies showing that SDT motivation, including autonomy, competence and relatedness satisfaction, nurtured positive emotions, such as language motivation, self-efficacy, grit, and even life satisfaction [6, 38]. Recent studies [23, 52] have emphasized the role of learning motivation as an assessment in language learning outcomes. Positive relationships between students and teachers corresponded with relatedness satisfaction, nourishing effective feedbacks [50], probably making students more content in learning, for which SDT motivation and the intrinsic motivation it derived were once again highlighted as a key for learning satisfaction.

The findings affirmed a robust positive influence of teacher support on learning engagement (H5), with a significant correlation ($\beta = 0.563$, $p < 0.001$), echoing with results from both traditional and online educational settings [17, 35, 47], as well as in blended learning context

[45]. According to a previous study [20], most teachers and students cherished their nurturing and supportive relationships and interactions facilitated by teacher support, which in turn, bolstered learning engagement [35]. However, it should be noted that learners perceiving superfluous instructional support from the synchronous online learning environment tended to be less emotionally engaged [50]. Therefore, practitioners are advised to supply proper support with the aim of engaging learners, making them genuinely and meaningfully involved in the learning process.

In terms of the correlations between learning engagement and learning satisfaction (H6), learning engagement significantly and positively related with learning satisfaction ($\beta = 0.747$, $p < 0.001$). This argument has been explained in the aforementioned literature of different authors [2, 47, 50]. One possible reason was that students with more behavioral and emotional engagement always held positive attitude towards the outcomes [49], which contributed to higher learning satisfaction. This suggests that lecturers should provide learning activities that inspire enthusiasm and enjoyment among learners [24, 48, 49].

This study also found the positive bond between SDT motivation and learning engagement in blended English learning (H8, $\beta = 0.714$, $p < 0.001$). The influence of certain constructs in SDT motivation on learning engagement was significant in several studies [32, 35, 57], which partially supported our results. Contrarily, a survey proved that autonomy satisfaction, one aspect of SDT motivation, failed to enhance learning engagement of Chinese adolescents [58]. In this case, the salient intercultural differences might be blamed. In Western societies with prevalent individualism, students long to act autonomously and independently. However, in a collectivist-oriented Asian environment, learners profit from care and harmony [59]. Therefore, when faced with different educational settings, educators should tailor supportive behaviors to suit cultural preferences.

Variable-centered study: mediating role of SDT motivation and learning engagement

This research explored the indirect effects between learners' perceived teacher support and learning satisfaction via the mediation of SDT motivation and learning engagement. The mediating pathways are as follows: teacher support → SDT motivation → learning satisfaction (H4); teacher support → learning engagement → learning satisfaction (H7), and teacher support → SDT motivation → learning engagement → learning satisfaction (H9).

Firstly, the findings indicated that SDT motivation had a significant mediation role between teacher support and learning satisfaction in blended English learning, aligning with studies showing that teacher support was apt to improve some or all of the three psychological needs of students [31, 52], thus accelerating students' intrinsic motivation [23], underlining the importance of inner-generated learning behaviors.

It is therefore incumbent upon educators to support learners in autonomy, competence, and relatedness. Autonomy-supportive atmosphere could be created when teachers devolving more freedom to students to decide independently, supplemented with meaningful academic information for accelerating competence and sympathetic appreciation for enhancing relatedness [7]. In specific view of blended English learning, offline instructions for language proficiency with face-to-face interactions, and free-choice online learning materials might be learning-motivation-friendly. Combined with course videos online, English teaching materials becomes more accessible and comprehensible because students are provided with chances to re-fetch knowledge online when there is any ambiguity after offline learning [25], contributing to a more attractive learning environment and a flexible learning schedule, a more thorough intellectual dissemination and a more inclusive zone, guaranteeing autonomy, competence, and relatedness satisfaction.

Secondly, the effect of teacher support on learning satisfaction was successfully mediated by learning engagement. The result formed an alignment with previous studies, revealing that learners who experienced stronger teaching presence engage more in academic activities, and are more satisfied with their learning [47, 49].

Consequently, teachers are expected to facilitate students bearing the target to engage them in blended learning process. The pedagogical suggestion for blended English teaching might be the appropriate selection of teaching methods in different educational settings. As was indicated by the existing literature, students majoring in humanities (such as English) would be more satisfied when engaging in interactive and flexible lecture forms with connections between the professor and students, such as practice and demonstrations, discussions flowing in the classroom, and case studies [26]. However, in the online part of blended learning, course videos are usually filmed beforehand and invariant over years for sake of convenience, so in instructional design of blended English courses, teachers of students from different majors or with different interests should adjust the offline part of teaching to engage them. Moreover, innovative technological incorporation of technological tools, such as artificial intelligence and metaverse, are also anticipated to create possibilities for teachers to enhance immediate communication and immersive engagement [48].

Thirdly, the present study confirmed the chain mediator formed by SDT motivation and learning engagement

that explained the internal mechanism within the association of teacher support and learning satisfaction. The finding partially echoed with recent studies, which examined that individuals with a stronger sense of teacher support could attain a better level of SDT motivation, and thereby enhance the satisfied attitudes towards learning [34, 35]. Noticeably, the pathway effect size of the chain mediator possessed 31.42% of the total effect, larger than the single-mediation pathways and the direct pathway, while the direct effect was the smallest. It indicated that SDT motivation and learning engagement together was an influential role in the association of teacher support with learning satisfaction.

A comprehensive consideration of the three successful pathways and their direct effects yielded some insights. The decisive chain mediator formed by SDT motivation and learning engagement, which outperformed the two single mediators, stressed the importance of inner-motivated learning engagement. Since SDT motivation is a kind of motivation derived intrinsically [51], the fundamental difference between engaging students merely (the mediator learning engagement) and engaging students by satisfying them (the chain mediator) is whether students are driven intrinsically to learn and well internalize extrinsic motivation [3]. Introspecting into the blended English learning mode in this study, there might be an absence or lack of intrinsic motivation underneath the high learning engagement, because students could be engaged for some obligations involuntarily because their performance online took a proportion of the total course score. For instance, students were usually required to launch a certain number of comments or discussions online. Consequently, they would engage in such activities even though they were not interested or satisfied. Hence, the enlightenment is that educators should stimulate students to participate spontaneously and voluntarily in blended English learning, by positioning students as the center of educating and learning, caring for their needs, enhancing interactive engagement, and ensuring the meaningfulness of learning activities [5, 33, 53]. Aiming at promoting the quality of the increasingly prevalent blended learning approach, our findings disclose the chain mediating roles of SDT motivation and learning engagement, thus explaining the interplays between teacher support and learning satisfaction in blended English learning context.

Person-centered study: teacher support and learning satisfaction profiles

In order to explore the differentiated mechanism in the impact of teacher support on learning satisfaction of different groups of students, an LPA was conducted. All of the samples were categorized in accordance with their perception in teacher support and learning satisfaction,

so that differences in SDT motivation and learning engagement could be demonstrated as fine-grained explanations for the intrinsic effects. Although studies delving into the heterogeneity in teacher support and learning satisfaction were scant, we successfully identified 3 profiles using LPA. Grounded on the results, the first profile was characterized as below-average-both profile, in which the means of teacher support and learning satisfaction reported by the students were slightly below the average means. The second profile was referred to as average teacher support and learning satisfaction since the perceived teacher support and learning satisfaction of learners in this class were very close to the average level. Moreover, we portrayed the third profile as high teacher support and learning satisfaction, because students of this profile had high teacher support and learning satisfaction, compared with other 2 profiles. The inter-profile relationship, which vindicated that students with stronger perception of teacher support tended to simultaneously perceive a stronger learning satisfaction, echoed with the outcomes in Pearson correlation analysis and the linear regressions, and again evidenced H1.

The average teacher support and learning satisfaction profile was the largest profile, accounting for 55.1% of the total sample size, indicating that in blended English language learning, a majority of the learners received an average level of teacher support, were moderately satisfied, and were offered an average course quality. The second largest profile was the below-average-both profile, contributing a proportion of 27.7%. Although this class of students reported the lowest level of teacher support and learning satisfaction in the present study, the means only fell slightly short of the average level, verifying that students' experience of feeling supported and satisfied was fundamentally ensured in blended English learning mode compared to characteristics of mere online learning satisfaction [13]. Moreover, the high teacher support and learning satisfaction profile possessed the least ratio, sharing 17.3% of the whole population, implying the difficulty to achieve high teacher support and learning satisfaction. This outcome presented a partially contradictory distribution with a study involving LPA on teacher support indicating over 60% of the Chinese primary school students with a high perception of teacher support [65]. This might be due to the dual differences in both grade and learning mode. University students might be in favor of a higher independence in learning, and the mode of blended learning may have extremely diversified their accesses to different types of social support, making their learning engagement and positive emotions [19] depend less on teacher support than, for example, middle school students [17].

Additionally, similarities in teacher support and learning satisfaction across profiles offer valuable pedagogical

insights. As depicted in Fig. 2, notable deficiencies lied in the second item in teacher support for competence (The English teacher makes me feel like I am good at English.) and the fourth item in teacher support for relatedness (The English teacher is interested in me.). The lower scores in the second item in teacher support for competence might be caused by students' diffidence of being good at English, and students' perceived English proficiency depends on both teacher support and test-based learning outcomes [2]. Given the variability in student performance, this item may not resonate with all. Moreover, students' responses to relatedness item could serve as a reminder for teachers to express their appreciation and interest to students, for which they might feel more supported.

Person-centered study: differences in SDT motivation and learning engagement across profiles

Statistics in Table 5; Fig. 3 corroborated that the learners of high teacher support and learning satisfaction profile excelled across observed indexes, followed by the students of average teacher support and learning satisfaction profile, and those of below-average lagged behind. This implied that a heightened sense of teacher support was linked with higher satisfaction of basic psychological needs, increased engagement, and more contentment with English learning experience, paralleling with the results in the variable-centered study. Thus, the hypothesized correlations concerning the correlations between the variables and the chain mediation model were more profoundly confirmed.

Furthermore, significant variations in students' perception of SDT motivation, learning engagement, and their subscales were evidenced across profiles, highlighting "crucial stages" in students' developmental phases. For students with below-average teacher support and learning satisfaction, they found the greatest need satisfaction in competence needs and least in relatedness. Moreover, they were predominantly engaged in cognitive learning activities, with the lowest inclination toward agentic learning engagement. In contrast, students in average teacher support and learning satisfaction profile reported a major relatedness satisfaction and agentic learning engagement, alongside moderate autonomy satisfaction and emotional learning engagement. Moreover, learners in high teacher support and learning satisfaction profile exhibited the most pronounced satisfaction with autonomy and a strong inclination to emotional learning engagement, while competence satisfaction and behavioral learning engagement are the least remarkable. The disparities across profiles might stem from differed priorities in SDT motivation and habitual predilection in learning. The results could be partially elucidated by Hierarchy of Needs [36], in which security, love and belonging, and esteem needs are desired in sequence. Since university students are contacting increasingly with the society, job preparation and anxiety have become their great concern [22], for which the need for competence, a component considered as a criterion for employment, acts as a preliminary perception of need satisfaction. Competence needs supported, desire for being related would be prominent out of love and belonging needs [36]. For those students sensing themselves as strongly supported, needs for esteem might be dominant, with learners longing for autonomy to feel respect and uniqueness. However, though meaningfully connected, Maslow's needs theory and SDT still diverge with differed focus, and more comparative studies are needed to illustrate students' specific sequence of need satisfaction and especially preference in learning activities.

The study's findings could cast insights into pedagogical practice, suggesting that tailored scaffoldings from the practitioner can significantly accelerate students' well-being and learning. Despite the necessary efforts covering all aspects, to help students of below-average teacher support and learning satisfaction transit positively into the average level, teachers are expected to focus on offering more targeted assistance for fulfilling their relatedness needs and fostering their agentic learning engagement. For students in average teacher support and learning satisfaction, in order to manage a crossover to the high level, though omni-directional encouragements are indispensable, educators are suggested to cater to their autonomy needs and foster a more emotionally involved learning process.

Limitations and implications for future studies
Limitations

There exist certain limitations in this study in need of remedies in future research. In terms of the participants, the samples for this study were obtained solely from one university in the east of China, albeit from different classes and majors, and the genders are unevenly distributed. Therefore, the participants in the study may not represent the entire population under the universal mode of blended learning. Future researchers could enlarge the size of sampling and including students from various universities and majors who have been exposed to blended English teaching. This would enhance the generalizability of the research discoveries significantly. Secondly, with a variable- and person-centered view, this study focused on the four variables, aiming at verifying the chain mediation model and identifying latent profiles among samples, for which the demographic features of participants were less explored. Hence, future research may expound more in demographic variables such as grades, ages, and locations of the samples to develop more specific advice.

Implications for future study

Firstly, future research may consider involving participants of different cultural backgrounds and diverse courses to testify whether the effect of teacher support, SDT motivation, and learning engagement on learning satisfaction is course-dependent or culture-dependent. It helps to discover more about the effect of various backgrounds and surroundings on the variables. Second, future research may continue to employ person-centered methods such as LPA to conduct more in-depth investigations to figure out the mechanisms across profiles and depict various learning habits and mental patterns of learners with different traits. Moreover, person-oriented approaches are also serviceable in assisting teachers with concrete pedagogical styles or choices that are desired and preferred by learners, to better create a supportive and inspiring learning environment, and foster a positive learning experience driven by students' intrinsic motivation.

Conclusion

Grounded on the variable- and person-centered method, the current study investigated the intrinsic mechanism among teacher support, SDT motivation, learning engagement, and learning satisfaction. We concluded that: [1] The four variables significantly and positively correlated with each other, in line with H1, 2, 3, and 8 [2]. The mediation roles of SDT motivation, learning engagement, and the chain mediator formed by SDT motivation and learning engagement were positive and significant, conforming with H4,7, and 9 [3]. Three profiles were identified based on the analysis of teacher support and learning satisfaction, namely below-average-both, average-both, and high-both profiles, with the below-average having the least desired results while the high profile the most. Armed with the dual analytical lens, lecturers would be more capable to promote learning satisfaction by focusing especially on students' needs and stimulating their intrinsic motivations, and implement individualized instructions.

Abbreviations

AIC	Akaike Information Criterion
ANOVA	Analysis of covariance
BIC	Bayesian Information Criterion
BLRT	Bootstrap Likelihood Ratio Test
CI	Confidence interval
DV	Dependent variable
IV	Independent variable
LE	Learning engagement
LEa	Agentic learning engagement
LEb	Behavioral learning engagement
LEc	Cognitive learning engagement
LEe	Emotional learning engagement
LLCI	Lower level of confidence interval
LPA	Latent profile analysis
LS	Learning satisfaction
L-M-R LRT	Lo-Mendell-Rubin Likelihood Ratio Test
M	Mean
SD	Standard deviation
SE	Standard error
SDT	Self-Determination Theory
SEM	Structural equation modeling
SM	SDT motivation
SMa	SDT motivation of autonomy
SMc	SDT motivation of competence
SMr	SDT motivation of relatedness
SPSS	Statistical Product and Service Solutions
TS	Teacher support
ULCI	Upper level of confidence interval
aBIC	Ample-size adjusted Bayesian Information Criterion

Author contributions
Xuan Yang: Methodology, Data analysis, Writing the original draft; Ling Li: Conceptualization, Methodology, Review and editing; Jingjing Jiang: Review and editing; Jiangfen Ying: Revising and editing.

Data availability
The data that support the findings of this study are available on request from the corresponding author, upon reasonable request.

Declarations

Ethics approval and consent to participate
The research involving human participants was conducted in compliance with the ethical guidelines established by the institutional and national research committees, adhering to the principles of the 1964 Helsinki Declaration and its subsequent amendments. Ethical approval for this investigation was granted by Zhejiang Normal University's Research Ethics Committee (No. ZSRT2024169).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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