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ORIGINAL RESEARCH

Transactional Distance and College Students' Learning Engagement in Online Learning: The Chain Mediating Role of Social Presence and Autonomous Motivation

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Purpose: Transactional distance remains an important issue in online education, which is an important indicator to evaluate the quality of teaching and learning in online courses and is closely related to the success of learners' online learning. The purpose of this study is to evaluate the potential mechanism of transactional distance and its three modes of interaction on the impact of learning engagement of college students.

Participants and Methods: Online Education Student Interaction Scale, Online Social Presence Questionnaire, Academic Self-Regulation Questionnaire and Utrecht Work Engagement Scale-Student scales were used, revised questionnaire for cluster sampling of college students, 827 valid samples. SPSS 24.0 and AMOS 24.0 were used for analysis, and Bootstrap method was used to test the significance level of the mediating effect.

Results: Transactional distance (including the three interaction modes) was significantly and positively related to college students' learning engagement. Autonomous motivation played a chain mediating role between transactional distance and learning engagement. In addition, social presence and autonomous motivation mediated the chain between student-student and student-teacher interaction on learning engagement. In addition, however, student-content interactions did not significantly impact social presence, and the chain mediating effect of social presence and autonomous motivation between student-content interaction and learning engagement was not supported.

Conclusion: Based on transactional distance theory, this study reveals the role of transactional distance on college students' learning engagement and the mediating effect of social presence and autonomous motivation in the relationship between transactional distance (and three interaction modes of transactional distance) on college students' learning engagement. This study supports the findings of additional online learning research frameworks and empirical studies to enhance our understanding of how online learning affects college students' learning engagement and the important role of online learning in college student's academic development.

Keywords: transactional distance, learning engagement, social presence, autonomous motivation, online teaching reform

Introduction

Since 2020, up to 1.5 billion students and youth worldwide (more than 98% of the world's student population) has been affected by school closures due to COVID-19.[1] As countries worldwide move their educational activities online at all levels, the emergency transition to online learning and teaching presents new challenges for students and teachers. In China, in an emergency response to COVID-19, classes were suspended without delay, and online learning activities began to be conducted using Internet platforms to maintain everyday teaching and learning.[2] Online learning is further popularised and developed as universities use the 24,000 courses on 22 online course platforms launched by the Ministry of Education (such as Tencent Classroom, Rain Classroom, and Learning Pass) to carry out online teaching activities in an orderly manner.[3]

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University students are among the most critical stakeholders in higher education, and their perception of the transactional distance of the learning environment is closely related to the success of online learning.[4] However, online teaching and learning break down the temporal and spatial boundaries of traditional learning and enhances the flexibility and autonomy of student learning.[5] But online learning is more virtual, open, and complex, and thus places higher demands on the learner's ability to learn autonomously and their level of commitment to learning.[6] In particular, transaction distance remains a significant issue in online teaching and learning, as ensuring and supporting the success of online learning does not depend solely on technological capabilities but may also depend on the channels of interaction, communication, and motivation introduced into teaching and learning practices.

Transactional distance is considered one of the most critical parts of the learning experience in both traditional and online learning environments and an essential indicator for evaluating the quality of teaching and learning in online courses.[7–9] However, a persistent problem with online learning is that learners feel isolated or disconnected from the course, the instructor, or other students due to the lack of a more interactive and practical learning experience, and learner motivation and learning engagement decline.[10,11] If university students are to be provided with the support they need to succeed in online learning, a clearer understanding of these students' online learning processes is required.[12] Learning engagement is an essential indicator of learning satisfaction and academic achievement. It can accurately predict learners' online learning quality and psychological state during the learning process. In this sense, it is necessary to determine students' perceptions of transactional distance and take preventive and intervention measures in interactive environments with high perceptions. Therefore, a comprehensive understanding of the main antecedents affecting academic engagement in university students' online learning and exploring their potential mechanisms of action are crucial to improving the online learning process and the online learning experience.

Literature
Transactional Distance and Learning Engagement

According to the theory of transactional distance (Moore's Theory of Transactional Distance, 1993), transactional distance refers to the online learning gap associated with communication and understanding due to the physical distance between students and teachers. This is not only geographical distance but also the learner's perception of the transactional space between them and the teacher.[13] Transactional distance contains three components: student-teacher interaction, student-student interaction, and student-content interaction, which refers to interactions between individual students or students working in small groups. Student-teacher interaction relates to techniques used by teachers to stimulate and maintain student-teacher interaction is a technique that teachers use to promote and sustain learners' interest in course content.[14] Student-content interaction refers to the interaction of learners with course content to construct meaning, relate prior knowledge, or solve problems. As transactional distance is perceived to decrease, students develop and maintain positive attitudes in their learning experience through a high level of engagement in these three different types of interactions, resulting in a higher learning experience.[15,16]

Transactional distance has been shown to play an excellent role in online learning,[14,17–20] especially for learners' learning engagement.[21–23] Learning engagement is an active, fulfilling, learning-related state of mind in which the learner is engaged in the learning process.[24–28] Previous researches on interaction have found that learners who feel they have higher levels of interaction with teachers or peers have higher levels of satisfaction and academic engagement than learners who think they experience lower levels of interaction.[29–32] Other studies report that more learner-to-learner interactions produce higher satisfaction, implying that more learner-to-learner interactions promote more effective online learning behaviors.[17,33] In addition, Moore's study noted that student-content interaction occurs in students' minds when they interact with learning materials, which enables students to acquire and expand their knowledge and increases learner engagement.[34,35] These studies suggest that students' perception of transactional distance for online courses appears to be a key factor influencing learning engagement. Based on the above discussion, the following hypotheses are proposed in this study:

H1:The transactional distance of students' online learning positively affects their learning engagement.

H1a:Student–student interaction of students' online learning positively affects their learning engagement.

H1b:Student–teacher interaction of students' online learning positively affects their learning engagement.

H1c:Student–content interaction of students' online learning positively affects their learning engagement.

Social Presence in Online Teaching

Numerous studies have confirmed that social presence is an essential factor closely related to social interaction in online learning environments.[36] Social presence is one of the most critical components of the quality of the online learning experience, alleviating learner isolation during the online learning process and increasing learner engagement.[37,38] More importantly, social presence is the ability of learners to project themselves socially and emotionally as "real people, as a community of learners".[39] Research on social relations in online learning suggests that social presence reflects a sense of intimacy, immediacy, social context, online communication, and interactivity to build a supportive environment for understanding.[40] Social presence is a crucial indicator of media and communicators' perceptions of presence in various student-teacher interactions.

Social presence theory points to the critical role of social learning and social relationship building for academic engagement and integration into online learning.[36] This point suggests that interactions in online learning can affect learners' social presence and may lead to de-motivation and disengagement or minimal engagement and withdrawal.[34,35] A recent study of student interactions found that student-student interaction stimulates reflection on cognitive patterns and contributes to social cohesion and motivation to sustain online learning.[41] Specifically, students who take online courses with a perceived higher sense of social presence are more likely to experience greater enjoyment and interest and are more likely to engage in online classes.[42] Zhang et al's study suggests that instructors enhance students' sense of community, ie, enhance learners' sense of social presence, by engaging in and leading online discussions, prompting them to feel higher levels of learning satisfaction and academic engagement.[10,43] The literature on the relationship between student-content interaction and social presence is limited. However, some information on this association can be observed from studies of online learning environments.

A study on creating online learning spaces noted that student-content interaction could facilitate a different learning experience for students.[15] A better learning experience leads to higher learning engagement as learners perceive the higher social presence and develop and maintain positive attitudes toward learning.[16] However, previous research is insufficient to determine the relationship between student-content interaction, social presence, and learning outcomes.[44] Therefore, more empirical research is needed to examine whether this interaction can influence college students' academic engagement through social presence. Based on the above discussion, the following hypotheses are proposed in this study:

H2: Social presence mediates the relationship between transactional distance and learning engagement.

H2a: Social presence mediates the relationship between student–student interaction and learning engagement.

H2b: Social presence mediates the relationship between student–teacher interaction and learning engagement.

H2c: Social presence mediates the relationship between student–content interaction and learning engagement.

The Mediating Effect of Autonomous Motivation

According to self-determination theory (SDT), autonomous motivation is an individual's motivation to perform a behavior out of their own will and is an essential indicator of online learning initiative.[45] In an online learning environment, if learners lack the motivation to learn, they are prone to wandering attention and lack of persistence.[46] Negative behavior in learning occurs because the motivation for the target behavior is a motivation or controlled, ie, self-control.[47,48] If the individual's motivation for the target behavior is autonomous, the individual does not need much self-control in performing the behavior. Therefore, the independent reason is significant for online learning participation.[49]

Previous researches have shown that students' transactional distance affects their intrinsic motivation, learning experiences, and learning outcomes.[6,50–53] For example, student-teacher interaction directly predicts increased student

motivation and self-regulated learning.[54,55] A qualitative study based on a traditional classroom showed that students who had good interaction experiences with teachers showed stronger autonomous motivation in learning, higher willingness to engage in learning tasks, and tremendous effort to do so.[56] Similarly, through interactions with peers, individuals can acquire skills to work with teams to enhance student motivation and engage in learning tasks through idea sharing and collaborative thinking among students.[57] In addition, online learning requires students' self-motivation to engage in their learning process and maintain their strong commitment to learning. Student interaction with course content is significant in this context. If students perceive online learning as valuable and meaningful, they will be motivated and thus increase their engagement in online learning.[58] Thus, students' automatic motivation to participate in online courses seems critical in keeping them engaged in online learning. Based on the above literature exploration, it is reasonable to suggest that Autonomous motivation, as an essential indicator of online learning initiatives, may be an important mediating variable for transactional distance to influence academic engagement, the following hypotheses are proposed in this study:

H3: Autonomous motivation mediates the relationship between transactional distance and learning engagement.

H3a: Autonomous motivation mediates the relationship between student–student interaction and learning engagement.

H3b: Autonomous motivation mediates the relationship between student–teacher interaction and learning engagement.

H3c: Autonomous motivation mediates the relationship between student–content interaction and learning engagement.

The Chain Mediating Effect of Social Presence and Autonomous Motivation

After years of development, the theory of social presence (Theory of Social Presence) has become one of the essential fundamental theories in online education research. Social presence is the foundation and condition to realize learners' self-directed learning, generally speaking, social presence enables online learners to have a sense of learning community and to interact with other learners, learning organizers, learning content and other materials online voluntarily. As a prerequisite for online self-directed learning, the sense of social presence is positively related to learners' self-directed learning.[59] This suggests that the stronger the sense of social presence, the more effective the learner's practice of autonomous motivation for online learning. This is because social constructivists indicate that the contextual and situational factors of the learning environment play a crucial role in fostering motivation.[60] Particularly in online environments, social presence (eg, factors related to emotional expression, comfortable conversation, recognition, and collaboration) is likely to be a contextual factor that influences learners' automatic motivation.[61] Lin et al reported that they might have higher autonomous motivation when they have high levels of social presence through timely classroom feedback and interaction. However, direct tests of the impact of social presence on autonomous motivation in online learning empirical studies remain scarce.[62]

Therefore, one of the main objectives of this study was to examine the role of social presence in autonomous motivation in the online learning process among college students. Based on the above discussion, the following hypotheses are proposed in this study:

H4: Social presence and Autonomous motivation play a chain mediating role in the relationship between transactional distance on learning engagement, social presence positively influences autonomous motivation.

H4a: Social presence and Autonomous motivation play a chain mediating role in the relationship between student–student interaction on learning engagement.

H4b: Social presence and Autonomous motivation play a chain mediating role in the relationship between student–teacher interaction on learning engagement.

H4c: Social presence and Autonomous motivation play a chain mediating role in the relationship between student–content interaction on learning engagement.

Current Study

To sum up, transactional distance can maintain learners' motivation for continuous learning and increase learners' willingness to participate and engage. At the same time, current research lacks the ability to separate different interaction modes from transactional distance and examine the relationship with learning engagement separately. The current study lacks a separate examination of the relationship between different interaction modes from transactional distance and learning engagement. Therefore, it is necessary to confirm the mechanism of transactional distance and its different interaction modes on learners' learning engagement through empirical evidence. The Theory of Transactional Distance (TTD) provides a valuable research framework to examine the three interaction modes of transactional distance (student-teacher interaction, student-student interaction, and student-content interaction) to predict college students' academic engagement. On the other hand, it examines how transactional distance affects college students' learning engagement by promoting their social presence and autonomous motivation.

Participants and Measures

Participants

Participants in this study were recruited from a public university in southwest China and all experienced online courses for the entire first semester of 2022 (September 2022 - January 2023). All participants were enrolled in a course entitled Marxist Theory, a compulsory course for university students as stipulated by the Chinese Ministry of Education. The participants were, therefore, from different faculties such as Economics, Marxism, and Software Engineering. They were all under the supervision of the same teacher, eliminating the influence of different teachers' teaching styles as much as possible. Participants used the online learning platform Tencent Classroom (one of the most popular online learning platforms used by Chinese university). Although most students had fully taken the online course in the previous semester and were well prepared for the online learning environment of the course, during the first week of the semester, the instructor was not fully prepared for the online learning environment. However, in the first week of the semester, the instructor introduced the course to all students and guided them to use the online teaching features of Tencent Classroom. Before the class, teachers prepared sufficient materials, courseware, audio, and video in advance and uploaded the teaching materials used in the class to the shared file. Teachers can teach through four modes: "screen sharing", "PowerPoint presentation", "video playback", and "webcam". Four modes of teaching are available. The teaching toolbar provides teaching tools such as a drawing board, check-in, picture-in-picture mode, and hand raising (students can apply for voice connection) for teachers. At the same time, the "Discussion Board" is available for teachers and learners to interact and discuss in real time, and the web group is open for teachers and students to communicate after class.

The study eventually recruited 827 participants, including 304 male (36.759%) and 523 female (63.241%) students from different departments such as the School of Economics, Marxism, and Software Engineering. Since the course was only for freshmen or sophomores, the student year included only freshmen (55.744%) and sophomores (44.256%). The students were between 17 and 20 years old, with a mean age of 18.44± 0.572. Informed consent was obtained from all students before completing the questionnaire, and participation was voluntary. Students were informed that personal information as confidential and no incentives were given.

Measures

Transactional Distance

Using the Online Education Student Interaction Scale (OESIS) developed by Kuo, Walker et al.[17] The scale consisted of 3 factors and a total of 18 items, and the factors included: eight items on student-student interaction (TDSS) (eight items), six on student-teacher interaction (TDST) (six items), four on student-content interaction (TDSC) (4 items), items including "The group activities in the online classroom allow me to interact with my classmates", "I get enough feedback from the instructor when I need it", "The online course materials helped me understand the content better", etc. The scale uses the 5-point Likert scale ranging from 1 (completely disagree) to 5 (completely agree), the higher the score, the more interaction they perceive. The results of the confirmatory factor analysis (CFA) indicate that construction of this scale is effective, with CFI=0.988, GFI=0.975, TLI=0.986 and RMSEA=0.023. And the Cronbach's α for the total scale was 0.908.

Social Presence

This study used the Eunmo and Richard Online Social Presence Questionnaire (OSPQ), a five-item online distance education social presence scale.[63] The scale has five dimensions: social respect (5 items), social sharing (5 items), open-mindedness (3 items), social identity (4 items), and closeness (2 items). The sample items were "I feel a sense of presence when students and teachers have multiple characteristics in my online community" and "I feel a sense of presence when students and teachers call me by my name". The results of the confirmatory factor analysis (CFA) indicate that construction of the scale is effective, with CFI=0.916, GFI=0.900, TLI=0.906 and RMSEA=0.074. And the Cronbach's α for the total scale was 0.942.

Autonomous Motivation

The Academic Self-Regulation Questionnaire (SRQ-A: Academic Self-Regulation Questionnaire) developed by Ryan and Connell was used.[64] The 32-item questionnaire was divided into four dimensions: external regulation (9 items), internal regulation (9 items), Identified (7 items), and Internal (including integrated regulation, 7 items). And the sum of identified and internal subscale was used to measure students' autonomous motivation.[65,66] The questionnaire was scored on a 4-point scale, with 1 meaning not at all and 4 meaning solid fit. The results of the confirmatory factor analysis (CFA) indicate that construction of the scale is effective, with CFI=0.908, GFI=0.931, TLI=0.891 and RMSEA=0.076. And the Cronbach's α for the total scale was 0 0.893.

Learning Engagement

The scale was developed by Schaufeli as the Utrecht Work Engagement Scale-Student (UWES-S), with 17 items divided into Vigor (6 items), Dedication (5 items), and Absorption (6 items).[24] The scale was scored on a 7-point scale, with 1 representing "never" and 7 representing "always". The higher the score, the higher the student's learning engagement. The results of the confirmatory factor analysis (CFA) indicate that construction of the scale is effective, with CFI=0.915, GFI=0.895, TLI=0.900 and RMSEA=0.082. In this study, Cronbach's α of the scale was 0.934.

Data Processing

First, using SPSS 24.0, we calculated descriptive statistics and Pearson correlation coefficients between key variables. Second, we used Amos 24.0 to construct a structural equation model to examine the influence mechanism between transactional distance and learning engagement. Finally, the bias-corrected percentile bootstrap method based on 5000 samples and 95% confidence intervals (95% CIs) was applied to determine whether the indirect effect is significant at the 0.05 level.

Results

Bivariate Correlations Among Key Study Variables

Table 1 has shown the statistical information and Pearson correlation coefficients for each key variable. As shown in Table 1, all three dimensions of transactional distance were significantly correlated with learning engagement and autonomous motivation, such as student-student interaction was significantly and positively correlated with learning engagement (r=0.218, p<0.01), and autonomous motivation (r=0.233, p<0.01). Social presence had a significant positive relationship with student-student interaction (r=0.200, p<0.01) and student-teacher interaction (r=0.209, p<0.01), but the correlation between social presence and student-content interaction was not significant (r=0.061, p>0.05). In addition, there was a significant positive relationship between learning engagement and social presence and autonomous motivation.

Structural Equation Modeling Analytical Results

In H1~H4, we hypothesized the effects and potential mechanisms of transactional distance on Learning Engagement. And first, we developed a structural equation model to test the effects of transactional distance on students' learning engagement and the mediating effect of social presence and autonomous motivation in this relationship. In order to further clarify, we built three structural equation models to separately examine the effect of each dimension of

Table 1 Bivariate Correlations Among Key Study Variables

	Mean	**SD**	**1**	**2**	**3**	**4**	**5**	**6**
1.Student–Student Interaction	24.851	6.752	1					
2.Student–Teacher Interaction	18.549	5.124	0.770**	1				
3.Student–Content Interaction	12.302	3.593	0.583**	0.517**	1			
4.Learning Engagement	54.149	11.789	0.218**	0.180**	0.092**	1		
5.Social Presence	65.452	16.325	0.200**	0.209**	0.061	0.154**	1	
6.Autonomous Motivation	3.956	8.312	0.233**	0.221**	0.129**	0.225**	0.183**	1

Note: **p<0.01.

transactional distance on students' learning engagement, and the mediating role of social presence and autonomous motivation to verify H1abc~H4abc. The results are presented in Table 2 and Figures 1–4.

In Model 1, we created a Structural equation model with transaction distance as the independent variable, the overall fit of the model showed a good fit to the data (χ^2/df=2. 326, CFI=0. 994, GFI=0. 994, AGFI=0.981, TLI=0.984, RMSEA=0. 040).

As is shown in model 1 of Table 2, the CFA results show that the standardized factor loadings are all greater than 0.6, therefore, can be considered moderate.[67] Precisely, the latent construct of transactional distance can be measured by three observations, student–student Interaction (λ=0.934), student–teacher interaction (λ=0.826), and student–content interaction (λ=0.622). The results of path analysis showed that transactional distance was significantly positive associated with social presence (β=0.215, p<0.001), autonomous motivation (β=0.221, p<0.001), and learning engagement (β=0.188, p<0.001). At the same time, social presence was significantly positive associated with autonomous motivation (β=0.136, p<0.001) and learning engagement (β=0.088, p<0.05). Additionally, autonomous motivation was significantly positive associated with learning engagement (β=0.168, p<0.001). Figure 1 shows a visualization of this model.

Models 2 to 4 in Table 2 show the test results of the structural equation model when the three dimensions of transactional distance are used as independent variables, and the visualization results of this model are shown in Figures 2–4, respectively. In models 2 and 3, the path significance in the structural equation model when student-student interaction and student-teacher interaction are used as independent variables is consistent with model 1, with each variable demonstrating a statistically significant relationship with each other. However, in model 4, we found that the effect of student-content on social presence was not significant (β=0. 061, p>0.05).

Testing Mediating Effect with the Bootstrap Method

We used the Bootstrap method to confirm each path's effect size and significance. As shown in Table 3, Model 1 shown the bootstrap testing result when Transactional Distance as independent variable, the mediating effect of Social Presence between Transactional Distance to Learning Engagement 95% BootCI does not contain 0 (95% BootCI [0.008, 0.073]), therefore the mediating effect is significant and the mediating effect estimate is 0.36; The 95% BootCI of the mediating effect of Autonomous Motivation between Transactional Distance to Learning Engagement did not contain 0 (95% BootCI [0.036, 0.116]), so the mediating effect was significant, and the mediating effect estimate was 0.70; Finally, the chain mediation of Social Presence and Autonomous Motivation between Transactional Distance to Learning Engagement was also significant (95% BootCI [0.021, 0.077]), with a mediation effect estimate of 0.41. Thus, the H1 ~ H4 were supported.

Models 2 to 4 in Table 3 show the test results of the structural equation model when the three dimensions of transaction distance are used as independent variables. In model 2 and model 3, student-student interaction and student-teacher interaction were used as independent variables, respectively. The 95% BootCI of each indirect path in the structural equation model does not contain 0, so the effect estimates are significant. Therefore, H1ab~H4ab were supported.

Table 2 Structural Equation Modeling Analytical Results

Path	Std. Est	Unstd. Est	SE	t
Model 1: Transactional Distance as independent variable				
Transactional Distance→ Student–student Interaction	0.934	1	–	–
Transactional Distance→ Student–teacher Interaction	0.826	0.671	0.028	23.620***
Transactional Distance→ Student–content Interaction	0.622	0.354	0.019	18.488***
Transactional Distance→ Social Presence	0.215	0.558	0.094	5.930***
Transactional Distance→ Autonomous Motivation	0.221	0.292	0.048	6.046***
Social Presence → Autonomous Motivation	0.136	0.069	0.017	3.944***
Transactional Distance→ Learning Engagement	0.163	0.305	0.069	4.421***
Social Presence > Learning Engagement	0.088	0.064	0.025	2.563*
Autonomous Motivation → Learning Engagement	0.168	0.239	0.049	4.834***
Model 2: Student–Student Interaction as independent variable				
Student-Student Interaction→ Social Presence	0.200	0.484	0.082	5.875***
Student-Student Interaction→ Autonomous Motivation	0.204	0.252	0.042	5.979***
Social Presence → Autonomous Motivation	0.142	0.072	0.017	4.163***
Student-Student Interaction→ Learning Engagement	0.160	0.280	0.060	4.623***
Social Presence > Learning Engagement	0.091	0.066	0.025	2.651**
Autonomous Motivation → Learning Engagement	0.171	0.243	0.049	4.963***
Model 3: Student–Teacher Interaction as independent variable				
Student-Teacher Interaction→ Social Presence	0.209	0.665	0.108	6.139***
Student-Teacher Interaction→ Autonomous Motivation	0.191	0.310	0.056	5.558***
Social Presence → Autonomous Motivation	0.143	0.073	0.017	4.175***
Student-Teacher Interaction→ Learning Engagement	0.120	0.276	0.080	3.447***
Social Presence > Learning Engagement	0.096	0.069	0.025	2.782**
Autonomous Motivation → Learning Engagement	0.181	0.257	0.049	5.234***
Model 4: Student–Content Interaction as independent variable				
Student-Content Interaction→ Social Presence	0.061	0.278	0.158	1.763
Student-Content Interaction→ Autonomous Motivation	0.118	0.274	0.079	3.478***
Social Presence → Autonomous Motivation	0.176	0.090	0.017	5.173***
Student-Content Interaction→ Learning Engagement	0.059	0.195	0.111	1.753**
Social Presence > Learning Engagement	0.115	0.083	0.025	3.353***
Autonomous Motivation → Learning Engagement	0.197	0.279	0.049	5.712***

Note: ***p<0.001; **p<0.01; *p<0.05.

But in model 4, when student–content interaction is the independent variable, the 95%BootCI of path "Student–Content Interaction→Social Presence→Learning Engagement" (95% BootCI[−0.001, 0.066]) and "Student–Content Interaction→Social Presence→Autonomous Motivation→Learning Engagement" (95% BootCI[−0.002, 0.059])
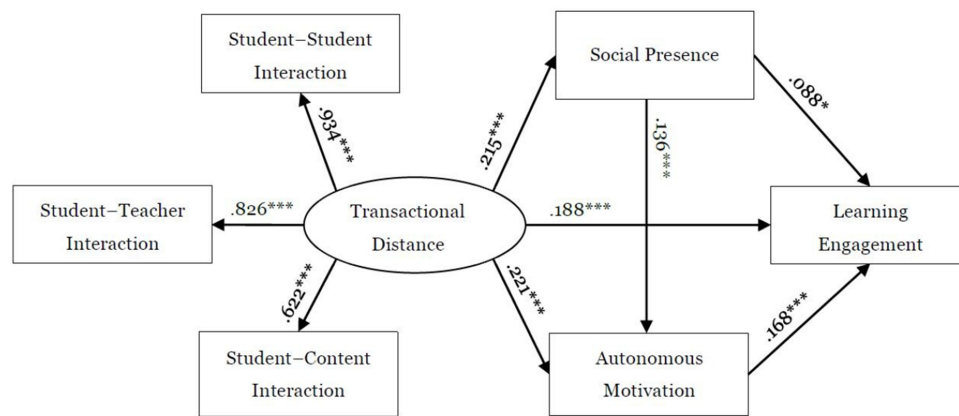
Figure 1 The structural equation model result of model 1(Transactional distance as independent variable).
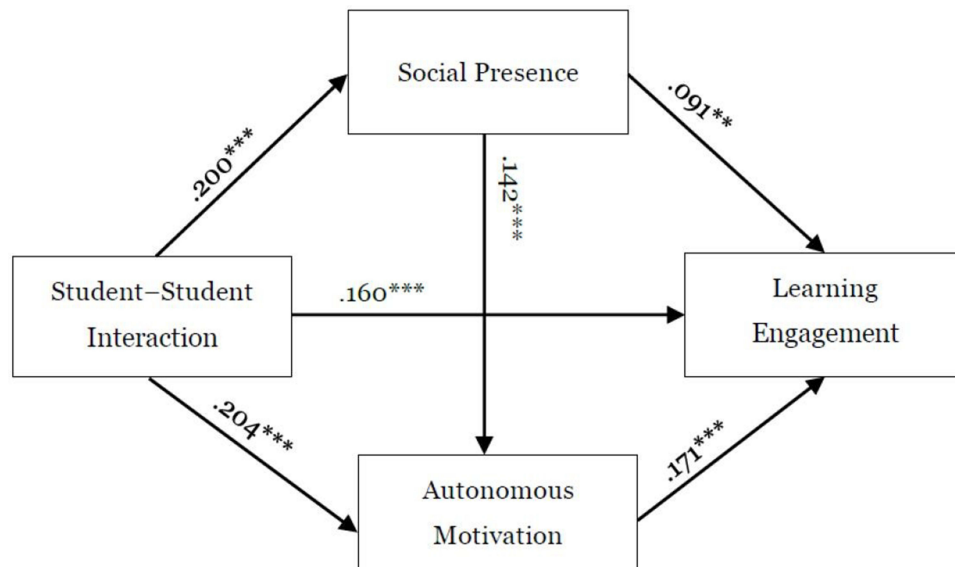**Note**: ***p<0.001; *p<0.05.

Figure 2 The structural equation model result of model 2(Student-student interaction as independent variable).
Note: ***p<0.001; **p<0.01.

including o. Thus, the mediating effect of social presence between student-content interaction to learning engagement and the chain mediating effect of social presence and autonomous motivation between student-content interaction and learning engagement were insignificant. In summary, H1c and H3c were supported, but H2c and H4c are not statistically supported.

Discussion

Online learning has become a valuable supplement to classroom instruction, especially during the COVID-19 pandemic, and online learning has become an essential way for college students to learn. Therefore, understanding the learning engagement of college students in online learning is crucial to their academic success and satisfaction. This study explored the mechanisms underlying transactional distance in online learning on college students' academic engagement based on transactional distance theory. The results of this study confirmed the close relationship between transactional
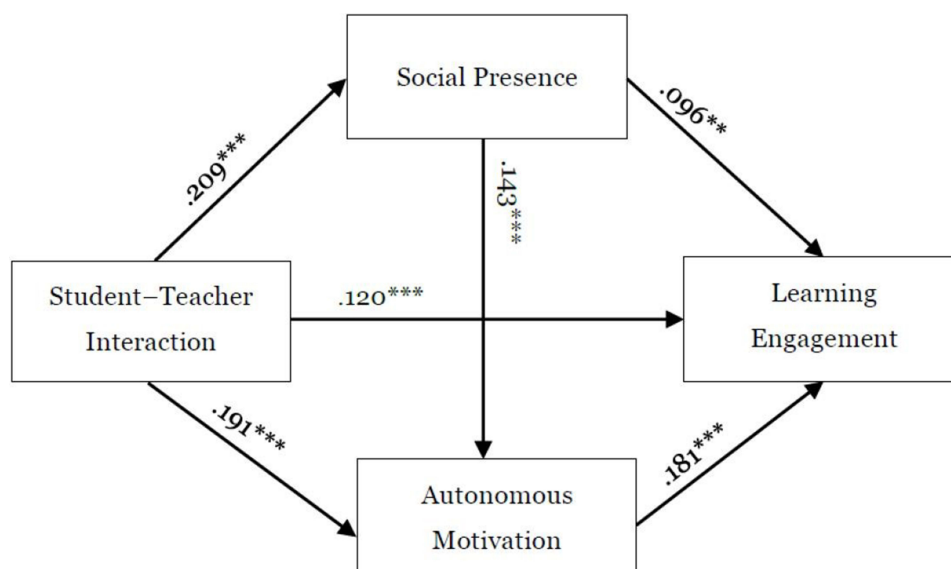
Figure 3 The structural equation model result of model 3(Student-teacher interaction as independent variable).
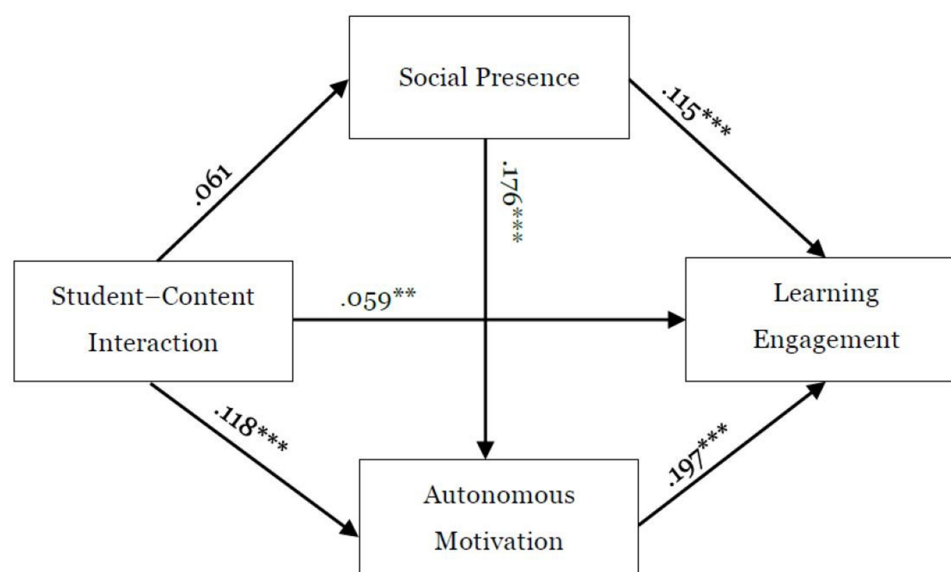**Note**: ***p<0.001; **p<0.01.

Figure 4 The structural equation model result of model 4(Student-content interaction as independent variable).
Note: ***p<0.001; **p<0.01.

distance and social presence, autonomous motivation, and college students' learning engagement. This study found that transactional distance strongly predicted college students' learning engagement, and all three interaction types positively predicted learning engagement. In addition, transactional distance indirectly influenced learning engagement through the social presence and autonomous motivation, and social presence positively influenced autonomous motivation. This study extends the literature on transactional distance perceptions from prior research, validates the finding that social presence positively predicts academic engagement, and supports the findings of additional online learning research frameworks and empirical studies. The results of this study also highlight the importance of transactional distance on the academic experience of college students in online learning environments. This result reminds us of the need for effective interventions to promote academic engagement and help college students succeed in the online learning environment.

Table 3 Testing Mediating Effect with Bootstrap

Path	Effect	Boot SE	95% BootLLCI	95% BootULCI
Model 1: Transactional Distance as independent variable				
Transactional Distance→Social Presence→Learning Engagement	0.036	0.016	0.008	0.073
Transactional Distance→Autonomous Motivation→Learning Engagement	0.070	0.020	0.036	0.116
Transactional Distance→Social Presence→Autonomous Motivation→Learning Engagement	0.041	0.013	0.021	0.077
Model 2: Student–Student Interaction as independent variable				
Student–Student Interaction→Social Presence→Learning Engagement	0.032	0.014	0.008	0.065
Student–Student Interaction→Autonomous Motivation→Learning Engagement	0.061	0.017	0.032	0.101
Student–Student Interaction→Social Presence→Autonomous Motivation→Learning Engagement	0.033	0.011	0.017	0.062
Model 3: Student–Teacher Interaction as independent variable				
Student–Teacher Interaction→Social Presence→Learning Engagement	0.046	0.019	0.013	0.091
Student–Teacher Interaction→Autonomous Motivation→Learning Engagement	0.080	0.023	0.042	0.132
Student–Teacher Interaction→Social Presence→Autonomous Motivation→Learning Engagement	0.047	0.017	0.021	0.092
Model 4: Student–Content Interaction as independent variable				
Student–Content Interaction→Social Presence→Learning Engagement	0.023	0.016	−0.001	0.066
Student–Content Interaction→Autonomous Motivation→Learning Engagement	0.076	0.027	0.032	0.140
Student–Content Interaction→Social Presence→Autonomous Motivation→Learning Engagement	0.015	0.014	−0.002	0.059

This study shown that transactional distance significantly predicted college students' learning engagement (H1 has supported), and all three interaction types positively predicted learning engagement, H1a, H1b, H1c had supported. The present study confirms previous research on the relationship between transactional distance and learning engagement in online learning.[68] For example, some scholars believe that learners can maintain a more positive attitude toward learning through a series of effective interactions throughout the online learning process.[69] Although the results of previous studies have reported inconsistent effects of multiple interaction modes of transactional distance on learning engagement,[15,16,18] however, this study confirmed all three types of transactional distance interactions (student-student interaction, student-teacher interaction, and student-content interaction) were found to directly and positively predict learning engagement. This result may be because student-teacher interaction is one of the most important modes of interaction in online learning. The instructor guides students in understanding the course topic but also encourages students to ask questions and participate in discussions; Learners receive feedback and encouragement from the instructor,[70,71] which in turn influences learners' self-perceived cognitive and affective learning and increases engagement in online learning.[72]

Among the CFA result, student-student interaction has the most important impact on students' learning engagement. Regarding student-student interaction, learners can engage in critical thinking and more constructive learning perspectives, enhance their interest and motivation in online learning, and engage in academic activities.[73] This mode of interaction allows students to engage directly in online learning to share ideas, knowledge, and resources. It plays a crucial role in understanding course requirements and the learning process.[7] Therefore, the results of this study are

consistent with previous studies that student-student interaction is the most valuable type of interaction in the online learning environment in this study.[73,74] In addition, student-teacher interaction has a greater impact on learners' learning engagement. It demonstrates the importance of the teacher in online learning. Without direct assistance of teacher in online learning, students may not be able to achieve better learning outcomes through in-learning or maintain meaningful multimodal communication. This also reflects the critical responsibility of teachers in online learning to stimulate and sustain students' interest and motivate them to learn.[73] Furthermore, the predictive effect of student-content interaction on learning engagement was confirmed in this study. This is consistent with McClure et al's findings that learning resources such as discussion forums, PowerPoint presentations, and videos in online learning provides more opportunities for students to engage with the resources, which is particularly effective in increasing interaction and reducing transactional distance.[75] It follows that by enhancing the perception of interaction, college students may achieve more effective learning and higher levels of the learning experience, which are strong predictors of college students learning engagement.[17]

The results regarding the relationship between transactional distance, social presence, and learning engagement partially validated previous research. Specifically, transactional distance indirectly influenced college students' engagement through social presence, H2 has supported. However, the results were slightly different for the three different interaction patterns. For example, the results of the Kuo's study showed that, student-teacher interaction, a source of learners' social presence and a significant predictor of learning engagement,[17] social presence had a direct predictive effect on learning engagement, H2a was effectively verified in this study. This suggests that this mode of interaction in the online learning courses explored in this study, in which the instructor encourages student participation through online discussions or group projects, promotes students' sense of social presence and positively affects their learning engagement.

In addition, high-quality student-student interactions have been shown to stimulate high levels of social presence in college students' online learning, making learners more willing to devote more time and effort to learning tasks,[76] H2b has supported. This result may be because student-student interaction can provide students with emotional support such as caring, closeness, safety, acceptance, and helpfulness.[77] Otherwise, according previous study, this collaborative learning environment promotes the development of trust and belonging relationships among students, who are more likely to perform well when participating in online courses.[73,78] However, student-content interaction has not been shown to predict students' learning engagement through a sense of social presence, a result we believe is of concern, H2c does not support. The study by Quong may explain this result, they suggests that instructors in online courses may play an essential role in the delivery of content as well as the quality of the course, determining the level of acceptance of the learning content and playing a key role in shaping learners' learning behaviors.[79] However, student-content interaction does not allow students to experience the human interaction connection in the learning process more fully as student-student interaction versus student-teacher interaction.

In addition, the results of this study found that transactional distance significantly predicted automatic motivation and was an indirect predictor of learning engagement among college students, H3 has supported, This is consistent with previous research findings. Specifically, good interactions in online courses can create a supportive learning environment for students and improve their chances of auto-motivation, promoting students' engagement in learning tasks. Thus, the perceived negative effect of transactional distance in the online environment may enhance the positive impact of autonomous motivation on learning engagement. This also validates the Self-determination theory that autonomous motivation is performed out of interest and is sustained by the spontaneous thoughts and feelings that emerge when you engage in online learning activities.[80] For example, student- teacher interaction in an online environment has a positive effect on developing students' interest in the course and motivating them to learn[81] (H3a has supported). It means that, individuals with high levels of autonomous motivation are more receptive to learning tasks, more likely to experience more positive emotions such as pleasure and accomplishment, and thus more willing to engage in online learning.[82,83] Likewise, the mediating effect of autonomous motivation in the relationship between student-student interaction and learning engagement has verified, H3b was supported. This also verifies the findings of Guay that student-student interaction stimulates the desire to explore knowledge, enhancing learners' autonomous motivation.[84] Importantly, student-student interaction satisfies students' relational needs and allows them to experience a supportive interpersonal climate, enhancing their autonomous motivation. In addition, the relationship between student-content interactions and

autonomous motivation and learning engagement was also validly confirmed, ie, H3c was supported. From this it is clear that during student-content interactions, when learners perceive the learning content as valuable, they have a greater autonomous motivation to learn, are more inclined to want to acquire knowledge and skills through online courses, and are more actively engaged in learning activities, this result also validates the study by Saeed.[56] In particular, during COVID-19, online learning is the main mode of learning for college students, and various effective interaction modes can enhance individual autonomous motivation and increase learners' learning engagement.[85]

Finally, this study confirms that Social presence and Autonomous motivation play a chain mediating role between Transactional distance and learning engagement (H4a and H4b were supported). Precisely, student-teacher interaction in online courses, student-student interaction satisfies learners' perception of social presence in the learning process and stimulates learners' autonomous motivation, which in turn has a facilitating effect on learning engagement.[86] This finding may be explained by the fact that teachers enhance students' sense of community by participating in and leading online discussions and group projects, increasing learners' sense of social presence.[43] Student-student interactions make learners feel more welcome, safe, and autonomous and internalize this perception into their experience, demonstrating greater learning engagement.[6,87] This also validates the social presence theory, which states that establishing social relationships between individuals in an online learning environment plays a key role in learning engagement.[36] For example, teachers enhance students' sense of community by participating in and leading online discussions, which enhances learners' sense of social presence,[43] resulting in higher levels of learning satisfaction and academic engagement. Interactions among students stimulate reflection on cognitive patterns and improve social cohesion and motivation for continued online learning.[88] Furthermore, the chain mediating relationship between social presence and autonomous motivation in student-content interactions was not verified, H4c has not supported. That is, student-content interactions did not improve student learning engagement by the path of increasing college students' sense of social presence, leading to higher autonomous motivation.

Limitations and Implications

Although the relationship between transactional distance and learning engagement in online learning has been explored, several significant limitations remain. First, the cross-sectional design failed to show a longitudinal effect of transactional distance on learning engagement outcomes. Further research should use a longitudinal or experimental design to test the causal hypothesis. Second, all variables were self-reported by students, which may have strengthened or weakened the actual relationships between the variables. Although students' self-reported outcomes are essential or their subjective experiences, future studies must also collect teacher-reported transactional distance perceptions from replicating results. Furthermore, the results of this study confirm the relationship between student-content interaction and social presence as well as learning engagement. However, we did not focus on the effectiveness of specific learning resource design and production, instructional strategies, audio messages, and digital media. Moreover, how learners process learning materials/content can make a difference in the study results. Therefore, further validation of learning resource design and production based on learner-content interaction studies is needed. Finally, although we collected samples from multiple universities, the data were geographically limited, with all participants coming from universities in southwestern China, and our sample still limits the ability to generalize the results of this study to all university students. Future studies will require a broader and more representative sample.

Conclusion

We developed a research framework based on transactional distance theory to explore the mechanisms underlying the effect of transactional distance on learning engagement among college students studying online during the COVID-19 pandemic. The results showed that transactional distance (including the three interaction modes) was significantly and positively related to college students' learning engagement. Autonomous motivation played a chain mediating role between transactional distance and learning engagement. In addition, social presence and autonomous motivation mediated the chain between student-student and student-teacher interaction on learning engagement. Overall, this study supports the findings of additional online learning research frameworks and empirical studies to enhance our

understanding of how online learning affects college students' learning engagement during the COVID-19 pandemic and the importance of online learning in college student's academic development.

Ethical Statement and Informed Consent

The study was approved by the Academic Ethics Committee of School of Marxism, Chongqing College of Finance and Economics. Participants were informed that their responses to the task would be anonymous and confidential.

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Disclosure

The author reports no conflicts of interest in this work.

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