Article
Does the Seat Matter? The Influence of Seating Factors and Motivational Factors on Situational Engagement and Satisfaction in the Smart Classroom

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Abstract: As a technology-enhanced student-centered learning environment, smart classrooms are becoming increasingly popular in higher education. It is undoubtedly important to understand how seating and motivational factors affect situational engagement and satisfaction in smart classrooms. Pre-survey, experience sampling method, and post-survey were used in this study to conduct a longitudinal survey of 113 pre-service teachers in three courses at a university in central China. Descriptive statistics, bivariate correlations, hierarchical linear modeling, and hierarchical linear regression were used to investigate the effects of seating factors and motivational factors on engagement and satisfaction in smart classrooms. We found: (1) for the seating factor, the distance of the seat from the center point predicted student situational engagement in the smart classroom; (2) for motivational factors, needs of competence and competence during the activity predicted student situational engagement, while autonomous motivation at the beginning of a course strongly predicted student situational engagement in subsequent activities; and (3) of all the factors, situational engagement was a significant predictor of students' final course satisfaction and fully mediated the relationship between autonomous motivation and satisfaction. Finally, some practice implications are discussed to improve engagement and satisfaction in technology-enhanced environments.

Keywords: smart classroom; situational engagement; student satisfaction; experience sampling method; seating factors; self-determination theory; flow theory

1. Introduction

A smart classroom (or active learning classroom) is a typical technology-enhanced face-to-face environment that combines students’ active learning process with advanced tools of educational technology to support a personalized learning experience [1]. This environment is a possible approach to education for sustainable development [2]. Smart classrooms integrate advanced forms of educational technology, such as multiple touch-screen televisions, student-centered interactive whiteboards, student mobile terminals, and so on, to increase student engagement in formal educational environments [3], better present the content and social interactions, and optimize the learning experience [4]. In this environment, constructivist epistemology is used as a foundation, and multiple forms of collaborative group learning are conducted to support the proactive construction of meaning in the learning process [3]. Moveable tables and chairs are used to support student-centered active learning [5]. More empirical exploration is needed to explore the impact of smart classrooms on the process of achieving education for sustainable development [2]. While seating factors have an effect on student engagement and performance in traditional
lecture environments with fixed seating arrangements [6], it is worth exploring whether the smart classroom, a technology-enhanced student-centered environment, still affects student engagement and performance. However, the research literature has paid little attention to how student seating in smart classrooms affects student engagement.

Student engagement is recognized as an important aspect of the learning process and is linked to positive learning outcomes (learning satisfaction, grades, and achievement) [7,8]. Student engagement can be conceptualized as overall engagement and situational engagement [9,10], with the former having been extensively studied [11]. In technology-enhanced learning environments, the exploration of situational engagement contributes to the understanding of how learning occurs at the micro-level and how between-individual and within-individual factors explain situational engagement [12]. Therefore, it is valuable to understand the influencing factors and effects of situational engagement in smart classrooms to facilitate the effective use of smart classrooms.

According to self-determination theory, situational engagement is driven by motivation [12,13]. Meanwhile, situational engagement is also influenced by the environment (e.g., seating factors [6]). Although many studies on engagement have argued that a situational perspective (person-in-context) should be adopted [14], most studies of motivation and the effect of seating on engagement have used cross-sectional studies rather than a situational and longitudinal approach. Capturing situational engagement and experiences longitudinally requires a specific situational approach [15]. The experience sampling method (ESM) is a longitudinal data sampling method that captures individuals’ subjective experiences multiple times in natural, spontaneous contexts [16]. Compared with traditional self-reports, ESM is closer to the real situation in which the event occurred, thus reducing recall bias and social expectations [15,17]. Therefore, to fill this gap in the literature, this study used ESM to explore the effects of seating factors and motivational factors on situational engagement and satisfaction. The contribution of this study lies in the impact and effect of student situational engagement fluctuations in smart classrooms, which helps to promote an understanding of the nature of the learning experience in technology-supported learning environments and provides theoretical guidance for optimizing the learning experience.

2. Literature Review

2.1. Situational Engagement and Satisfaction in the Smart Classroom

2.1.1. Activity Level: Situational Engagement

Student engagement refers to “the energy and effort that students employ within their learning community” [18]. Recently, this term has been suggested to operate on two levels: overall and situational engagement [9,10]. Overall engagement is often referred to as the cumulative or average student engagement at the institution or course level [10]. Situational engagement, also known as momentary engagement [19], is situated at the activity level and is associated with specific activities or tasks [20], which is regarded as a personal state [21,22].

Many previous studies used Csikszentmihalyi’s flow theory to conceptualize situational engagement [20,23,24]. Based on the flow theory, situational engagement was defined in our study as a highly synchronized experience of concentration, interest, and enjoyment [25]. The experience of concentration is described as the state of being highly focused or absorbed in an activity. Interest in the activity is intrinsic and engaged with curiosity and is the basis of the flow experience, which helps with moving toward more complex tasks [26]. Enjoyment is the pleasant and satisfying experience in an activity, providing students with a sense of creative fulfillment and satisfaction [26]. Within learning activities in the smart classroom, these three components are not only central to optimal learning moments but are also related to meaningful learning [24,26].

2.1.2. Course Level: Situational Engagement

Student satisfaction and its potential determinants have been widely examined. Student satisfaction refers to students’ perceptions of the learning experience or course and
the perceived value of the education received at the educational institution [27]. Several studies indicated that student satisfaction is a critical factor in students’ decision to continue their learning of the course and is an important predictor of academic performance [28,29]. Student satisfaction not only is an indicator of the learning experience [30] but also an important measure of learning outcomes in technology-enhanced environments [29]. Although course grades are a more objective learning outcome variable, inconsistent assessment or testing criteria may be used when multiple instructors or courses are involved. In contrast to course scores, student satisfaction is a valid and direct measure of learning across courses. In our study, student satisfaction with the specific course in the smart classroom, as a learning outcome, was focused on at the end of the smart classroom course.

2.2. Influencing Factors of Situational Engagement and Student Satisfaction

2.2.1. Seating Factors

The seating factor refers not only to where one sits (i.e., actual seat) but also involves a preference for where one prefers to sit (i.e., preferred seat), which may reflect underlying personal traits, and there is a relationship between preferred seat and academic performance [31].

A large number of previous studies have concluded that seating factors have an impact on student engagement, attention, participation, and performance [32]. These studies have focused on seating characteristics such as distance from podium, distance from the screen, and interaction areas.

First, the effect of distance from the podium/board was explored. Seats in the front row had a significant positive effect on student engagement and performance [6,33,34], that is, there appears to be some inverse relationship between student engagement (or performance) and distance from the front row. For example, Shernoff et al. found that students sitting in the back of the classroom were less engaged, less attentive, and had a lower quality of learning experience compared to those in the front or middle rows [6].

Second, the effect of distance from the screen was explored. Joshi et al. analyzed the effect of multimedia and seating factors on student engagement and found that students sitting near the multimedia screen paid more attention and performed better than those sitting in the middle [35].

Third, interaction zones were explored in the classroom [36,37]. Prior research has shown that students in high interaction zones have high interaction rates and have a positive impact on student engagement [36]. These zones are located in the “front” and “center” of the classroom and present an equilateral triangle [38], and seats in high interaction zones are generally more visible to facilitate interaction with the teacher and peers.

However, these studies mainly focused on traditional lecture-based classrooms, multimedia classrooms, experiment teaching centers, etc., rather than technology-enhanced student-centered learning environments. Whether the seat effect still exists in smart classrooms is unknown; thus, it is worthwhile to explore the impact of comprehensive seating factors.

Building on existing literature, we explored the extent to which students’ actual seat (distance from podium, distance from screen, and distance from center of interaction) and preferred seat (distance from podium, distance from screen, and distance from center of interaction) in a smart classroom predicted their situational engagement and course-level satisfaction.

2.2.2. Motivational Factors

Self-determination theory (SDT) provides a theoretical perspective for motivation that is popular in education and has strong implications for classroom practice [39,40]. The theory suggests that all individuals possess three basic psychological needs that drive their behavior and engagement [39,40]. First, autonomy refers to the need to engage in self-chosen activities, and it has been the most investigated and important influencing factor to self-determined motivation and engagement [41]; second, competence refers to
the need to achieve effectively and feel competent; and third, relatedness refers to the need to connect with others. According to SDT, instructors can motivate and engage students by meeting these needs, potentially improving learning outcomes [42].

In SDT, motivation is viewed as a continuum containing different behavioral self-determinations. Within this continuum, motivation is differentiated from less to more: amotivation, controlled motivation, and autonomous motivation. Controlled motivation is regulated by external and introjected motives, while autonomous motivation is managed by intrinsic, identified, and integrated regulations [43].

The extant literature documents that motivational factors are closely related to engagement and outcomes. Research has shown that positive learning processes and outcomes (e.g., interest, enjoyment, higher course performance, and satisfaction) occurred when these psychological needs were met [41,44]. For example, research demonstrated a direct relationship between students’ psychological needs and engagement in both K–12 and college contexts [45–48]. Mason found that psychological needs (i.e., autonomy and relatedness) were significantly and positively correlated with graduate student course satisfaction [49]. Leyton Roman et al. found that autonomy, competence, and relatedness had a direct positive correlation with course satisfaction [50].

In addition, research has shown that course-level motivation can be considered a key factor contributing to individual differences in engagement and satisfaction [50,51]. For example, one study on smart classrooms found that autonomous and controlled motivation had a significant impact on behavioral and cognitive engagement [12]. Another study found that there is a strong relationship between autonomous motivation and course satisfaction [50].

Building on the existing literature, we investigated the extent to which motivational factors (three psychological needs, controlled motivation, and autonomous motivation) predict contextual engagement and student satisfaction in smart classrooms.

2.2.3. Situational Engagement and Student Satisfaction

Numerous prior studies have indicated that student engagement has a significant influence on student satisfaction in technology-mediated learning environments [52]. Through structural equation modeling, Murillo-Zamorano et al. found that student engagement predicted their satisfaction with the flipped classroom [53]. Using a larger sample size than previously, Roque-Hernández et al. found that student engagement positively predicted their satisfaction in online courses during COVID-19 in Mexico [52]. El-Sayad et al., through structural equation modeling, found that Egyptian undergraduate students’ satisfaction with online learning during the epidemic was significantly influenced by behavioral and affective engagement [54]. Based on a cross-sectional study, Pandita and Kiran found that student engagement mediated the relationship between the technology interface and student satisfaction [55]. However, these studies agreed that longitudinal studies are needed in the future, which will provide further evidence to strengthen the relationship between student engagement and satisfaction [54,55]. We conducted a longitudinal study to fill a gap in the literature by exploring the relationship between students’ situational engagement in specific activities in the smart classroom and end-of-course satisfaction.

3. The Present Study

This study aimed to hierarchically investigate the effects of seating and motivational factors on situational engagement and satisfaction in a smart classroom environment. By integrating SDT and flow theory, we also incorporated seating factors and course satisfaction and then proposed a conceptual model (Figure 1), which helps conceptualize and apply classical theories. We specifically investigated the effects of seating factors (i.e., preferred seat and actual seat) and motivational factors (autonomous motivation, controlled motivation, and psychological needs) on situational engagement and course satisfaction. The seating factors in this study include students’ “preferred seat” and “actual seat”. The former was obtained on the pre-test and was a between-individual factor, while the latter
was the seats students sat in during each session and was a within-individual predictor. Motivational factors include academic motivation and psychological needs. Academic motivation is the student’s value appraisal of the reason for learning at the beginning of the course and is a between-individual predictor, while psychological needs are the degree to which the student’s basic needs are met in a specific learning activity and are within-individual predictors. Situational engagement and student satisfaction are both outcome variables. Situational engagement refers to the student’s flow experience during the activity and is a within-individual factor that may be influenced by seating and motivational factors. Student satisfaction refers to students’ satisfaction with the course at the end of the course and is a between-individual factor that may be influenced by seating factors, motivational factors, and situational engagement. Situational engagement, actual seat, and psychological needs fluctuate across situations and are located at the intra-individual level, whereas individual preferred seat, academic motivation, and course satisfaction are relatively stable and located at the inter-individual level. In addition, the dashed arrows in the model are associations of the control variable with the outcome variables.

Figure 1. Multilevel model for situational engagement and satisfaction.

According to the model, we examined the impact of seating factors and motivational factors on situational engagement and satisfaction in the smart classroom using the following research questions (RQ):

**RQ1:** How do seating factors (preferred seat and actual seat) and motivational factors (autonomous motivation, controlled motivation, and psychological needs) predict situational engagement in a smart classroom?

**RQ2:** How do seating factors, motivational factors, and situational engagement predict subsequent course satisfaction in smart classrooms?

### 4. Materials and Methods

#### 4.1. Participants

The sample was recruited from Central China Normal University, a research-based university located in central China. In recent years, this university has focused on the construction, use, and research of smart classrooms. The talent training system in this school was reconstructed by creating an active learning environment, and the transformation of undergraduate education won the special prize of the 2018 Higher Education National Teaching Achievement Award [56]. As of April 2019, more than 60 smart classrooms
have been built to realize the implementation of functions such as rich media content presentation, instant teacher–student interaction, and adaptive teaching services [57].

The valid sample consisted of 113 pre-service teachers, 77 female and 36 male, aged 17 to 23 years, with a mean age of 19.02 years; standard deviation: 1.028. They were recruited from three courses, and teachers in each course presented the content on multi-screens. Group collaborative learning is the main form in classrooms, and the classes involved activities such as group discussion, group reports, etc. Three courses have two sessions per week, and the two sessions total 90 min. These two sessions per week are connected with a 15 min break in between. Each course was delivered over the 18-week semester. Data collection occurred during the interval between sessions and did not interfere with the normal smart classroom teaching process.

4.2. Procedures
4.2.1. Pre-Survey and Post-Survey

During the first week of the spring 2020 semester, participants took a pre-survey to obtain their demographic information, self-efficacy, preferred seat, and course-level motivation. During the last week of the semester, a post-survey was administered to participants to measure their satisfaction with the course.

4.2.2. Experience Sampling Method

Many previous studies have used the experience sampling method to measure students’ situational engagement (e.g., [10,15]). Random sampling, fixed sampling, and event-based sampling are common sampling approaches [15]. Fixed sampling was used in our study. To minimize the level of disruption to participants, short messages with a link to the experience sampling form were sent to half of the students each week at the exact time of the first session’s completion, and text messages were sent to the other half of the class in the following week. During the interval between sessions, the research assistant prompted participants to complete the ESM survey to capture their actual seat, psychological needs, and situational engagement at that time.

The data collection process is shown in Figure 2. Overall, 531 responses were obtained from 113 students with a sampling response rate of 63.21%, and most of the reasons for not filling out the form were absences, with an average response of 1–7 responses per student (M = 4.69 responses).

![Time Line of Experiment](image)

**Figure 2.** Data collection procedure.

4.3. Measures

Except for demographic information in the pre-survey, all items were rated on a six-point Likert scale.
4.3.1. Self-Efficacy

Self-efficacy in the pre-survey was adapted from the self-efficacy scale [58], and it included 6 items. The tool has been shown to have good reliability (α = 0.856), with a consistent confirmatory factor structure (χ² = 10.465, χ²/df = 1.495; CFI = 0.987; GFI = 0.967; TLI = 0.972; RMSEA = 0.069).

4.3.2. Academic Motivation

The survey of academic motivation in the pre-survey was adapted from the 16-item Academic Self-Regulation Scale [59]. This scale assesses students’ reasons for taking specific courses and includes external regulation, introjected regulation, identified regulation, and intrinsic motivation. A sample item for introjected regulation is “I’m studying this course because I would feel guilty if I didn’t study”. A sample item for identified regulation is “I’m studying this course because it is personally important to me”. A sample item for intrinsic motivation is “I’m studying this course because I am highly interested in doing this”. The first two were aggregated as controlled motivation, while the last two were aggregated as autonomous motivation [12], with a consistent confirmatory factor structure (χ² = 118.064, χ²/df = 1.617; CFI = 0.939; GFI = 0.854; TLI = 0.924; RMSEA = 0.077). Internal consistency was adequate (α = 0.803 for total items; α = 0.874 for autonomous motivation; and α = 0.801 for controlled motivation).

4.3.3. Seating Factors

The survey of smart classroom seating preference in the pre-survey was adapted from the previous study [60]. Students mark the seat they want to sit in most in the smart classroom layout, as shown in Figure 1 [61]. In the follow-up sessions, we recorded students’ actual seating in the smart classroom through video recording.

4.3.4. Situational Engagement

When collecting empirical sampling data, short scales (1–3 items per dimension) are usually acceptable due to multiple repetitions of measurements, and the reliability of short scales has been validated [62,63].

The situational engagement measure was adapted from previous ESM research and has been utilized and validated in several studies [6,26,64,65]. Based on flow theory, situational engagement was a composite of three items (α = 0.859): enjoyment (“In the learning activity just now, did you enjoy what you were doing?”), concentration (“In the learning activity just now, how hard were you concentrating?”), and interest (“In the learning activity just now, was it interesting?”).

4.3.5. Psychological Needs

The survey of psychological needs was adapted from self-determination variables in the study of Park et al. [66]. Autonomy, competence, and relatedness were each measured with a single item (α = 0.753). According to the SDT, an individual’s need for autonomy is most likely to emerge when students have the choice and are relatively free from external control; thus, choice is an indicator of autonomy. Autonomy was measured using the item “In the learning activity just now, how much choice did you have?” As one’s understanding of learning activities is a key indicator of competence, competence was measured using the item “In the learning activity just now, how much did you understand what was going on?” Students feel relatedness in situations where a caring and supportive environment can be created by teachers or peers. Relatedness was measured using the item “In the learning activity just now, how satisfied were you with the support teachers or peers were giving you?”

4.3.6. Student Satisfaction

The measurement of student satisfaction in the post-survey was adapted from the survey of perceived e-learner satisfaction [67]. It included 9 items, and a sample statement was
“I was very satisfied with the course”. The tool showed a confirmatory factor structure with one factor ($\chi^2 = 34.592$, $\chi^2/df = 1.384$; CFI = 0.984; GFI = 0.925; TLI = 0.978; RMSEA = 0.063; and $\alpha = 0.920$).

4.4. Data Analytical Procedure

SPSS 23.0 and Mplus 7.4 were used to analyze the questionnaire data.

4.4.1. Preprocessing and Preliminary Analyses

First, pre-survey, experience sampling method, and post-survey data were associated together based on user ID.

Secondly, “preferred seat” and “actual seat” were coded separately. The upper left corner of the classroom is used as the origin (math.) in the plane figure, with the direction of the two screens on the left as the Y-axis and the direction of the two screens in front as the X-axis. Computer-aided design software (AutoCAD 2010) was used to create a plane coordinate system to obtain the coordinates of each seat. Preferred and actual seats were coded to four new variables, i.e., X coordinate (Pseat X, Seat X), Y coordinate (Pseat Y, Seat Y), distance from the interaction center (Pseat C, Seat C), and distance from the screen (Pseat SCR, Seat SCR), which were normalized. The X coordinate reflects the distance from the window/door, while the Y coordinate reflects the proximity to the podium.

In previous studies, we have found that #11 is the most popular seat, so #11 is considered the center of interaction in the classroom [61]. In our study, the Euclidean distance, defined as the distance $d_s$ from seat #11, was used to calculate the distance from the center point. Therefore, the formula is as follows:

$$d_s = \sqrt{(x_a - x_{11})^2 + (y_a - y_{11})^2}$$

(1)

In Equation (1), $x_a, y_a$ denote the coordinates of the seat where student $S_a$ is seated, while $x_{11}, y_{11}$ denote the coordinates of seat 11.

After coding, variables were analyzed for missing data patterns. According to Little’s MCAR test, ($\chi^2 (8) = 12.617$, $p = 0.126$, for pre-survey; $\chi^2 (4) = 8.044$, $p = 0.090$, for experience sampling survey; $\chi^2 (1) = 3.322$, $p = 0.068$, for post-survey), and data were missing completely at random (MCAR). To deal with missing data, we used mean filling on SPSS 23.0, and $t$-tests were conducted to test for statistical differences between the filled variables and the original missing data. We found no statistical differences in means or variances.

All variables for outliers, normality, skewness, kurtosis, and reliability of measurements were examined. Then, we conducted descriptive statistics and Pearson correlation.

4.4.2. Hierarchical Linear Modeling Procedure

The ESM design produces two levels of nested data with repeated responses nested within individual students [66]. Hierarchical linear modeling (HLM) has been used to account for this non-independence between responses within students [68]. The null model, random coefficient model, intercepts-as-outcomes model, and full model are required in HLM analysis [69]. The null model, which includes no independent variables, is the first step of the HLM analysis. The intraclass correlation (ICC) is calculated in this model to judge the necessity of constructing HLM. Subsequent HLM analysis is acceptable only if the value of ICC is greater than 0.059 [70]. After the null model analysis, there is a random coefficient model (Model 1). Variables in level 1 including Seat X, Seat Y, Seat C, Seat SCR, autonomy, competence, and relatedness were added to level 1 after group mean centering. There was no independent variable in level 2. Next, the intercepts-as-outcomes model (Model 2) was conducted to examine the effects of controlled motivation, autonomous motivation, Pseat X, Pseat Y, Pseat C, and Pseat SCR on the situational engagement, and the grand mean centering of these variables was added to level 2. Finally, the full model (Model 3) is conducted to examine the effects of between-individual and within-individual variables on the dependent variable in level 1. Models 1 to 3 were analyzed stepwise in
Mplus 7.4. Although we also analyzed cross-level interactions, these interaction effects were not significant. The Akaike information criterion and Bayes information criterion were used to compare different models. The model fits better when the values of these indicators are lower [71].

4.4.3. Hierarchical Linear Regression Procedure
To answer our second research question, we constructed a prediction model using hierarchical linear regression. Since student satisfaction is located at the between-individual level, we converted the unit of the empirical sampling variable from the within-individual level to the between-individual level through an aggregated analysis. Models 4 and 5 were constructed sequentially. We added pre-test variables (i.e., gender, self-efficacy, autonomous motivation, controlled motivation, preferred seat factors) to Model 4.

In Model 5, we constructed a holistic framework to examine how the pre-survey variables and the experience sampling variables (i.e., actual seat factors, autonomy, competence, relatedness, situational engagement) work together to predict end-of-course student satisfaction.

5. Results
5.1. Preliminary Analyses
Firstly, we present the overall seat distribution of the students’ preferred and actual seats in the form of a heat map: the darker the color, the more frequent this seat is. As shown in Figure 3a, number 11 is the most popular seat; therefore, this seat is considered as the center of the smart classroom. However, the seats facing the back in desks ABCD (i.e., #2, #8, #14, #20), and #37 and #41 in desk G, were hardly preferred.

![Figure 3a: Preferred seating distribution](image1)

![Figure 3b: Actual seating distribution](image2)

Figure 3. Overall seating distribution of students in the smart classroom: (a) preferred seating distribution; (b) actual seating distribution.

As shown in Figure 3b, the distribution of actual and preferred seats shows some differences. The seat that students sat in the most was seat 28, and the seats facing the back (e.g., #20, #25, #26, #31, and #32) had relatively fewer students sitting in them. Although #41 was not preferred, a relatively large number of students sat in this seat.

As shown in Table 1, descriptive statistics and correlation analysis involved variables in the pre-survey, experience sampling, and post-survey. At the between-individual level, students’ autonomous motivation (M = 4.61; SD = 0.65) was higher, while students’ controlled motivation (M = 3.66; SD = 0.88) was lower and more fluctuating. Student satisfaction with the course (M = 4.89; SD = 0.68) was higher and more stable. At the within-individual level, students’ three basic needs and situational engagement were higher, along with higher volatility (M = 4.40–4.56; SD = 0.87–1.05). Compared to boys, although girls have lower...
self-efficacy and competence in activities, they have higher autonomous motivation and prefer to sit in the front row and closer to the center point. Distances from the podium in the X-axis and screen preference were positively and significantly correlated with satisfaction, while distances from the podium in the Y-axis and center preference were negatively and significantly correlated with situational engagement and satisfaction. In addition, distances from the podium in the X-axis and center were negatively and significantly correlated with situational engagement only. Autonomous motivation, psychological needs, situational engagement, and satisfaction were all significantly correlated ($r = 0.241–0.543; p < 0.01$), while controlled motivation was significantly correlated with situational engagement ($r = 0.119; p < 0.01$).

5.2. Hierarchical Linear Modeling Results

To examine between- and within-individual variation in situational engagement using ICCs, we first estimated the null model in which situational engagement is the dependent variable and there is no independent variable. The ICC for situational engagement in the null model was 0.518, indicating that 51.8% of the variation in situational engagement was due to inter-individual characteristics. Thus, these results suggest that students’ situational engagement varied by nearly half between activities and by more than half between individuals. Furthermore, these results suggest that HLM is appropriate for this study [72].

To address RQ1, the two-level HLM analysis results for situational engagement are presented in Table 2. This study used a series of models to examine the effects of seating factors and motivational factors on situational engagement. Model 1, Model 2, and Model 3 represent the random coefficient model, the intercepts-as-outcomes model, and the full model, respectively.

As shown in Model 3 in Table 2, distance from the center ($\beta = -0.081, p < 0.05$) predicted situational engagement after controlling for other variables. For psychological needs, competence ($\beta = 0.210, p < 0.001$) and relatedness ($\beta = 0.190, p < 0.001$) had a significant positive beta for situational engagement except for autonomy ($\beta = 0.105, p > 0.05$). Among the between-individual level variables, autonomous motivation ($\beta = 0.394, p < 0.001$) positively predicted situational engagement, whereas controlled motivation had no significant effect on situational engagement.
Table 1. Descriptive statistics and bivariate correlations.

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<td>0.310 **</td>
<td>0.089 *</td>
<td>0.131 **</td>
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<td>0.00</td>
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<td>2.05</td>
<td>3.07</td>
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<td>−1.73</td>
<td>−1.76</td>
<td>−1.76</td>
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Note. * p < 0.05, ** p < 0.01.
Table 2. Hierarchical linear modeling analysis for situational engagement (n = 531).

<table>
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<tr>
<th>Fixed Effect</th>
<th>Model 1</th>
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<th>Model 2</th>
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<th>Model 3</th>
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<td>SE</td>
<td>B</td>
<td>SE</td>
<td>B</td>
<td>SE</td>
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<tr>
<td>Intercept</td>
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<td>0.248</td>
<td>1.751 **</td>
<td>0.832</td>
<td>0.555</td>
<td>0.555</td>
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<td>Within-individual level</td>
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</tr>
<tr>
<td>Seat X</td>
<td>−0.042</td>
<td>0.034</td>
<td></td>
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<td>0.036</td>
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<tr>
<td>Seat Y</td>
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<td></td>
<td></td>
<td>−0.011</td>
<td>0.041</td>
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<tr>
<td>Seat C</td>
<td>−0.082 *</td>
<td>0.042</td>
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<td>−0.081 *</td>
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<td>Autonomy</td>
<td>0.106 **</td>
<td>0.037</td>
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<td>0.210 ***</td>
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<td>0.042</td>
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<td>0.190 ***</td>
<td>0.056</td>
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<td>Gender</td>
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<td>−0.103</td>
<td>0.124</td>
<td>−0.145</td>
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<tr>
<td>Self-efficacy</td>
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<td>0.083</td>
<td>0.097</td>
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<tr>
<td>Autonomous motivation</td>
<td></td>
<td></td>
<td>0.516 ***</td>
<td>0.093</td>
<td>0.394 ***</td>
<td>0.155</td>
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<tr>
<td>Controlled motivation</td>
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<td>−0.027</td>
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<tr>
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<td>0.004</td>
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<tr>
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<td>−0.032</td>
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<td>Pseat SCR</td>
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<tr>
<td>Random effect (residual variance)</td>
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<td>0.235 ***</td>
<td>0.041</td>
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<td>Residual (σ²)</td>
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Note. Statistics are unstandardized coefficients. *p < 0.05. **p < 0.01. ***p < 0.001.

5.3. Hierarchical Linear Regression Results

We built two hierarchical linear regression models (Models 4 and 5) to examine the unique and combined effects of between-individual factors (i.e., gender, self-efficacy, autonomous motivation, controlled motivation, and preferred seat factors) and activity-level factors (actual seat factors, autonomy, competence, relatedness, and situational engagement) on student satisfaction at the end of the course (see Table 3). Scores of variable inflation factors (VIFs) below five indicate that there are no strong collinearity issues between these independent variables.

The results of Model 4 showed that individual differences in gender, self-efficacy, autonomous motivation, controlled motivation, and preferred seat factors accounted for 0.236 in student satisfaction, with self-efficacy (β = 0.173, p < 0.05) and autonomous motivation (β = 0.296, p < 0.01) being two significant predictors.

Adding the experience sampling variables to Model 5, we observed 16.2% more variance in course satisfaction (ΔR² = 0.162, p < 0.001), holding the Model 4 variable constant. The results suggest that learners’ activity-level situational engagement plays a significant role in student satisfaction in smart classrooms. Specifically, we only found that the situational engagement experienced by students at the activity level positively predicted their satisfaction (β = −0.262, p < 0.001), and self-efficacy and autonomous motivation were not significant anymore. The R² and adjusted R² of Model 5 were 0.398 and 0.297, respectively.

The bootstrapping method was used to test the mediation effect. The total effect of autonomous motivation on student satisfaction was significant (β = 0.376 ***), the direct effect was not significant (β = 0.149), and the indirect effect was significant (β = 0.228 ***), with confidence intervals of [0.2215, 0.5311], [−0.0155, 0.3131], and [0.1149, 0.3639], respectively. The direct effect’s 95% confidence interval contains 0, indicating that situational...
engagement fully mediated the relationship between autonomous motivation and course satisfaction.

Table 3. Hierarchical linear regression analysis for student satisfaction (n = 113).

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<td>SE</td>
<td>VIF</td>
<td>B</td>
<td>SE</td>
<td>VIF</td>
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<td>0.086</td>
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<td>1.831</td>
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<td>1.402</td>
<td>0.105</td>
<td>0.101</td>
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</tbody>
</table>

R² (Adjusted R²) | 0.236 (0.177) | 0.398 (0.297) | 0.190*** | 0.3639, 0.2357 | 0.3639, 0.2357 |

ΔR² | – | 0.162 (M5 vs. M4) | 0.162 (M5 vs. M4) |

AIC | −130.904 | −144.791 | 0.394*** |

BIC | −106.358 | −593.355 | 0.210*** |

*p < 0.05. **p < 0.01. ***p < 0.001.

The final significant paths in HLM and hierarchical linear regression analyses models are shown in Figure 4.

![Figure 4. Diagram of paths in Models 3 and 5; * p < 0.05. ** p < 0.01. *** p < 0.001.](image)

6. Discussion

Unlike cross-sectional studies, this study used a longitudinal research approach to measure seating factors, motivational factors, situational engagement, and satisfaction in the smart classroom. The ESM was used to capture actual location, psychological needs,
and situational engagement at the activity level, and these variables were variable within individuals. This in situ data collection method allows for a more accurate investigation of the nature of the impact of the learning experience in a smart classroom. HLM and hierarchical linear regression analyses were employed to explore the impact of seating factors and motivational factors on situational engagement and satisfaction.

6.1. Influence of Seating Factors on Situational Engagement

We did not find that distance from the podium in both preferred and actual seats predicted situational engagement, which is inconsistent with most prior research findings. Previous studies found a negative correlation between distance from the podium and student engagement (or performance) [6,34]. We speculated two explanations. On the one hand, we focused on student situational engagement at the activity level, and prior research focused on student overall engagement. On the other hand, we speculated that the type of classroom and teaching method played a moderating role. While previous studies focused on traditional lecture-style or multimedia classrooms with teacher-centered orientation, our context was a smart classroom with a student-centered orientation; thus, distance from the podium no longer played a role.

We also did not find that distance from the screen predicted situational engagement, which is different from the findings of Joshi et al. [35]. They found that distance from the multimedia screen predicted academic engagement and performance [35]. We speculated that the difference in results is partially attributable to the layout of classrooms. Joshi et al. used a traditional row-by-row layout, where the multimedia screen was deployed in the center, parallel to the row of seats in the middle of the classroom. In our smart classroom, the multimedia screen is deployed on both sides of the wall except in the front, so that every student can have close access to the multimedia resources. Access to multimedia learning resources is fair to every student in the smart classroom, so the distance from the screen did not play a role.

We only found that the distance from the center point in the actual seat predicted situational engagement at the micro-activity level, which is our unique finding. Through longitudinal measures and analysis, it was verified that student distance from the center point in a smart classroom predicted students’ situational engagement, controlling for other psychological factors. Prior studies showed that round tables and moveable desks and chairs in classrooms increased student engagement, and the more the teacher moves around the classroom, the more social interaction there is, and the better the results are [5,34]. Although smart classrooms eliminate positional discrimination (e.g., shadow zones) to some extent [5], this seating inequality still exists to some degree. Unlike traditional classrooms where the high interaction zone is located in the “front” of the classroom [38], the high interaction zone in smart classrooms seems to be located in the “center” of the classroom.

6.2. Influence of Motivation Factors on Situational Engagement

We found that autonomous motivation was the strongest predictor of situational engagement (i.e., the flow experience during activities), which echoes self-determination theory [13]. The present study confirms the critical role of course-level autonomous motivation for situational engagement in the technology-enhanced learning environment. Students possessed higher levels of autonomous motivation at the beginning of the course in smart classrooms and then had higher situational engagement in follow-up learning activities.

Our finding is consistent with previous empirical studies [12,51,72]. The difference is that in these studies, situational engagement was conceptualized as a three-dimensional structure of engagement, including behavioral, cognitive, and affective aspects, whereas our study conceptualized situational engagement based on flow theory.
We did not find a significant effect of controlled motivation on situational engagement. We speculated that controlled motivation is more controlled by external reinforcers and is of lower quality and effectiveness to situational engagement than autonomous motivation.

In addition, we found that competence and relatedness needs were significantly correlated with situational engagement, which was consistent with previous research [41,46,47]. Specifically, the more students felt competence and relatedness during the activity, the more likely they were to produce optimal learning engagement.

Although prior studies also found the effects of psychological needs on engagement, the strength of the effects varies. Many studies gave primacy to autonomy and emphasized its importance in enhancing self-determined motivation and student engagement [41,46,48]. For example, Koch et al. found that, compared to other needs, university students’ autonomy had the greatest influence on engagement [48], whereas we found autonomy to be the least contribution. This phenomenon can be explained by different cultural values. Autonomy works more in individualistic societies, whereas in collectivistic societies, students are more focused on harmonious and friendly relationships [47]. Since our study was conducted in China with collectivist cultural values, the effect of student autonomy on engagement was relatively low.

We did not find that motivational factors directly predicted end-of-course satisfaction, which is inconsistent with previous studies (e.g., Leyton Roman et al. [50], Mason [49]). These studies used only a single survey that measured overall psychological needs, not activity-specific needs. However, we used a more rigorous longitudinal research design, which more closely approximates causal relationships. As we found, in the mediation effect test, the effect of motivational factors (i.e., autonomous motivation) on satisfaction is fully mediated by situational engagement.

### 6.3. Influence of Situational Engagement on Student Satisfaction

We found that students’ situational engagement at the activity level has a positive impact on student satisfaction at the course level. The more engaged students are in smart classroom activities, the more satisfied they subsequently are with the course. Our findings are consistent with previous studies (e.g., El-Sayad et al. [54]) and support their findings in different contexts at different levels. They used a cross-sectional design to measure student overall engagement at the institutional or school levels. However, we used a longitudinal research design that measured student situational engagement at the activity level, addressing a limitation highlighted in their study.

### 6.4. Implications for Practice

According to our results, some pedagogical practice implications were made to help instructors improve student situational engagement and satisfaction in smart classrooms.

First, appropriate seating assignment strategies may be needed, even in smart classrooms. We found that seating in smart classrooms has a significant effect on situational engagement. Students who sit on the edge of the classroom for long periods may have lower situational engagement. Independent choice and appropriate intervention need to be combined in seating arrangements to prevent some students from sitting at the edge of the classroom for long periods [61].

Second, smart learning environments that support greater competence and relatedness need to be designed. Teaching activities should be in the student’s zone of proximal development, meeting their needs of competence; a technology-enhanced student-centered learning environment full of teacher and peer care/support and parental concern can be created to meet the need for relatedness [45]. The fulfillment of these psychological needs can promote student situational engagement.

Finally, increasing course-level autonomous motivation is critical to situational engagement and satisfaction. Rich technology and media do not automatically promote learning, but high autonomous motivation is what drives learning. Instructors can engage students by communicating the importance of the curriculum and designing interesting learning
activities to increase students’ autonomous motivation, which in turn improves situational engagement and satisfaction in smart classrooms.

7. Conclusions

This study contributes to the existing literature by examining the effects of seating and motivational factors on situational engagement and satisfaction in a smart classroom. In contrast to the cross-sectional design, we used an innovative ESM to capture real-time responses in the technology-enhanced environment. This longitudinal measurement design allowed us to note the impact and effect of situational engagement at different stages of coursework.

Overall, fluctuations in students’ situational engagement in smart classrooms were influenced by distance from the center point, psychological needs, and autonomous motivation. Situational engagement was the only factor that predicted course satisfaction. According to our findings, student seating factors were less important for situational engagement than their course-level autonomous motivation, competence, and relatedness needs. Course-level autonomous motivation is the strongest predictor of situational engagement. Student seats still matter despite the technology-enhanced learning environment. When controlling for course-level autonomous motivation, reducing distance from the center point and meeting students’ competence and relatedness needs can increase students’ situational engagement, which in turn can increase student satisfaction.

There are some limitations to this study. First, we only selected a sample of pre-service teachers from three courses in one university. To reduce bias in samples and pedagogical methodologies, other diverse samples can be expanded in the future to explore the effects of environmental and psychological factors on student engagement and performance in other technology-enhanced learning environments. Second, we focused only on physical seating, motivational variables, and experiential variables. Because objective indicators of student performance were not obtained, this study could be replicated in future research to overcome this limitation. Third, we used only traditional self-reporting and experience sampling methods. More objective data, such as student interviews and online learning footprints, could be included in the future to test and enrich existing theoretical models.

Author Contributions: Conceptualization, G.L. and K.X.; methodology, G.L. and C.Z.; validation, G.L., Q.L. and K.X.; formal analysis, G.L. and Y.S.; investigation, G.L. and C.Z.; resources, G.L. and Q.L.; data curation, G.L. and Q.L.; writing—original draft preparation, G.L.; writing—review and editing, G.L. and C.Z.; visualization, X.H. and C.Z.; supervision, Q.L. and C.Z.; project administration, Q.L.; funding acquisition, Q.L., Y.S. and X.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National Natural Science Foundation of China, grant numbers 61977035, 62167007, and 62307013, the 2023 Young Faculty Research Capacity Enhancement Program Project, grant number NWNU-SKQN2023-18, and the Humanities and Social Sciences of China MOE, grant number 22YJC880061.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of the Northwest Normal University (NWNU IRB-QN18).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The datasets generated during the current study are available from the first or corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.
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