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How Do K–12 Students’ Perceptions of Online Learning Environments Affect Their Online Learning Engagement? Evidence from China’s COVID-19 School Closure Period

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Abstract: A learning environment’s quality has crucial influence on a student’s engagement. In this study, we utilized a structural equation modeling approach to explore the structural relationships between students’ perceptions of an online learning environment and their online learning engagement during China’s COVID-19 school closure period by focusing on an online learning environment and the specific features that facilitate student engagement. The online learning environment was conceptualized as a multidimensional structure consisting of four elements: pedagogy, social interaction, technology, and the consideration of home learning conditions. Student engagement was conceptualized as a multifaceted construct comprising behavioral, emotional, and cognitive engagement. The results showed that teaching presence significantly predicted deep behavioral engagement (β = 0.246), emotional engagement (β = 0.110), and cognitive engagement (β = 0.180). Social presence significantly positively predicted cognitive engagement (β = 0.298) and emotional engagement (β = 0.480), whereas its effect on behavioral engagement was not significant. The perceived ease of technology use significantly predicted only emotional engagement (β = 0.324), and the family learning presence significantly predicted only behavioral engagement (β = 0.108). The results also indicated that emotional and cognitive engagement had indirect effects on the predictive power of the online learning environment for behavioral engagement. These findings provide valuable guidelines and effective strategies for teachers and parents to design suitable online learning environments to enhance K–12 student engagement.

Keywords: COVID-19; online learning; student engagement; environment perceptions

1. Introduction

Education systems across the globe have been frequently disrupted since the outbreak of COVID-19 in February 2020; school closures were mandated as part of public health efforts to mitigate the spread of COVID-19 in most countries and affected nearly 1.6 billion learners in more than 190 countries at the peak of the pandemic in 2020 [1]. Facing unprecedented chaos and challenges, most educational systems around the world ensured continuity of learning through online teaching and learning [2,3]. However, there have been major concerns regarding online teaching and learning and the quality of students’ learning experiences during the global pandemic, with most students rating the quality of teaching and learning as compromised [4]. Thus, online learning is an important research theme worth studying in the educational field during COVID-19 [5].

Previous research results on the quality of online learning have shown that the efficacy of online learning relied on student engagement with the process [6]. Student engagement has been defined as a student’s psychological investment and effort in learning, understanding, or mastering knowledge and skills [7,8]. Research studies have regarded student engagement as a proxy for learning quality [9] because of its contribution to positive learning outcomes, deep learning, critical thinking, retention rates, student satisfaction, etc. [10,11]. Engagement itself is the outcome of a positive interaction between a student...
and his/her learning environment, namely, the response of a student to changes in his/her social and physical learning environments [12]. Thus, the learning environment has a significant influence on the degree of student engagement [13]. Previous research has reported that 76% of the variation in student engagement caused by an individual moves from one activity or learning environment to another; only about 24% of the variation in student engagement was found to exist among students, which is potentially explainable by personal factors [14].

However, based on this literature review, we found the following gaps: (1) Although student engagement has been accepted as one of the important factors that affects student learning outcomes in an online learning environment [15], there are still limited studies in the literature on student engagement in online learning [16], and the problem of engagement in online learning environments continues [17]. (2) Previous research has highlighted the importance of the learning environment for student engagement; however, the mechanisms of how the online learning environment affects student engagement have not been studied in detail [18]. (3) Although attention has been given to structural and dispositional influences on student engagement, the potential contributions of students’ perceptions of a learning environment have been underemphasized [19]. (4) Most previous studies on online learning have primarily been conducted in higher education settings with adult learners [20]. There is a lack of understanding of the practices that support K–12 student learning in online settings; in particular, very little is known about K–12 student engagement in online learning, and the relationship between a student’s perception of an online learning environment and student engagement remains unclear.

To address these research gaps, in this paper we examine the structural relations between China’s K–12 student online learning environment perceptions and engagement during fully online teaching and learning in the period of COVID-19 school closures. The study results can be applied for the design of fully online learning environments during the COVID-19 pandemic or other uncertain crises of extreme severity and online learning in blended learning environments after COVID-19 that are directed toward positive learning performance.

2. Literature Review and Conceptual Framework

2.1. Student Engagement

Student engagement is vital to academic achievement; it is a key locus for interventions to improve learning performance and to reduce the dropout rate, as well as to develop personal and cognitive skills [10,12,14,21]. Student engagement has been widely regarded as central to understanding and improving student learning [22]. The meaning and applications of student engagement have evolved over time, and recent research has reinforced that student engagement is a complex, multifaceted, and multidimensional meta-construct [23]. Researchers have used different methods to characterize and measure engagement due to theoretical differences. Schaufeli et al. [24] adopted an engagement questionnaire for students based on the Utrecht Work Engagement Scale that contains three subscales, namely “vigor”, “dedication”, and “absorption”. Shernoff et al. [25] conceptualized student engagement as a composite of “enjoyment”, “concentration”, and “interest” based on flow theory. Fredricks et al. [26] constructed engagement with “behavioral”, “emotional”, and “cognitive” aspects and included “social” engagement as a dimension in later research studies [27]. Other studies have considered “agentic” engagement as a fourth aspect of engagement in addition to the three dimensions of engagement (behavioral, emotional, and cognitive engagement) [28,29]. The view that cognitive, emotional, and behavioral engagement are three primary dimensions or subtypes of student engagement is now widely embraced [30]. In our research model, student engagement consists of behavioral, emotional, and cognitive subtypes.
2.2. Online Learning Environment

Online learning is the fastest-growing type of distance education \[30,31\], and it has developed into a new era during the COVID-19 pandemic due to school closures \[32\]. Many institutions and researchers have adopted terms such as “emergency remote instruction” to describe online learning programs during the COVID-19 pandemic period \[33,34\]. In the present study, we use the term online learning as it has been a dominant media description, and most institutions have used this as the main alternative mode of instruction in response to school closures. Learning environments are a far-reaching construct with various definitions. Likewise, the nature of online learning environments is complex. Online learning environments are often defined as constructivist learning environments, and the community of inquiry framework (CoI) \[35\] provides a theory to understand the pedagogic, social, and technological processes that lead to collaborative learning. A useful online learning environment must be a combination of the fundamental designs of pedagogical, social, and technical elements for a specific context \[36\]. Thus, online learning environments have been designed based on three perspectives: pedagogical, social, and technological \[37\]. During the pandemic, educational institutions ensured that teaching and learning activities continued through online learning from home, and parents were required to provide students with physical spaces, learning materials, content instruction, and monitoring. Therefore, we considered family support an important factor associated with an online learning environment during the emergency conditions.

2.3. Student Engagement and Online Learning Environments

Many researchers have emphasized the importance of student engagement for online learning, as enhanced engagement is known to bring various benefits to online learners such as increased academic achievement, critical thinking, self-esteem, and persistence to complete tasks \[38\]. Based on the consensus that student engagement is essential in online learning, previous studies have investigated the antecedents of student engagement in online environments, i.e., the preconditions of student online learning engagement that include motivational characteristics, technological issues, prior experience, instructor presence, peer interaction, learning analytics, etc. \[39\]. Heo et al. \[40\] examined the relationship between self-efficacy and learning engagement through a structural equation model, and the results showed that self-efficacy in an online learning environment significantly influenced learning engagement. Yang et al. employed multiple linear regressions to examine the associations among students’ affective engagement, parental involvement, and teacher support \[41\]. In the following five subsections, we summarize some of the research results regarding the relationship between student engagement and online learning environment perceptions, as well as the findings of the internal dynamics of engagement.

2.3.1. Teaching Presence and Engagement

Teacher support plays a central role in the motivational dynamics of engagement \[12\]; it has the strongest relationship with student engagement \[41\] and it is positively associated with student engagement \[42\]. Jung and Lee \[43\] took 306 learners who were taking MOOCs in South Korea as research subjects and found that teaching presence had a significant direct effect on student engagement. Regarding the three dimensions of student engagement, teacher support has been shown to shape changes in student behavioral engagement \[12\]; higher levels of teacher support have been shown to result in higher levels of student emotional engagement \[41\]. Based on structural equation modeling analysis results, Wang \[44\] reported that teaching presence accounted for 34.3% of cognitive engagement.

2.3.2. Social Presence and Engagement

The establishment of social presence is heavily shaped through interaction. Interactivity is an important aspect of online learning, which includes student–teacher interactions, student–student interactions, and student–content interactions \[45\]. When these types of interactions are meaningfully integrated, students perceive online interactions posi-
tively [46], thus increasing student engagement in an online learning environment and thereby increasing the learning outcomes [47]. In a study by Fredricks et al., peer support was found to be correlated with student engagement [48]. More and more research has attributed student engagement, at least in part, to how teachers promote interactions [49].

2.3.3. Perceived Ease of Use and Engagement

The effective use of technology is the most abundant and clearly defined element of online learning [50], and its premise is that individuals can easily and effortlessly use a certain technology. Waite et al. found that the perceived ease of using learning support systems is a robust factor associated with student engagement [51]. O'Shea et al. believed that having the digital skills required to comfortably and competently use the technological aspects of online learning was necessary for successful engagement [52]. In contrast, Jung and Lee reported inconsistent findings and reported that perceived ease of use did not have a significant effect on student engagement [43]. The research results from multiple studies have indicated that the relationship between students’ perceived ease of using learning technologies and student engagement was not sufficiently clear, and no consistent conclusion has been reached; however, most of the results have shown they have a positive relationship.

2.3.4. Family Learning Conditions and Engagement

The provision of learning conditions and physical and psychological supports are the basic components of family support for learning, and they are important forms of parental involvement. Parental involvement with student learning is more critical when the learning environment is online compared with a traditional learning environment [38,53]. Researchers have recognized and concluded that parents have significant impacts on student learning and developmental processes [54]; the more parents are involved in their children’s education, the more socially and academically successful their children become [55]. Yang et al. found that higher levels of parental involvement resulted in higher levels of student emotional engagement [41]. In another study, the results showed that parental involvement had a direct effect on behavioral, emotional, and cognitive engagement [55].

2.3.5. Internal Dynamics of Engagement

Engagement is considered a construct of dynamic interaction. In terms of internal dynamics, Skinner et al. found that emotional engagement was a contributor to bolstering behavioral engagement [12], and Lam et al. concluded that emotional engagement was the catalyst for change in cognitive and behavioral engagement [56]. Researchers have hypothesized that changes in students’ affective and cognitive engagement could precede observable changes in behavioral engagement [57].

2.4. Hypotheses and Conceptual Model

As discussed above, previous studies have explored the effect of specific online learning environment variables on student engagement. However, there is a lack of research on student engagement from the perspective of students’ perception of the online learning environment during China’s COVID-19 school closure. In this context, the present study aims to explore the influential mechanism of online learning environment perceptions on student engagement by examining the structural relationships among teaching presence, social presence, perceived ease of use, family support presence, and student engagement. In line with the aforementioned studies, in the present study we consider that pedagogical support has a significant influence on all three dimensions of engagement, and social presence and the perceived ease of use have a positive influence on student engagement. In addition, we believe that students are directly affected by parental involvement in the process of home learning during a school closure period.
In summary, the present study proposes a conceptual model to illustrate the linkages between environmental variables and student engagement and the internal dynamics of the aspects of engagement (see Figure 1). The research hypotheses are as follows:

**Hypothesis 1 (H1).** Student-perceived teaching presence has a positive impact on behavioral engagement (H1a), emotional engagement (H1b), and cognitive engagement (H1c);

**Hypothesis 2 (H2).** Student-perceived social presence has a positive impact on behavioral engagement (H2a), emotional engagement (H2b), and cognitive engagement (H2c);

**Hypothesis 3 (H3).** Student-perceived ease of use has a positive impact on behavioral engagement (H3a), emotional engagement (H3b), and cognitive engagement (H3c);

**Hypothesis 4 (H4).** Student-perceived family support has a positive impact on behavioral engagement (H4a), emotional engagement (H4b), and cognitive engagement (H4c);

**Hypothesis 5 (H5).** Emotional engagement has a positive impact on behavioral engagement;

**Hypothesis 6 (H6).** Emotional engagement has a positive impact on cognitive engagement;

**Hypothesis 7 (H7).** Cognitive engagement has a positive impact on behavioral engagement.

3. Method

3.1. Data Collection and Participants

Anonymous online questionnaires were sent to students through a WeChat community, which was built into the class unit for use in interactions between teachers and students, sending learning materials, assigning and assessing homework, etc. Thus, we collected a large amount of questionnaires between 2 July and 9 July 2020, at the end of the first spring semester after the COVID-19 outbreak. The sampling population for the present survey research was from seven schools in three provinces in central and eastern China, which enhanced the representativeness of the overall K–12 online learning situation as much as possible. Among the 2144 K–12 students who were approached, 1095 (51.07%) students returned a valid questionnaire. Among the valid responses, 541 (49.4%) respondents were males and the remaining 554 (50.6%) respondents were females. The grade levels were distributed as follows: primary school 56.8%, junior high school 37.6%, and senior high school 5.6%.
3.2. Instruments

In addition to the demographic information of respondents, the questionnaire included all of the constructs in the proposed model. All measures of constructs came from existing instruments with good validity and reliability based on earlier studies. In order to fit the context of the current research, we made minor modifications to the items in these instruments. All of the items were measured with a five-point Likert-type scale, ranging from 1 (strongly disagree) to 5 (strongly agree). In the Appendix A, we include all items for each variable that were retained in the final analyses.

Teaching and social presence subscales were adapted from the subscales of the community of inquiry instrument [58]. The items for measuring the perceived ease of technology use were adapted from the instrument validated by Venkatesh et al. [59]. Regarding measures of family presence for online learning, based on actual situations, in this study we finally determined four items including the availability of learning equipment, materials, and places. Online learning engagement for sharing was evaluated by Sun et al. [8], who measured three types of engagement: behavioral engagement, emotional engagement, and cognitive engagement.

The reliability and confirmatory factor analysis (CFA) results of these instruments for this study are presented in the Section 4.

3.3. Common Method Bias Testing

Because some of the variables were collected at the same point in time, we tested for common method bias. We conducted a Harman’s single-factor test that included all of the five-point Likert scale items. The results showed that one factor explained <42.25% of the variance, which was well under the recommended limit of 50% [60], indicating that common method bias did not seem to be a problem in the dataset.

3.4. Data Analysis Method

For this study, we used IBM SPSS Statistics 23.0 (Chicago, IL, USA) and IBM AMOS 21.0 (Armonk, NY, USA) for data statistics and analysis. Firstly, confirmatory factor analysis, internal consistency using Cronbach’s alpha, reliability indices of the coefficient of composite reliability (CR), and the average variance extracted (AVE) were performed to ensure suitability. Secondly, descriptive, related, and difference analyses of online learning perceptions and student engagement were conducted. Finally, the proposed hypotheses were tested.

4. Results

4.1. Assessment of the Measurement Model and Structural Model

4.1.1. Reliability and Validity

Table 1 shows the acceptable convergent validity and internal reliability of the measurement model. The standardized factor loadings of all of the items in the measurement ranged from 0.831 to 0.941, exceeding the recommended cutoff value of 0.7 [61]. The composite reliability (CR) values were larger than 0.7, confirming that all constructs had good reliability [62]. The average variance extracted (AVE) values for all constructs exceeded 0.5, supporting the convergent validity [63]. In addition, all of the Cronbach’s values were larger than 0.7, indicating that all constructs had appropriate internal consistency [64]. The findings also showed that the square roots of the AVEs exceeded the correlations between any two constructs, showing discriminant validity [65].

4.1.2. Assessment of the Structural Model

The structural model was assessed using the chi-square value by the degrees of freedom (χ²/df), the root mean square error of approximation (RMSEA), the comparative fit index (CFI), the Tucker–Lewis index (TLI), and the standardized root mean square residual (SRMR). The SEM results showed that the hypothesized model fit the data well:
\[ \chi^2/df = 3.263 < 5, \text{RMSEA} = 0.045 \leq 0.05, \text{GFI} = 0.921 \geq 0.90, \text{CFI} = 0.961 \geq 0.90, \text{TLI} = 0.956 \geq 0.90, \text{and SRMR} = 0.036 < 0.08. \]

Table 1. Structure of the questionnaire and its reliability, validity, and correlations.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Cronbach’s α</th>
<th>CR</th>
<th>AVE</th>
<th>PP</th>
<th>SP</th>
<th>TE</th>
<th>FP</th>
<th>BE</th>
<th>EE</th>
<th>CE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP</td>
<td>0.941</td>
<td>0.941</td>
<td>0.697</td>
<td>0.835</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP</td>
<td>0.881</td>
<td>0.883</td>
<td>0.601</td>
<td>0.584 **</td>
<td>0.775</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PEU</td>
<td>0.876</td>
<td>0.878</td>
<td>0.706</td>
<td>0.414 **</td>
<td>0.599 **</td>
<td>0.840</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FP</td>
<td>0.877</td>
<td>0.879</td>
<td>0.645</td>
<td>0.464 **</td>
<td>0.481 **</td>
<td>0.488 **</td>
<td>0.803</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BE</td>
<td>0.831</td>
<td>0.834</td>
<td>0.626</td>
<td>0.500 **</td>
<td>0.467 **</td>
<td>0.349 **</td>
<td>0.392 **</td>
<td>0.791</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EE</td>
<td>0.931</td>
<td>0.932</td>
<td>0.735</td>
<td>0.441 **</td>
<td>0.601 **</td>
<td>0.564 **</td>
<td>0.392 **</td>
<td>0.491 **</td>
<td>0.857</td>
<td></td>
</tr>
<tr>
<td>CE</td>
<td>0.891</td>
<td>0.892</td>
<td>0.622</td>
<td>0.476 **</td>
<td>0.561 **</td>
<td>0.445 **</td>
<td>0.390 **</td>
<td>0.618 **</td>
<td>0.555 **</td>
<td>0.789</td>
</tr>
</tbody>
</table>

Note: TP, teaching presence; SP, social presence; PEU, perceived ease of use; FP, perceived family support; BE, behavioral engagement; EE, emotional engagement; CE, cognitive engagement. Diagonal elements shown in bold are the square root of the average variance extracted (AVE) by constructs from their indicators; values under them are the correlations of the latent variables. Significance: ** \( p < 0.01 \).

4.2. Student Engagement by Demographic Variables

Table 2 summarizes the descriptive statistics for student-perceived online learning environment support and engagement and the differences in the demographic variables. Overall, the participants expressed favorable opinions about their online learning experiences; the ratings for all aspects (ranging from 3.59 to 4.34) were higher than the neutral point on the five-point Likert scale. Additionally, among all of the dimensions of student-perceived online learning environment support and self-reported engagement, the aspects of female students were higher than those of male students. However, only family support, behavioral engagement, and cognitive engagement had statistically significant differences, while the other four aspects did not have significant differences. Compared with these, grade level had a greater impact on student-perceived online learning environment support and engagement. Interestingly, as shown in Table 2, higher-grade students tended to have a lower level of student-perceived online learning environment support and engagement in online learning.

Table 2. Means and standard deviations for online learning environment and engagement.

<table>
<thead>
<tr>
<th>Sex</th>
<th>TP Mean (S.D.)</th>
<th>SP Mean (S.D.)</th>
<th>PEU Mean (S.D.)</th>
<th>FP Mean (S.D.)</th>
<th>BE Mean (S.D.)</th>
<th>EE Mean (S.D.)</th>
<th>CE Mean (S.D.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>4.34 (0.65)</td>
<td>3.87 (0.71)</td>
<td>3.79 (0.83)</td>
<td>4.07 (0.75)</td>
<td>4.19 (0.68)</td>
<td>3.59 (0.87)</td>
<td>3.74 (0.73)</td>
</tr>
<tr>
<td>Female</td>
<td>4.38 (0.68)</td>
<td>3.84 (0.73)</td>
<td>3.76 (0.84)</td>
<td>4.00 (0.75)</td>
<td>4.14 (0.72)</td>
<td>3.56 (0.88)</td>
<td>3.68 (0.75)</td>
</tr>
<tr>
<td>F</td>
<td>4.37 (0.62)</td>
<td>3.87 (0.70)</td>
<td>3.82 (0.82)</td>
<td>4.14 (0.75)</td>
<td>4.24 (0.64)</td>
<td>3.62 (0.85)</td>
<td>3.79 (0.69)</td>
</tr>
<tr>
<td>p</td>
<td>4.44 (0.56)</td>
<td>3.93 (0.69)</td>
<td>3.84 (0.80)</td>
<td>4.10 (0.74)</td>
<td>4.22 (0.70)</td>
<td>3.76 (0.83)</td>
<td>3.76 (0.74)</td>
</tr>
<tr>
<td>Primary</td>
<td>4.31 (0.64)</td>
<td>3.82 (0.70)</td>
<td>3.78 (0.87)</td>
<td>4.08 (0.74)</td>
<td>4.22 (0.64)</td>
<td>3.45 (0.86)</td>
<td>3.75 (0.69)</td>
</tr>
<tr>
<td>Grade level</td>
<td>3.50 (0.88)</td>
<td>3.40 (0.84)</td>
<td>3.38 (0.82)</td>
<td>3.72 (0.90)</td>
<td>3.75 (0.71)</td>
<td>3.96 (0.73)</td>
<td>3.40 (0.79)</td>
</tr>
<tr>
<td>Senior high</td>
<td>66.5 (17.01)</td>
<td>8.46 (7.33)</td>
<td>13.65 (13.05)</td>
<td>35.49 (13.65)</td>
<td>7.14 (13.05)</td>
<td>8.46 (7.33)</td>
<td>13.65 (13.05)</td>
</tr>
<tr>
<td>p</td>
<td>*** *** *** ** ** *** *** **</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* \( p < 0.05 \), ** \( p < 0.01 \), *** \( p < 0.001 \).

4.3. Hypothesis Testing

Table 3 and Figure 2 show the results of hypothesis testing for the direct path coefficients of the initial structural model.
4.3.1. Learning Environment Perceptions and Engagement

The path analysis results showed that the engagement components were positively predicted, fully or partly, by the perceived learning environment variables; emotional engagement and cognitive engagement had indirect effects on the predictive power of the online learning environment for behavioral engagement; and, although the home and school environments were very different from each other, in terms of online learning, family support conditions had a small impact on changes in student engagement and had a significant impact only on behavioral engagement. The detailed results are as follows: teaching presence significantly predicted deep behavioral engagement ($\beta = 0.246$, $p < 0.001$), emotional engagement ($\beta = 0.110$, $p < 0.05$), and cognitive engagement ($\beta = 0.180$, $p < 0.001$). Furthermore, social presence significantly positively predicted cognitive engagement ($\beta = 0.298$, $p < 0.001$) and emotional engagement ($\beta = 0.480$, $p < 0.001$), whereas its effect on behavioral engagement was insignificant. Notably, the perceived ease of technology use significantly predicted only emotional engagement ($\beta = 0.324$, $p < 0.001$) and family presence significantly predicted only behavioral engagement ($\beta = 0.108$, $p < 0.001$).

4.3.2. The Dynamic Interplay between the Three Dimensions of Engagement

For the intertwined relationship of the three types of presence, in this study, we found that students who experienced higher emotional engagement indicated deeper cognitive engagement ($\beta = 0.246$, $p < 0.001$) and behavioral engagement ($\beta = 0.124$, $p < 0.001$). The
results also emphasized the importance of cognitive engagement for promoting behavioral engagement ($\beta = 0.411, p < 0.001$).

4.4. Mediating Effect Analysis

Significant positive effects of the online learning environment on emotional engagement and cognitive engagement on behavioral engagement were observed (see Figure 2). Therefore, a bootstrap test was also conducted, based on 5000 samples at a confidence level of 95%, to examine the mediating effects of emotional engagement and cognitive engagement. Table 4 illustrates the mediating test results of the final modified model. As shown in Table 4, the indirect effects of emotional engagement and cognitive engagement on the predictive power of the online learning environment with respect to behavioral engagement were statistically significant, which indicated that emotional and cognitive engagement played mediating roles in behavioral engagement in an online learning environment. However, cognitive engagement could not significantly mediate family presence and perceived ease of technology use with respect to behavioral engagement.

Table 4. Mediating effects among variables.

<table>
<thead>
<tr>
<th>Path</th>
<th>Unstandardized Effect</th>
<th>Standardized Effect</th>
<th>Bias-Corrected 95% CI</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP $\rightarrow$ EE $\rightarrow$ CE</td>
<td>0.027</td>
<td>0.024</td>
<td>0.002 0.060</td>
<td>Supported</td>
</tr>
<tr>
<td>SP $\rightarrow$ EE $\rightarrow$ CE</td>
<td>0.118</td>
<td>0.115</td>
<td>0.079 0.171</td>
<td>Supported</td>
</tr>
<tr>
<td>PEU $\rightarrow$ EE $\rightarrow$ CE</td>
<td>0.080</td>
<td>0.096</td>
<td>0.050 0.119</td>
<td>Supported</td>
</tr>
<tr>
<td>TP $\rightarrow$ EE $\rightarrow$ BE</td>
<td>0.014</td>
<td>0.013</td>
<td>0.002 0.034</td>
<td>Supported</td>
</tr>
<tr>
<td>SP $\rightarrow$ EE $\rightarrow$ BE</td>
<td>0.060</td>
<td>0.062</td>
<td>0.028 0.103</td>
<td>Supported</td>
</tr>
<tr>
<td>PEU $\rightarrow$ EE $\rightarrow$ BE</td>
<td>0.040</td>
<td>0.051</td>
<td>0.019 0.070</td>
<td>Supported</td>
</tr>
<tr>
<td>TP $\rightarrow$ CE $\rightarrow$ BE</td>
<td>0.074</td>
<td>0.070</td>
<td>0.035 0.122</td>
<td>Supported</td>
</tr>
<tr>
<td>SP $\rightarrow$ CE $\rightarrow$ BE</td>
<td>0.122</td>
<td>0.128</td>
<td>0.070 0.189</td>
<td>Supported</td>
</tr>
<tr>
<td>FP $\rightarrow$ CE $\rightarrow$ BE</td>
<td>0.022</td>
<td>0.026</td>
<td>0.019 0.070</td>
<td>Supported</td>
</tr>
<tr>
<td>PEU $\rightarrow$ CE $\rightarrow$ BE</td>
<td>0.004</td>
<td>0.004</td>
<td>0.002 0.037</td>
<td>No supported</td>
</tr>
<tr>
<td>EE $\rightarrow$ CE $\rightarrow$ BE</td>
<td>0.101</td>
<td>0.131</td>
<td>0.090 0.143</td>
<td>Supported</td>
</tr>
<tr>
<td>TP $\rightarrow$ EE $\rightarrow$ CE $\rightarrow$ BE</td>
<td>0.011</td>
<td>0.010</td>
<td>0.001 0.026</td>
<td>Supported</td>
</tr>
<tr>
<td>SP $\rightarrow$ EE $\rightarrow$ CE $\rightarrow$ BE</td>
<td>0.049</td>
<td>0.050</td>
<td>0.031 0.076</td>
<td>Supported</td>
</tr>
<tr>
<td>PEU $\rightarrow$ EE $\rightarrow$ CE $\rightarrow$ BE</td>
<td>0.033</td>
<td>0.044</td>
<td>0.036 0.127</td>
<td>Supported</td>
</tr>
</tbody>
</table>

5. Discussion

In this section, we discuss the findings in three parts: engagement differences in learners’ demographic characteristics, how perceived learning environment support affects engagement, and the internal dynamics of engagement.

5.1. Student Engagement Varies by Sex and Age

The results from previous research have indicated that student engagement is related to sex; boys generally show lower engagement, e.g., as reported by Reyes et al. [66,67]. Partly consistent with earlier research [42], the present study also revealed that girls had higher behavioral and cognitive engagement than boys, but there was no statistically significant difference in emotional engagement between boys and girls. In terms of perceived learning environment support, only family support conditions showed a sex gap, indicating that girls’ perceived learning environment support was significantly higher than that of boys. However, in this study, we did not examine the mediating role of environmental factors for sex differences in engagement; therefore, it was impossible to determine whether and how the sex gap was affected by the learning environment.

Spence and Usher’s research results showed that age was a factor governing the effectiveness of e-learning [68]. In our study, we found a similar result, i.e., compared with sex, grade level had a greater impact on perceived online learning environment support.
and engagement. There were significant differences in students’ perceptions of the online learning environment and behavioral, emotional, and cognitive engagement in terms of age. In summary, student engagement was negatively related to age in online learning settings, suggesting that older students had less engagement in their online learning.

5.2. Perception of the Learning Environment Affects Student Engagement

In this study, we found significant associations between the online learning environment and student engagement, but different environmental variables had differential predictive effects. Teacher support and pedagogy were significant and consistent predictors of the cognitive, behavioral, and emotional aspects of engagement; social support was a significant predictor of cognitive and emotional engagement; perceived ease of technology use was a predictor only of emotional engagement; and perceived family support was a predictor only of behavioral engagement. Emotional engagement predicted deeper cognitive and behavioral engagement, and cognitive engagement promoted behavioral engagement.

5.2.1. Teaching Presence Has a Positive Relationship with Engagement

Bryson and Hand concluded that students were more likely to engage if they were supported by teachers [69], and Kuh et al. reported that teaching and teachers were central to engagement [70]. The results of the present study confirmed those of previous studies, i.e., teaching presence was the most important influencing factor in all engagement dimensions. Hence, pedagogical design is the primary aspect of online learning environment design, which requires intentional preparation and action on design, facilitation, and the direction of learning [71]; increasing instructor visibility in online activities or videos to enliven the class; using both instant messages and asynchronous tools to maintain interactions with students; developing a well-structured course to reduce student anxiety; presenting instructional material in multiple formats to adapt to students’ different learning styles; monitoring students’ learning processes; etc.

5.2.2. Social Presence Is the Second-Most Important Variable for Engagement

Creating a socializing interaction proves to be essential for student satisfaction. In contrast, the lack of social presence can trigger potential computer-mediated communication anxiety stressors and then affect student engagement [72,73]. The previous conclusions were also confirmed by this study’s findings, which showed social presence had direct impact on emotional and cognitive engagement, and through them, indirectly affected behavioral engagement. As Watts concluded, a “lack of face-to-face (F2F) interactions between students and instructors or among students remain a major concern of online learning, and there is a need to look for more effective ways to improve student engagement in online learning environments” [46]. Suggested strategies that can promote student engagement and success include facilitating social interactions among students, encouraging group discussions, responding to all student queries, etc., within 24 h; combining asynchronous and synchronous online interactions to optimize the learning experience; and reducing feelings of disconnection and frustration via interaction and feedback.

5.2.3. Perceived Ease of Use Only Significantly Affects Students’ Emotions

PST models assume that ease of technology use is not the main factor affecting learning; rather, the main factors are the extent to which teaching support and social interactions support learning [74]. Saadé and Kira argued that perceived ease of technology use was related to technology-related anxiety [75]; the results of this study showed that perceived ease of technology use had a significant impact only on emotional engagement, which is consistent with previous research conclusions. Although the main factors affecting online learning are instructional design and social interactions rather than technology, and teaching tools are only optional supporting factors rather than decisive factors that determine the teaching effect, technical design provides a strong foundation for the realization of pedagogical and social designs [74]. In addition, the use of and commitment to technology
was affected by gender and age [76]. Therefore, the combined influence of technology that interacts with implementation, context, and student characteristics cannot be ignored. As the initial requirement for the construction of an online learning environment, the choice and use of technology should follow the principles of ease of access, learning, and use, and should be adopted to learner characteristics.

5.2.4. Family Support Has a Significant Impact on Behavioral Engagement

The issue of family as a factor influencing student outcomes is often addressed in educational research, and family variables that are frequently investigated include perceived parental support, socioeconomic status, perceived rights, family authority styles, etc. [77]; parental support is a more powerful force than the other family variables. The results from our study indicate that perceived family or parental support has a significant impact on behavioral engagement. Moreover, as Lawrence and Fakuade concluded, older students may be able to adapt and adjust to online learning without parental support, whereas younger learners need parental involvement [78]. Our findings supported the conclusion that student-perceived parental support and beneficial home environment decrease with age. During the epidemic, limitations related to parental support and home environments led to difficulties in completing distance learning tasks [79]. Parents have to offer support for children’s online learning, such as parental monitoring, family expectations, and a quiet and undisturbed space, creating an encouraging learning environment and participating in children’s homework, consideration of age-based differences, and so on.

5.3. Internal Dynamics of Engagement

Each of the three indicators (dimensions) of engagement has its own distinctive antecedents and its own role in the internal dynamics of engagement. Consistent with previous research on engagement [12], behavioral engagement seems to be a good summary indicator, but it is not a contributor to changes in the other two facets of engagement. In line with a previous study [56], our findings indicate that emotional engagement is the catalyst for change in the other dimensions of engagement, and cognitive engagement is a mediating factor of emotional engagement and behavioral engagement.

6. Conclusions

Similar to COVID-19, severe events such as extreme weather, serious conflict, and other unpredictable epidemics are expected to occur more frequently and bring unexpected chaos to human life. In terms of education, online teaching and learning become important measures to meet such severe events. How to conduct an online learning environment to make students engage in their learning is a key issue during these uncertain periods. Therefore, online learning in these special times should be studied to promote the sustainability of online learning. This study aimed to explore the structural relationship between students’ perceived online learning environment and student engagement by investigating K–12 students in China who participated in online learning at home in the spring semester of 2020. Overall, the results showed that the engagement components were positively predicted, fully or partly, by the perceived learning environment variables; emotional engagement and cognitive engagement had indirect effects on the predictive power of the online learning environment for behavioral engagement; and family support conditions had a small impact on changes in student engagement and only had a significant impact on behavioral engagement.

6.1. Implications

Home and school contexts and environments are very different from each other and dramatically change how students engage and learn [80]. In terms of online learning, the present study showed that student engagement in online learning was an outcome variable affected by students’ perceptions of the online learning environment. The research results put forward several practical application guidelines for creating online learning
environments in an emergency that promote student participation, and therefore we can be prepared for and respond to another global emergency.

6.2. Limitations and Future Research

First, in this study we did not consider the difference between synchronous and asynchronous online learning (we did not distinguish between synchronous and asynchronous online learning). As Hrastinski concluded, although the two forms of online learning complement each other, their effects on student engagement vary: asynchronous learning better supports cognitive engagement such as increased reflection, whereas synchronous learning better supports increased motivation, which is an important predictor of emotional engagement [81]. Hence, how different forms of online learning affect students is a key issue worthy of attention in the future.

Second, in terms of measures, in this study we relied heavily on students’ self-reports. To investigate the linkage between environmental factors and student engagement, experimental and longitudinal studies need to be conducted instead of a self-reported data survey because student engagement is highly dynamic and fluctuating.

Third, the background factors of the students included only sex and age and did not include prior achievement, the experiences of online learning, affective and motivational factors, etc., and did not consider self-regulation characteristics, which are strong predictors of engagement. Furthermore, the results call for further research to provide insight into which environmental factors may explain sex differences in engagement.

Fourth, there are other learning-environment variables that may be related to student engagement, but the present study addressed only four dimensions of the online learning environment.

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Institutional Review Board Statement: This research study was conducted in accordance with the ethical standards of the Helsinki Declaration. The Central China Normal University Institutional Review Board (CCNU IRB) usually exempts educational research from the requirement of ethical approval. This study was granted an exemption from the required ethical approval by the Central China Normal University Institutional Review Board because the survey was anonymous and did not include sensitive questions.

Informed Consent Statement: All participants were made aware that their participation in the study was voluntary, they could withdraw from the study at any time without penalty, and their personal identifiable information would be kept anonymous in all publications and presentations. By voluntarily completing the survey, all participants were considered to have given their consent to participate.

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

Appendix A

Scale 1. Teaching presence.

1. The instructor provided clear instructions on how to participate in course learning activities.
2. The instructor was helpful in guiding the class toward understanding course topics in a way that helped me clarify my thinking.
3. The instructor helped to keep course participants engaged and participating in productive dialogue.
4. The instructor helped keep the course participants on task in a way that helped me learn.
5. The instructor encouraged course participants to explore new concepts in this course.
6. Instructor actions reinforced the development of a sense of community among course participants.
7. The instructor provided feedback that helped me understand my strengths and weaknesses relative to the course’s goals and objectives.

Scale 2. Social presence.
1. Online or web-based communication is an excellent medium for social interaction.
2. I felt comfortable interacting with other course participants.
3. I felt comfortable disagreeing with other course participants while still maintaining a sense of trust.
4. I felt that my point of view was acknowledged by other course participants.
5. Online discussions help me to develop a sense of collaboration.

Scale 3. Technology—perceived ease of use.
1. My interaction with the system is clear and understandable.
2. I find the system to be easy to use.
3. I find it easy to get the system to do what I want it to do.

Scale 4. Family presence.
1. The books and equipment I need or want are easily available when learning at home.
2. The room is bright and comfortable.
3. When I study, I will not be disturbed.
4. Members of my family support my online learning.

Scale 5. Behavioral engagement.
1. I follow the rules of the online class.
2. I complete my homework on time.
3. I check my schoolwork for mistakes.

1. I like taking the online class.
2. I feel excited by my work in the online class.
3. The online classroom is a fun place to be.
4. I am interested in the work in the online class.
5. I feel happy when taking online classes.

Scale 7. Cognitive engagement.
1. I study at home even when I do not have a test.
2. I try to look for course-related information through other resources such as television, journal papers, magazines, etc.
3. When I read the course materials, I ask myself questions to make sure I understand what it is about.
4. I read extra materials to learn more about things we do in the online class.
5. If I do not know about a concept when I am learning in the online class, I do something to figure it out.

References


44. Wang, Y. Effects of teaching presence on learning engagement in online courses. *Distance Educ.* 2022, 43, 139–156. [CrossRef]


62. Fornell, C.; Larcker, D.F. Evaluating structural equation models with unobservable variables and measurement error. *J. Mark. Res.* 1981, 18, 39–50. [CrossRef]

63. Segars, A.H. Assessing the unidimensionality of measurement: A paradigm and illustration within the context of information systems research. *Omega* 1997, 25, 107–121. [CrossRef]


71. Shea, P.; Li, C.S.; Pickett, A. A study of teaching presence and student sense of learning community in fully online and web-enhanced college courses. *Internet High. Educ.* 2006, 9, 175–190. [CrossRef]


