Understanding Learner Satisfaction in Virtual Learning Environments: Serial Mediation Effects of Cognitive and Social-Emotional Factors

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Abstract: This study explored the relationship between technology acceptance and learning satisfaction within a virtual learning environment (VLE) with cognitive presence, cognitive engagement, social presence, and emotional engagement as mediators. A total of 237 university students participated and completed a questionnaire after studying in the Virbela VLE. The results revealed direct and indirect links between technology acceptance and virtual learning satisfaction. The mediation analysis showed the critical mediating roles of cognitive presence and emotional engagement in fostering satisfaction. There also appeared to be a sequential mediating pathway from technology acceptance to learning satisfaction through social presence and emotional engagement. Notably, cognitive engagement and social presence did not have a significant mediating effect on satisfaction. These results provide a supplementary perspective on how technological, cognitive, and emotional factors can enhance student satisfaction in VLEs. The study concludes with several implications for future research and practice of VLEs in higher education.

Keywords: virtual reality; virtual learning environment; learner satisfaction; presence; engagement; serial mediation

1. Introduction

Online learning has become increasingly prevalent in the post-pandemic era. However, despite the widespread use of online learning formats such as learning management systems and live-streaming teaching, their effectiveness has been unsatisfactory [1]. Students have generally expressed low satisfaction levels [2]. The limitations of traditional online learning environments are primarily responsible for students’ insufficient social interaction, a lack of emotional exchange, and shallow learning experiences [2–4]. These shortcomings have led to students’ doubts about and dissatisfaction with online learning practice [3]. In contrast, virtual learning environments (VLEs) create an immersive learning space for learners, emphasizing social presence and collaborative inquiry [5]. They introduce an unprecedented level of interactivity that enables learners to engage in deep learning and exploration in a more authentic and vivid environment [1,6]. This undoubtedly opens new avenues for improving the effectiveness of online learning and enhancing student satisfaction.

Research on VLEs has identified several possible influencing factors regarding learner satisfaction [7], which can be explained through two theoretical frameworks. The first framework is the technology acceptance model (TAM) [8] since VLEs often rely on emerging technologies such as virtual reality and the metaverse. Learner acceptance of such technological innovations, as measured by perceived ease of use and usefulness, is key to the success of online learning. The second framework is social learning theory, which was proposed by Bandura and Walters [9] and highlights the complex and multifaceted nature of social learning experiences influenced by various social, emotional, and cognitive factors [10].
Particularly, informed by the theoretical approaches such as the community of inquiry [11] and school engagement [12], the following factors merit our research attention, including social presence, cognitive presence, emotional engagement, and cognitive engagement.

Despite the importance of the aforementioned influencing factors, there has been insufficient empirical research investigating their direct and indirect effects on online learning experiences, as well as the mediating pathways from technology acceptance to learner satisfaction. Consequently, to further our understanding of learning in VLEs and provide suggestions for the application of VLEs in instructional practice, we employed a cross-sectional design to examine the relationship between acceptance of VLE technology and learning satisfaction, and took cognitive and emotional factors as a series of mediating variables in light of TAM and social learning theory.

2. Literature Review

2.1. Virtual Learning Environments

VLEs are computer-based digital spaces providing a variety of resources, including web-based and three-dimensional (3D) VLEs, whereby learners can interact and engage with other participants [13]. Web-based VLEs—such as the learning management system Moodle, online discussion forums, and online course platforms for MOOCs—are characterized by minimizing the distance among learners and transferring learning content [14]. With the development of virtual reality technology, 3D simulations and immersive virtual worlds have been created for teaching and learning, which are uniquely characterized by representational fidelity and learner interaction [15,16]. Representational fidelity, which incorporates aspects of single-user and multi-user context, involves realistic and smooth sensory quality, consistency of object behaviors, and user representation [15]. Learner interaction incorporates individual and collaborative actions and describes the degree to which users can control, manipulate, and construct the environment, as well as the embodiment of the experience of communication. Combined with these concepts of fidelity and interaction, 3D VLEs provide a highly collaborative learning community that contributes to the social nature of learning, motivates student engagement, and enriches the learning experience.

2.2. Relationship between TAM and Learning Satisfaction in VLEs

TAM is a theoretical framework that explains how users perceive, accept, and use technology [17]. TAM focuses on the factors influencing users’ decisions and beliefs in various contexts such as organizational, educational, and electronic collaboration [18–20]. TAM was proposed by Davis [8], who identified perceived usefulness and perceived ease of use as two fundamental determinants of a user’s acceptance of technology. To date, TAM has been broadly adopted to explore and explain students’ beliefs, attitudes, and intentions in VLEs [21,22]. Many researchers believe that technology acceptance is an important predictor of student satisfaction in technology-supported learning environment [23–25].

Satisfaction refers to the subjective fulfillment of needs and perceptions of contentment [26]. Learning satisfaction refers to students’ holistic perception of their educational experience, including satisfaction with their learning experience, context, instrument, and learning environment [27,28]. Information systems research has indicated that user satisfaction is one of crucial factors for evaluating the success of system implementation [29]. Student satisfaction has been studied as a significant indicator of learning effectiveness and course quality, as it contributes to motivation, engagement, and performance in learning [26,30,31]. Satisfaction presents students’ inner state. A reduction in student satisfaction could heighten the risk of burnout and therefore negatively affect psychological health and learning productivity [32,33]. Hence, students’ learning satisfaction merits our research attention.

There is a positive relationship between technology acceptance and learning satisfaction in both e-learning and blended learning. To ensure the success of an e-learning system, it is important to promote user satisfaction through factors including acceptance of the system’s technology [34]. Ai-Lim Lee et al. [35] argued that incorporating perspectives
Electronics 2024, 13, 2277

from TAM could help better explain how the features of virtual reality promote learning satisfaction. Research on technology-mediated learning has shown that technology acceptance, measured through the dimensions of perceived usefulness ($\beta = 0.12$, $p < 0.01$) and perceived ease of use ($\beta = 0.16$, $p < 0.001$) via regression analysis, is an important antecedent of learning satisfaction and is highly correlated with e-Learners’ satisfaction [36]. Perceived usefulness and perceived ease of use have been shown to be the strongest factors affecting perceived satisfaction [24,37]. Higher perceived usefulness indicates that the learning platform or instrument provides more useful context, while higher perceived ease of use enables students to concentrate on learning content rather than on adapting to new technologies. The acceptance of VLE technology could thus directly or indirectly affect learning satisfaction. Based on the review above, we proposed the following hypothesis:

**H1 (c’): Technology acceptance is positively correlated with learning satisfaction.**

2.3. Cognitive Presence and Cognitive Engagement as Mediators of Learning Satisfaction

Presence refers to the subjective perception of “being there”, which is generated by the user in a certain environment through an automatic and controlled psychological process [38]. The term cognitive indicates a concern conscious intellectual activity, and the concept of cognitive presence was proposed by Garrison et al. [11] to reflect learners’ experience of collaboratively constructing knowledge and developing critical thinking. Therefore, cognitive presence could be defined as the perception of conscious intellectual activity and higher-order thinking during cooperation and communication. Cognitive presence is a critical component for effective learning, because it enables students to integrate new knowledge by developing analytical skills and engaging in critical reflection [39,40]. Many researchers have examined the positive relationship between cognitive presence and satisfaction. Martin et al. [41] discovered their positive correlation ($r = 0.586$), and Joo et al. [42] confirmed the indirect effect of cognitive presence on satisfaction through flow ($Z = 4.69$, $p < 0.001$). Cognitive presence may also be influenced by technology acceptance. Technology is essential for active student participation and critical thinking in learning environments [43]. However, students who are reluctant to use or experience discomfort with new technology are less likely to actively process and reflect upon the presented material, which could significantly limit their cognitive presence [44].

Cognitive engagement is defined as the degree of psychological quality and investment in learning. It incorporates the thoughtfulness needed to acquire knowledge and master skills, as well as the willingness to cope with difficulties and failures [12,45,46]. In contrast to cognitive presence, which emphasizes the mental perception of the intensity of higher-order thinking activities, cognitive engagement places more emphasis on the cognitive effort that learners put into learning activities. Cognitive engagement plays a pivotal role in the learning process and has a positive correlation with technology acceptance and learning satisfaction. Learning environment design may influence cognitive engagement [47], and an easy-to-accept online learning platform can help students engage effectively in the learning process [48]. Cognitive engagement positively affects learning satisfaction by fostering self-regulation, motivation, and active participation [49,50]. However, Gao et al. [24] suggested that cognitive engagement alone does not significantly affect satisfaction, which is only affected by full emotional engagement.

There is a positive correlation between cognitive presence and cognitive engagement. Cognitive presence emphasizes the capacity to reflect and engage in discourse. This is conducive to deep learning [39], which leads to a more profound comprehension and application of the content, thus demanding greater cognitive effort from the learner [51]. Learners exhibiting a high level of cognitive presence are more engaged cognitively and are also more likely to be interested and motivated by the content [44]. This intrinsic motivation can inspire learners to invest consistent cognitive effort, thereby increasing their level of cognitive engagement [52,53]. Additionally, cognitive presence also facilitates the development of learners’ autonomy and self-regulation, which allows them to manage
their learning process and maintain sustained cognitive engagement effectively [54–56]. The following hypotheses were therefore developed:

**H2 (a1b1):** Cognitive presence mediates the relationship between technology acceptance and learning satisfaction.

**H3 (a2b2):** Cognitive engagement mediates the relationship between technology acceptance and learning satisfaction.

**H4 (a1d21b2):** Cognitive presence and cognitive engagement serially mediate the relationship between technology acceptance and learning satisfaction.

### 2.4. Social Presence and Emotional Engagement as Mediators of Learning Satisfaction

Social presence in a computer-mediated communication environment (e.g., online discussion groups or virtual environments) refers to the extent to which an individual feels, perceives, and responds to another intellectual entity; it is the learner’s ability to project themselves socially and emotionally [57,58]. Social presence has the potential to affect a learner’s performance [59], interaction [60], and learning satisfaction [28]. Research has shown that, particularly in online and collaborative learning activities, social presence could significantly affect student motivation and participation, improve course and instructor satisfaction with emerging technology as an educational delivery medium, and strongly predict satisfaction [28,57,61]. Social presence has also been confirmed to be positively influenced by technology acceptance, including perceived ease of use and perceived usefulness, and to be a mediating variable affecting online learning motivation [44].

Emotional engagement is another potential key factor for enhancing students’ online learning satisfaction [62]. Emotional engagement refers to the emotional reactions of students toward their class and teacher, as well as their identification with the learning community, including a sense of belonging or feeling important to the community, as well as valuing success in school-related outcomes [63–66]. Xia et al. [67] noted that emotional engagement is associated with professional identity and learning energy, which are demonstrated through interest, long-term professional planning, enthusiasm, and learning focus. They also confirmed that professional identity and learning energy directly contribute to learning satisfaction, with path coefficients of 0.19 ($p < 0.0001$) and 0.067 ($p < 0.0001$), respectively. According to Gao et al. [24], the path coefficient for the relationship between emotional engagement and learning satisfaction was found to be 0.478, with a t-statistic of 7.195 and $p < 0.001$, which indicates that emotional engagement could significantly affect satisfaction. Additionally, if a blended learning platform is perceived to be highly useful and easy to use, students are more likely to engage with the platform and become emotionally invested in their learning. This emotional response to learning can lead to increased satisfaction with the learning experience [24,48].

There is a positive correlation between social presence and emotional engagement in online learning environments [68]. Most studies on social presence in online learning have focused on students’ emotional experience of and satisfaction with learning. Social presence has been demonstrated to reduce students’ loneliness or isolation, remove emotional distance between learners, provide trustworthy and convenient learning contexts, and improve the socio-emotional climate of an online course, thereby enabling the development of a stronger sense of online community [58,68,69]. These factors are essential for positive student emotional engagement. According to the study by Grieve et al. [70], social presence facilitates learning more as a socio-emotional support than as a cognitive one. Therefore, based on the above, we developed the following hypotheses:

**H5 (a3b3):** Social presence mediates the relationship between technology acceptance and learning satisfaction.
H6 (a4b4): Emotional engagement mediates the relationship between technology acceptance and learning satisfaction.

H7 (a3d31b4): Social presence and emotional engagement serially mediate the relationship between technology acceptance and learning satisfaction.

Our research model was constructed, based on the literature, as shown in Figure 1. The model is intended to clarify and further elucidate how the different factors directly and indirectly influence learning satisfaction in the VLE.

Figure 1. Research model.

3. Method

3.1. The Virtual Learning Environment

An immersive virtual world platform called Virbela, https://www.virbela.com/ (accessed on 12 May 2024), was selected as the learning space. Virbela offers free registration for users worldwide. Upon their first entry into the platform, users can create their own avatar, which they can then use as a virtual representation of their presence to engage in activities within the virtual world. Once users enter the virtual world, they are greeted with a welcome interface, as shown in Figure 2a. Through the menu linked in the upper left corner, users can access various scenarios that offer opportunities for social activities, such as flying submarines and playing football. Basic social interaction functions are also provided, including shaking hands, clapping, and dancing. The platform provides various open spaces for events, and researchers can purchase concessions to access a private conference room for exclusive events.

The learning activity for this study took place in a private space, shown in Figure 2b. Similar to a conventional lecture-style classroom, the learning area consisted of a stage and several round tables. The stage was equipped with three large screens to facilitate document sharing and independent presentations, and the round tables provided an area for sitting and group discussion. Basic features within the VLE were used to enhance the learning experience. The user could choose between three viewing horizons directly above the interface to zoom in on the screen or stage. When the user was on the stage, presenter perspective was available that permitted the user to control the projection content, activate the laser pointer, and turn on the stage effects (e.g., balloon surround). The communication function area allowed users to chat with others using a microphone and chat board. It also included a raise-hand button that displays a hand above the avatar’s head when clicked. Furthermore, as the purchaser of the private room, the teacher had the authority to make decisions regarding the sound effects and private discussion. More specifically, sound levels could be set to decrease with increasing distance from the speaker or to be independent of distance. Private discussion was provided with a blue circle around each
round table. Those outside the circle are unable to hear discussions within it, but can view the speech bubbles above participants’ heads.

3.2. Participants

This research was conducted at a research university in China, with 237 students (52 males and 185 females; $M_{age} = 20.6$, SD = 1.33) volunteered as participants. These participants consisted of students from five classes taught by the same instructor, including 30 postgraduate students and 207 undergraduate students, who engaged in course presentation activities in the same VLE, and none of whom had any prior experience with the platform. Before the commencement of this study, the informed consent of all participants was obtained. The Institutional Review Board of Central China Normal University has granted ethical approval for this study (IRB No. CCNU_IRB_202111_047).

3.3. Procedure

Prior to the formal class, a pre-class assignment was given to the participants so they could become acquainted with the operation of the VLE and to mitigate the novelty effects. The assignment required the participants to work in groups to locate a scenery site within the VLE and take a group photo. During the formal class, students engaged in presentation activities in which one representative per group presented their instructional system design.
on stage, while the others remained offstage as spectators. After each presentation, the teacher invited questions from students and made comments. Several assistants were assigned throughout the process to aid students with technical difficulties.

The participants were provided with self-report questionnaires after completing their course presentation tasks and were informed that their involvement in the survey was entirely voluntary and anonymous. A QR code was displayed on the screen in the virtual conference room, so students could scan it via their mobile phones and complete a questionnaire, which ensured that only those students with authentic experience of the VLE were included in the survey. Data for the study were collected in two batches, one in December 2022, comprising two classes, and the other from April to June 2023, for three classes. To complement the qualitative data, several research assistants were assigned to observe the whole process, write fieldnotes, and record the presentation sessions.

3.4. Research Instrument

A questionnaire was used to collect basic demographic information (e.g., name, gender, and age) and scales were used for our research constructs related to technology acceptance, cognitive presence, social presence, cognitive engagement, emotional engagement, and learning satisfaction. All scales in this study were measured using a 5-point scale, from 1 (strongly disagree) to 5 (strongly agree). The complete text of the questionnaire is detailed in Appendix A. The reliability and validity of this questionnaire are shown in Table 1.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Items</th>
<th>Cronbach’s α</th>
<th>Factor Loading</th>
<th>CR</th>
<th>AVE</th>
<th>√AVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology acceptance</td>
<td>8</td>
<td>0.836</td>
<td>0.454–0.729</td>
<td>0.840</td>
<td>0.400</td>
<td>0.632</td>
</tr>
<tr>
<td>Cognitive presence</td>
<td>4</td>
<td>0.791</td>
<td>0.667–0.717</td>
<td>0.792</td>
<td>0.488</td>
<td>0.698</td>
</tr>
<tr>
<td>Cognitive engagement</td>
<td>4</td>
<td>0.800</td>
<td>0.608–0.772</td>
<td>0.776</td>
<td>0.466</td>
<td>0.683</td>
</tr>
<tr>
<td>Social presence</td>
<td>4</td>
<td>0.788</td>
<td>0.736–0.827</td>
<td>0.878</td>
<td>0.644</td>
<td>0.802</td>
</tr>
<tr>
<td>Emotional engagement</td>
<td>4</td>
<td>0.759</td>
<td>0.653–0.784</td>
<td>0.798</td>
<td>0.498</td>
<td>0.705</td>
</tr>
<tr>
<td>Learning satisfaction</td>
<td>4</td>
<td>0.877</td>
<td>0.652–0.759</td>
<td>0.802</td>
<td>0.504</td>
<td>0.710</td>
</tr>
</tbody>
</table>

Note: CR: composite reliability; AVE: average variance extracted.

The subscale for technology acceptance was adopted and modified from the User Acceptance Measurement Scale developed by Davis [8] and based on TAM. In the present study, the technology acceptance scale consisted of two subscales (perceived usefulness and perceived ease of use), and each subscale comprised four items. The technology acceptance scale was used to measure student acceptance of VLEs (the metaverse). This scale has been widely used in the literature in technology-enhanced learning environments, including VLEs and similar learning environments such as the metaverse and Second Life [21,22].

The subscales for cognitive presence and social presence scales were based on the questionnaire used by Law et al. [71], which was developed based on the community of inquiry theory and has been employed in blended learning setting. Each scale included four items. The cognitive presence scale examined students’ perception of cognitive activities in the VLE. The social presence scale was used to capture students’ sense of mutually beneficial and constructive interaction within the class in the VLE. The subscales for cognitive engagement and emotional engagement were derived from the Student Engagement Scale developed by Gunuc and Kuzu [72]. Each scale included four items. The cognitive engagement scale measured students’ understanding of the mental efforts they had invested in learning. The emotional engagement scale was designed to measure students’ emotional reactions to the VLE. The subscale for learning satisfaction was measured with four items taken from the Learning Effectiveness Scale used by Chou and Liu [30], which was adopted by Ai-Lim Lee et al. [35] to evaluate learners’ satisfaction in a desktop virtual reality environment.
3.5. Data Analysis

First, the reliability and validity of the questionnaire were assessed using SPSS 26.0 and AMOS 24.0. Second, descriptive, correlational, and difference analyses were conducted using SPSS 26.0. Finally, the serial multiple mediation effect was assessed using the PROCESS v3.3 macro (Model 82) with 5000 bootstrapping estimates to determine the significance of the indirect effects (which were considered significant when the bootstrapping 95% CI did not include zero).

In the serial multiple mediation model, the direct effect (c’ denotes the relationship between X and Y while controlling for all mediators. A specific indirect effect pertains to the relationship between X and Y through a particular mediator or mediators. The value of technology acceptance was entered as the predictor variable (X) and learning satisfaction as the outcome variable (Y). It was assumed that multiple mediators were sequentially linked in two causal chains. More specifically, we assumed that there would be six distinct indirect effects between technology acceptance and learning satisfaction, one through cognitive presence only, one through cognitive engagement only, one through both cognitive presence and cognitive engagement serially, one through social presence only, one through emotional engagement only, and one through both social presence and emotional engagement serially.

4. Results

4.1. Preliminary Analysis Results

4.1.1. Control for Common Method Bias

Since this study used self-report questionnaires, Harman single factor analysis was used to test for common method bias (CMB). According to Podsakoff et al. [73], an interpretation rate of the first factor less than 50% is acceptable. In this research model, the interpretation rate of the first factor was 41.15%, which is a preliminary indication that CMB did not explain most of the variation among variables. Additionally, confirmatory factor analysis (CFA) demonstrated that the one-factor model did not fit the data well: $\chi^2 = 1058.3$, df = 350, $\chi^2$/df = 3.024, CFI = 0.787, TLI = 0.770, RMSEA = 0.093. This suggested that bias due to CMB was unlikely [72].

4.1.2. Reliability and Validity

The preliminary analysis results regarding the reliability and validity of the questionnaire instruments are summarized in Table 1. Cronbach’s $\alpha$ was used to determine scale reliability, with an $\alpha$ value above 0.7 indicating good internal reliability. Convergent and discriminant validity were tested using CFA. Convergent validity is acceptable when the value of the factor loading is above 0.4, composite reliability (CR) is above 0.6, and the average variance extracted (AVE) values are above 0.5 [74]. Discriminant validity requires that the square root of the AVE for each construct is greater than the maximum value of the correlation coefficient between constructs [75]. As shown in Table 1, the statistical assumptions for Cronbach’s $\alpha$, factor loading values, CR, AVE, and $\sqrt{\text{AVE}}$ are largely satisfied, which indicates an overall acceptable reliability and validity for the measurement. However, it is crucial to acknowledge that some AVE values approach but do not surpass 0.5, which potentially poses some concern regarding convergent validity, which must be considered in subsequent interpretations.

4.1.3. Descriptive Statistics and Correlations

The descriptive statistics and Pearson correlations among the variables are presented in Table 2. It can be observed that technology acceptance, cognitive presence, cognitive engagement, social presence, emotional engagement, and learning satisfaction are all significantly positively correlated with each other.
Table 2. Descriptive statistics and Pearson correlations among the variables.

<table>
<thead>
<tr>
<th>Construct</th>
<th>M ± SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Technology acceptance</td>
<td>3.68 ± 0.59</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Cognitive presence</td>
<td>3.94 ± 0.54</td>
<td>0.578 **</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Cognitive engagement</td>
<td>3.92 ± 0.57</td>
<td>0.584 **</td>
<td>0.646 **</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Social presence</td>
<td>4.00 ± 0.57</td>
<td>0.625 **</td>
<td>0.676 **</td>
<td>0.597 **</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Emotional engagement</td>
<td>4.09 ± 0.57</td>
<td>0.581 **</td>
<td>0.654 **</td>
<td>0.647 **</td>
<td>0.683 **</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Learning satisfaction</td>
<td>4.00 ± 0.63</td>
<td>0.651 **</td>
<td>0.664 **</td>
<td>0.577 **</td>
<td>0.620 **</td>
<td>0.717 **</td>
<td></td>
</tr>
<tr>
<td>7. Gender</td>
<td>1.78 ± 0.42</td>
<td>−0.069</td>
<td>0.007</td>
<td>−0.050</td>
<td>−0.001</td>
<td>−0.035</td>
<td>−0.019</td>
</tr>
</tbody>
</table>

Note: M: Mean, SD: Standard deviation, ** p < 0.01, 1: Technology acceptance, 2: Cognitive presence, 3: Cognitive engagement, 4: Social presence, 5: Emotional engagement, 6: Learning satisfaction.

4.2. Mediation Analysis

The mediating roles of cognitive presence, cognitive engagement, social presence, and emotional engagement in the relationship between technology acceptance and learning satisfaction were tested after controlling for the effect of gender. Table 3 demonstrates the results of the regression analysis. Table 4 presents the results of the estimates for the indirect effects. As shown in Table 3, the control variable (gender) was not significantly related to any of the study variables.

Table 3. Multiple linear regression results among variables.

<table>
<thead>
<tr>
<th>Model</th>
<th>R²</th>
<th>F(df)</th>
<th>B</th>
<th>Boot SE</th>
<th>t</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outcome: Cognitive presence</td>
<td>0.334</td>
<td>59.356</td>
<td>1.885</td>
<td>0.226</td>
<td>8.346 ***</td>
<td>1.440 2.330</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td></td>
<td>0.528</td>
<td>0.049</td>
<td>10.895 ***</td>
<td>0.433 0.624</td>
</tr>
<tr>
<td>Technology acceptance</td>
<td></td>
<td></td>
<td>0.061</td>
<td>0.069</td>
<td>0.880</td>
<td>−0.076 0.198</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td>0.058</td>
<td>0.070</td>
<td>0.823</td>
<td>−0.080 0.195</td>
</tr>
<tr>
<td>Outcome: Social presence</td>
<td>0.392</td>
<td>75.388</td>
<td>1.685</td>
<td>0.228</td>
<td>7.398 ***</td>
<td>1.236 2.134</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td></td>
<td>0.598</td>
<td>0.049</td>
<td>12.279 ***</td>
<td>0.502 0.694</td>
</tr>
<tr>
<td>Technology acceptance</td>
<td></td>
<td></td>
<td>0.058</td>
<td>0.070</td>
<td>0.823</td>
<td>−0.080 0.195</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td>0.058</td>
<td>0.070</td>
<td>0.823</td>
<td>−0.080 0.195</td>
</tr>
<tr>
<td>Outcome: Cognitive engagement</td>
<td>0.485</td>
<td>73.015</td>
<td>0.965</td>
<td>0.240</td>
<td>4.030 ***</td>
<td>0.493 1.437</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td></td>
<td>0.304</td>
<td>0.055</td>
<td>5.505 ***</td>
<td>0.195 0.412</td>
</tr>
<tr>
<td>Technology acceptance</td>
<td></td>
<td></td>
<td>0.487</td>
<td>0.061</td>
<td>8.028 ***</td>
<td>0.368 0.607</td>
</tr>
<tr>
<td>Cognitive presence</td>
<td></td>
<td></td>
<td>−0.043</td>
<td>0.065</td>
<td>−0.663</td>
<td>−0.170 0.085</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td>−0.043</td>
<td>0.065</td>
<td>−0.663</td>
<td>−0.170 0.085</td>
</tr>
<tr>
<td>Outcome: Emotional engagement</td>
<td>0.506</td>
<td>79.620</td>
<td>1.104</td>
<td>0.231</td>
<td>4.774 ***</td>
<td>0.648 1.559</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td></td>
<td>0.245</td>
<td>0.057</td>
<td>4.303 ***</td>
<td>0.133 0.357</td>
</tr>
<tr>
<td>Technology acceptance</td>
<td></td>
<td></td>
<td>0.531</td>
<td>0.060</td>
<td>8.925 ***</td>
<td>0.414 0.649</td>
</tr>
<tr>
<td>Social presence</td>
<td></td>
<td></td>
<td>−0.023</td>
<td>0.064</td>
<td>−0.365</td>
<td>−0.150 0.103</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td>−0.023</td>
<td>0.064</td>
<td>−0.365</td>
<td>−0.150 0.103</td>
</tr>
<tr>
<td>Outcome: Learning satisfaction</td>
<td>0.627</td>
<td>77.749</td>
<td>−0.016</td>
<td>0.240</td>
<td>−0.067</td>
<td>−0.489 0.457</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td></td>
<td>0.292</td>
<td>0.059</td>
<td>4.922 ***</td>
<td>0.175 0.408</td>
</tr>
<tr>
<td>Technology acceptance</td>
<td></td>
<td></td>
<td>0.272</td>
<td>0.072</td>
<td>3.769 ***</td>
<td>0.130 0.414</td>
</tr>
<tr>
<td>Cognitive presence</td>
<td></td>
<td></td>
<td>0.000</td>
<td>0.065</td>
<td>0.005</td>
<td>−0.129 0.129</td>
</tr>
<tr>
<td>Cognitive engagement</td>
<td></td>
<td></td>
<td>0.029</td>
<td>0.070</td>
<td>0.412</td>
<td>−0.109 0.167</td>
</tr>
<tr>
<td>Social presence</td>
<td></td>
<td></td>
<td>0.422</td>
<td>0.068</td>
<td>6.171 ***</td>
<td>0.287 0.556</td>
</tr>
<tr>
<td>Emotional engagement</td>
<td></td>
<td></td>
<td>0.018</td>
<td>0.061</td>
<td>0.299</td>
<td>−0.102 0.139</td>
</tr>
</tbody>
</table>

Note: Non-standardized regression coefficients are reported above. Boot SE, bootstrap standard error; CI, confidence intervals. *** p < 0.001.
First, technology acceptance was found to be significantly positively correlated with learning satisfaction, as indicated by the significant regression coefficient \( \beta = 0.29, SE = 0.06, t = 4.92, p < 0.001 \). Therefore, H1 was supported. Second, technology acceptance was significantly positively correlated with cognitive presence \( \beta = 0.53, SE = 0.05, t = 10.90, p < 0.001 \), and cognitive presence was significantly positively correlated with learning satisfaction \( \beta = 0.27, SE = 0.07, t = 3.77, p < 0.001 \). In the estimation of the mediation effect, the results showed the indirect effect of technology acceptance on learning satisfaction via cognitive presence \( a_1b_1 \) was significant (effect = 0.144, SE = 0.04, 95% CI = [0.07, 0.23]), accounting for 21% of the total effects. Thus, H2 was supported. Third, cognitive engagement was not found to significantly predict learning satisfaction \( \beta = 0.00, SE = 0.07, t = 0.01, p = 0.996 \), and the indirect effect of technology acceptance on learning satisfaction via cognitive engagement \( a_2b_2 \) was not significant (effect = 0.000, SE = 0.03, 95% CI = [−0.06, 0.04]). H3 was therefore not accepted.

Fourth, social presence was not found to significantly predict learning satisfaction \( \beta = 0.03, SE = 0.07, t = 0.41, p = 0.681 \), and the indirect effect of technology acceptance on learning satisfaction via social presence \( a_3b_3 \) was not significant (effect = 0.018, SE = 0.05, 95% CI = [−0.08, 0.11]). H5 was therefore not accepted. Fifth, technology acceptance significantly positively predicted emotional engagement \( \beta = 0.25, SE = 0.06, t = 4.30, p < 0.001 \), and emotional engagement significantly positively predicted learning satisfaction \( \beta = 0.42, SE = 0.07, t = 6.17, p < 0.001 \). In the estimation of the mediation effect, the results showed the indirect effect of technology acceptance on learning satisfaction via emotional engagement \( a_4b_4 \) was significant (effect = 0.103, SE = 0.04, 95% CI = [0.04, 0.19]), accounting for 15% of the total effects. Thus, H6 was supported.

In the serial mediation analysis, the indirect effect of technology acceptance on learning satisfaction serially through cognitive presence and cognitive engagement \( a_1d_2b_2 \) was not significant (effect = 0.00, SE = 0.02, 95% CI = [−0.04, 0.04]), because cognitive engagement was not found to have a significant impact on learning satisfaction. H4 was therefore not supported. A significant indirect effect serially through social presence and emotional engagement \( a_3d_3b_4 \) was found (effect = 0.134, SE = 0.03, 95% CI = [0.08, 0.20]), however, accounting for 19% of the total effects, so H7 was supported.

The results above indicate that technology has a direct effect on learning satisfaction. Cognitive presence and emotional engagement also play a mediating role between technology acceptance and emotional learning, while social presence and emotional engagement serially mediate the relationship between technology acceptance and learning satisfaction. A serial mediating model was ultimately established, as shown in Figure 3.

### Table 4. Serial mediating effect of technology acceptance and learning satisfaction.

<table>
<thead>
<tr>
<th>Path</th>
<th>Effect</th>
<th>Boot SE</th>
<th>95% CI Lower</th>
<th>95% CI Upper</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total effect</td>
<td>0.688</td>
<td>0.052</td>
<td>0.585</td>
<td>0.792</td>
<td></td>
</tr>
<tr>
<td>Direct effect</td>
<td>0.290</td>
<td>0.059</td>
<td>0.174</td>
<td>0.406</td>
<td></td>
</tr>
<tr>
<td>Total indirect effect</td>
<td>0.398</td>
<td>0.053</td>
<td>0.297</td>
<td>0.506</td>
<td></td>
</tr>
<tr>
<td>H2: X→M1→Y</td>
<td>0.144</td>
<td>0.042</td>
<td>0.068</td>
<td>0.231</td>
<td>21%</td>
</tr>
<tr>
<td>H3: X→M2→Y</td>
<td>0.000</td>
<td>0.025</td>
<td>−0.056</td>
<td>0.044</td>
<td></td>
</tr>
<tr>
<td>H5: X→M3→Y</td>
<td>0.018</td>
<td>0.048</td>
<td>−0.075</td>
<td>0.113</td>
<td></td>
</tr>
<tr>
<td>H6: X→M4→Y</td>
<td>0.103</td>
<td>0.038</td>
<td>0.038</td>
<td>0.186</td>
<td>15%</td>
</tr>
<tr>
<td>H4: X→M1→M2→M4→Y</td>
<td>0.000</td>
<td>0.020</td>
<td>−0.042</td>
<td>0.039</td>
<td></td>
</tr>
<tr>
<td>H7: X→M3→M4→Y</td>
<td>0.134</td>
<td>0.032</td>
<td>0.078</td>
<td>0.203</td>
<td>19%</td>
</tr>
</tbody>
</table>

Note: 5000 bootstrap samples were used. Confidence intervals (95% CI) that contain zero are interpreted as non-significant. X, Technology acceptance; M1, Cognitive presence; M2, Cognitive engagement; M3, Social presence; M4, Emotional engagement; Y, Learning satisfaction.
Figure 3. Research model predicting learning satisfaction in the metaverse: Path coefficients. Note: Standardized coefficients are displayed above. *** $p < 0.001$. Dashed lines represent non-significant paths.

5. Discussion

The current study examined the relationship between technology acceptance and learning satisfaction by combining cognitive presence, social presence, cognitive engagement, and emotional engagement. This section provides a theoretical explanation for and interpretation of the results in light of the existing literature. Finally, the limitations of the current study and suggestions for future research are discussed.

Consistent with the research of Cheng and Yuen [76], it is evident that technology acceptance directly relates to learning satisfaction. This finding underscores the importance of incorporating user-friendly technology into learning environments, as doing so can effectively promote satisfaction. In line with TAM, perceived ease of use and perceived usefulness play a pivotal role in shaping users’ attitudes and behavioral intentions [77]. These perceptual factors not only inform users’ overall evaluation of the technology, but also directly correlate with their experience during use. Consequently, when technology in the learning environment is deemed both useful and easy to use, learners’ satisfaction with the learning process tends to increase significantly. This explains why technology acceptance has a direct bearing on learning satisfaction, because positive perceptions of technology translate directly into positive evaluations of the learning experience.

Technology acceptance also indirectly contributes to learning satisfaction. There is a significant mediating effect of cognitive presence in the relationship between technology acceptance and learning satisfaction, which suggests that learners with a high level of technology acceptance are more inclined to regard features within VLEs, including interaction and exploration, as instruments that augment their learning experience. This augmentation facilitates their perception of higher-order thinking activities, which ultimately contributes to heightened learning satisfaction [39]. Emotional engagement also emerged as a crucial mediating factor for learning satisfaction, which indicates that when the platform and instructional design align with the students’ emotional needs, their sense of identity and belonging are enhanced, which subsequently results in higher levels of student satisfaction. This finding is in line with previous research conducted by Gao et al. [24] and Lee et al. [48].

The present study also validated the pathway of technology acceptance → social presence → emotional engagement → learning satisfaction. This suggests that the usefulness and ease of use of virtual learning platforms provide technological support for students’ social and emotional self-projection, resulting in a positive emotional response to the course and to peers, ultimately enhancing learning satisfaction. In line with previous
studies [24,66,67], this also indicates that the transformation of students’ perceived sociality into emotional recognition and engagement within the VLE is essential for improving their overall satisfaction with the learning process.

It is noteworthy that cognitive presence—rather than engagement—was found to enhance learning satisfaction. This implies that when designing a VLE that aims at promoting learning satisfaction, the mere awareness of its functions to support higher-order thinking might suffice to induce students’ favorable opinions, even without heavy engagement with those functions. Indeed, enabling students to perceive the role of technology in supporting their cognitive endeavors is arguably more effective. Conversely, consistent with Joo et al. [78], social presence must be transformed into emotional connection to increase satisfaction. This partially explains why online video lectures, such as those conducted on platforms such as Zoom, often lead to substandard learning experiences [1,2]. Although learners are aware of the presence of their instructors and peers, the absence of emotional stimulation hinders satisfaction [3]. In our study, it appeared that the sense of representational fidelity and learner interactions were enhanced within the VLE. This enhancement also contributed to increasing emotional engagement, which ultimately led to improved learning experiences.

There are several practical implications for educators and designers based on the research findings. For educators, it is crucial to select appropriate technologies to facilitate effective learning, as perceived usefulness and ease of use are key to enhancing learning experience. Paying attention to the learners’ emotional needs and identity is also suggested, in addition to ensuring a social learning environment. To foster stronger connections among learners, teachers can leverage the unique features of the platform. For designers of VLEs, it is important to prioritize the platform’s technical usefulness and ease of use. The platform should also support a variety of social activities and scenarios to meet the needs of learners for dialogue, interaction, and meaning construction—that is, creating a learning environment where technology is not just a tool but also an enabler of deeper learning and satisfaction is recommended.

Limitations and Future Research

The current study has several limitations that should be acknowledged. First, the reliance on questionnaire surveys introduced a degree of subjectivity in the measurement, which may affect the validity and reliability of the results. Second, the research was conducted within a specific school and using a particular metaverse platform. As such, the findings may not be generalizable to other settings or platforms. Additionally, the study was conducted in the Chinese context, and thus the findings might be contextually bounded since student perception and behaviors in the VLE are shaped by cultural mores and social expectations. Future research could thus extend the study to include various educational institutions, cultural contexts, and metaverse platforms, thus providing a more comprehensive understanding of the phenomenon under investigation. Moreover, the model presented in this study only considered a limited set of variables. Future research could enrich the model by incorporating additional variables to provide a more nuanced perspective. Finally, the present study relied primarily on quantitative data but lacked qualitative data such as interviews and observations, making it difficult to interpret and explain the quantitative findings. Future researchers are encouraged to collect a broader array of data types to achieve triangulation between quantitative and qualitative data, thereby enhancing the trustworthiness and meaningfulness of the research findings.

6. Conclusions

This study sought to contribute to the existing literature on learning experiences within VLEs in response to calls to explore immersive instructional activities in VLEs [79]. This study therefore sought to clarify the underlying mechanism between technology acceptance and learning satisfaction from the perspectives of TAM and social learning theory. The results revealed that learning satisfaction is not merely driven by a student’s adoption of
new learning technology, but also by a range of cognitive and emotional attributes that reflect the user’s positive perception of and engagement within the system. In other words, students with a positive attitude toward technology are more likely to perceive the design intentions for fostering advanced thinking, actively communicate and collaborate with peers, and emotionally invest in the learning process. These affirmative experiences, in turn, result in higher satisfaction with the VLE learning experience.

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

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Institutional Review Board Statement: This research was conducted in accordance with the principles set forth in the Declaration of Helsinki and received ethical clearance from the Ethics Committee of CENTRAL CHINA NORMAL UNIVERSITY (with the protocol code ccnu-IRB-202111-047, approved on 24 November 2021).

Informed Consent Statement: Informed consent was received from all participants in this research. Written informed consent was obtained from participants for publication of this paper.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

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

Appendix A. Learning Experience Questionnaire
Part One: basic information

<table>
<thead>
<tr>
<th>Name:</th>
<th>Birth Sex:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age:</td>
<td>Majors:</td>
</tr>
</tbody>
</table>

Part Two: learning experience

This section is about experience on online discussion activities. There are 28 items below, ranging from “strongly disagree”–“strongly agree”, please choose one according to your actual feelings.

Technology acceptance
1. Using the metaverse platform improves my study performance.
2. Using the metaverse platform enhances the effectiveness of my studying.
3. The metaverse platform allows me to study at my own pace.
4. Overall, I find the metaverse platform useful for studying.
5. It was easy for me to use the metaverse platform to study.
6. The functions of the metaverse platform are intuitive and easy to understand.
7. I can complete the installation and use of the metaverse platform independently.
8. Overall, I find the metaverse platform easy to use.

Cognitive presence
9. I can quickly acquire knowledge from the course.
10. The course provides the chance for me to reflect on what I learned.
11. The course allows me to explore more ideas and integrate ideas into solutions.
12. Participating in the study about the metaverse has given me a new understanding of this course.

Social presence
13. The course provides opportunities for me to express my opinions.
14. The course offers the opportunity for me to interact formally with fellow students (e.g., face-to-face discussion).
15. The course provides enough collaborative activities.
16. I enjoy participating in the course activities.

Cognitive engagement

17. When learning in the metaverse, I motivate myself to learn.
18. I try to do my best during the class in the metaverse.
19. I enjoy the intellectual difficulties I encounter while learning in the metaverse.
20. I spend enough time and make enough of an effort to learn.

Emotional engagement

21. I think studying in this course in the metaverse is beneficial for me.
22. When learning in the metaverse, I feel that I am a part/member of a student group.
23. I like communicating with my teacher.
24. I like seeing my friends during this course.

Learning satisfaction

25. I was satisfied with this type of metaverse learning experience.
26. I was satisfied with the learning flexibility and independence of this course.
27. I was satisfied with the teaching methods in this type of metaverse learning environment.
28. I was satisfied with this type of metaverse learning environment.

References


38. Slater, M. How colorful was your day? Why questionnaires cannot assess presence in virtual environments. *Presence* 2004, 13, 484–493. [CrossRef]


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