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Research Article

The Mediating Role of Interaction in the Relationship between Engagement and Satisfaction in Synchronous Virtual Environments among Korean Students

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Abstract
The importance of learner engagement and interaction in shaping satisfaction has emerged as a central theme in educational technology research. Central to the discourse on satisfaction in synchronous virtual learning is the premise that interaction serves as a driver of learner engagement. Despite its importance, little research has explored the underpinnings of this relationship. The purpose of this study was to examine the impact of engagement and interaction on student learning satisfaction in a synchronous virtual learning environment. The study included a sample of two hundred middle and high school students, consisting of 101 males (51%) and 99 females (49%), who completed measures of engagement, interaction, satisfaction, and open-ended questions. Hypotheses were tested using mediation analysis. Results revealed a number of positive correlations between student engagement, interaction, and satisfaction. In addition, mediation analysis indicated an indirect effect of student engagement on satisfaction in the virtual learning environment, mediated by student interaction (*ab* = .33, SE = .04, 95% bootstrap CI .25 to .41). Sentiment analysis also revealed that 23% of respondents expressed positive opinions, while 67% and 10% of responses were neutral and negative, respectively. These findings suggest that future educators of synchronous virtual learning environments should consider prioritizing student engagement and interaction as a strategic approach to increasing satisfaction.
Keywords: Engagement, Virtual Learning, Student Interaction, Satisfaction.

Introduction

The catastrophic COVID-19 pandemic has created immense strain within secondary and higher education systems worldwide. As a response, numerous educational institutions in South Korea transitioned from conventional in-person instruction to home-based virtual learning. This swift paradigm shift towards online education has brought about profound changes in both teaching methodologies and student learning experiences. The terminology of "virtual learning" and "online learning" is often interchangeably used by educators and researchers, typically connoting the utilization of technology in facilitating educational access (Conrad, 2002; Carliner, 2004). Dillenbourg *et al.,* (2002), however, define the virtual learning context as a distinct subset of online learning, describing it as a "social space" where "educational interactions convert spaces into places" (p. 3). Given the undeniable significance of the social context within learning environments, this study is designed to investigate satisfaction outcomes for learners in virtual learning environments.

Similar to traditional physical classrooms, student engagement and interaction within a virtual learning environment are believed to be fundamental determinants of successful educational outcomes. Students who actively engage and interact in class are typically more successful learners. However, the majority of previous research has largely focused on physical classrooms rather than virtual learning environments. This study aims to fill this research gap by investigating the relationships among factors influencing satisfaction in synchronous virtual learning environments, as well as examining whether the correlation between student engagement and satisfaction is mediated by interaction within these virtual contexts. Through this investigation, the present study seeks to expand our understanding of students' perceptions of

their engagement, interaction, and satisfaction within virtual learning environments, and more broadly, their overall learning satisfaction during the unprecedented era of the COVID-19 pandemic.

Empirical Research on Engagement and Interaction with Regard to Satisfaction in Virtual Learning Environments

Student engagement is considered an important source of academic success and satisfaction in education (Marks, 2000; Robinson, 2011; Banna *et al.,* 2015; Hew, 2016). It has been shown that disengagement in school is one predictor of dropout (Achambault *et al.,* 2009). Generally, engagement refers to "students' level of involvement with and effort in learning" (Fredricks, *et al.,* 2004; Wang *et al.,* 2017). While researchers and practitioners conceptualize student engagement in multiple ways (Azvedo, 2015), Kuh (2003) identifies student engagement in terms of "time and energy" devoted to educational activities, and Kuh's operationalization gave rise to four factors showing how students devote their time and energy in the classroom: skills engagement, participation engagement, emotional engagement, and performance engagement (Handelsman *et al.,* 2005). Skills engagement is when students put forth effort (e.g., by doing a reading assignment). Participation engagement is when students actively discuss in small groups. Emotional engagement is when students apply the content of a lesson to their own lives. And performance engagement is when students do well on tests or receive a good course grade. In sum, student engagement involves both affective ad behavioral components.

In a recent study, Baloran *et al.,* (2021) conducted a study of a sample of 529 university learners in the Philippines. The majority of the participants were male (56%) and many were first year (42%) college students at the university. This study was designed to examine the level of course satisfaction and student engagement in online learning. They identified student engagement in terms of Kuh's four domains: skills engagement, emotion engagement, participation engagement, and performance engagement. They found that participants who were satisfied with online classes also had a high level of online learning engagement ($r = .336$, $p < .001$). Moreover, the subdomains of student engagement were statistically correlated with student satisfaction (skills, $r = .333$; emotion, $r = .322$; participation, $r = .295$; and performance, $r = .229$). Essentially the same conclusion was reached by Oraif and Elyas (2021) in a study involving high school girls in Saudi Arabia. The authors examined the level of engagement among girls with their online classes. The correlation between students' engagement and satisfaction in online classes was positive and large. In particular, they found that the sampled students showed engagement with their online classes in relation to their classroom participation, interaction with peers and teachers, emotional involvement with the course material, performance in the class.

Furthermore, the existing literature shows that positive engagement has benefits across grade levels as well as academic disciplines. When investigating student engagement across grade levels in secondary schools in two subjects (mathematics and social studies), Marks (2000) reported that the pattern of engagement across grade levels was positive and consistent, and that mathematics classes had higher levels of engagement among students than social studies classes. The concept of student interaction has been also shown to play a critical role in success in virtual learning contexts (Croxton, 2014; Martin and Bolliger, 2018). Previous research has suggested that the effects of interaction might be direct in virtual learning environment. However, this depends on the type of the virtual learning environment, whether it is a synchronous or asynchronous online learning environment. For example, Vuopala *et al.,* (2016) conducted a study with 54 higher education students attending three universities in Europe. Students attended online classes lasting from 45 to 120 minutes, and their instruction involved both synchronous and asynchronous virtual learning. Employing a qualitative approach, the researchers found that student interaction could be fairly described as learners actively engaged in planning and organizing joint activities. They also found that forms of interaction differed between the synchronous and asynchronous environment. Synchronous interactions included more informal discussions amongst the students.

Martin and Bolliger (2018) proposed the current model of online interaction, which divides into three types: student-student, student-teacher, and student-content. Student-student interaction means the extent to which students are sharing and discussing information among themselves. Student-teacher means the level of involvement the teacher has with the students. Student-content means the interaction between the learners and online materials like audio files, video clips, and PPTs. In a study involving post-secondary students, Martin and Bolliger (2018) explored the online learning of 146 (68% female, 21% male) graduate students, ranging in age from 20 to 67 and enrolled in a variety of graduate programs across eight universities in the United States. Based on Moore's (1993) research on interaction, the researchers developed a 36-item Likert-scale to investigate these three types of interaction. Their study found many

strategies to increase interaction in online classrooms, including realistic and authentic materials for discussions, and announcements and email reminders. Despite the growing literature on the importance of positive engagement and interaction on outcomes in the field of education, very little is known about the relationship between engagement and satisfaction vis-a-vis interaction in virtual learning contexts. Moreover, what prior research there is has often strictly focused on college students. The present study therefore seeks to explore how online interactions impact the association between engagement and satisfaction, with the aim of enhancing our understanding this process among Korean middle and high school students.

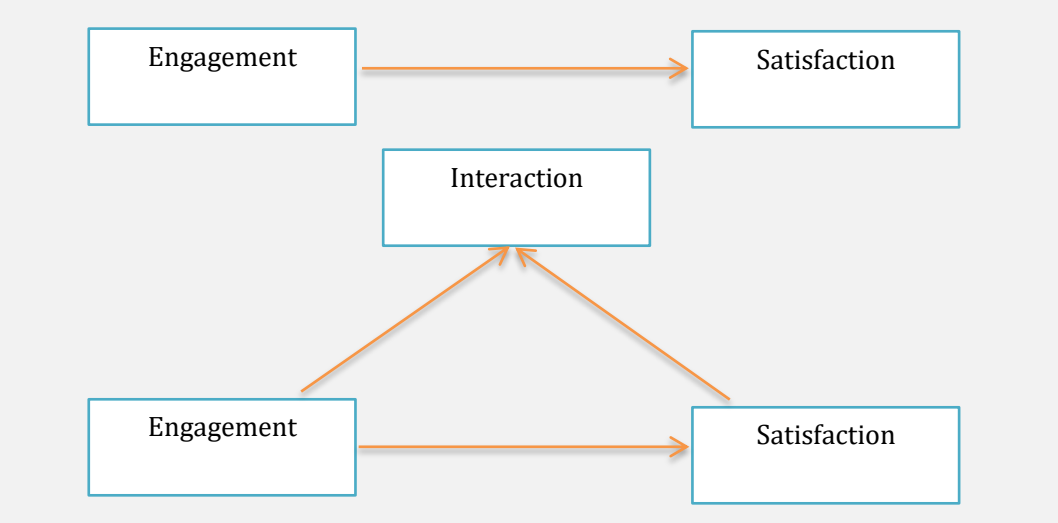

Figure 1. Conceptual model of relations among engagement, interaction, and satisfaction.

The Present Study

The body of literature reviewed above suggests that interaction may play an important role in student satisfaction in synchronous virtual learning environments. Thus, this study aims to understand how secondary school students' interaction level explains their own perception of engagement and satisfaction in a synchronous online learning environment, and in turn how to promote virtual learning during the unprecedented COVID-19 pandemic. The following research questions guide my inquiry:

Research Question 1: What is the correlation among secondary school students' engagement, interaction, and satisfaction in a synchronous virtual learning environment?

Research Question 2: Do secondary students' interaction mediate the relationship between engagement and satisfaction in a synchronous virtual learning environment?

Research Question 3: What are the attitudes of participants regarding their satisfaction with the virtual learning environment?

Methods

Participants

Participants in the study were secondary school students from Seoul in the Republic of Korea, with 30% (n = 59) of participants classified themselves as middle school students and 70% (n = 141) had high school student status. A total of 200 middle and high school students (n = 101, 51% male; n = 99, 49% female) responded to the questionnaire. Mean age for all participants was 16.42 years (SD = 1.48).

Measures

Measures of student engagement, interaction, and satisfaction were collected at the beginning of the summer of 2022. Table 1 shows all the items of the questionnaire for quantitative analysis. The items on the questionnaire aimed at the three domains (engagement, interaction, and satisfaction) of the study. Table 2 shows sub-domain, number of items per sub-domain, and reliability coefficients for all the sub-domains of the assessment. Specifically, the Cronbach's alpha reliability coefficient was also computed for each of the sub-domains of the assessment. The values ranged from .84 to .89, which showed acceptable internal reliability (Nunnally, 1978). The reliability of the full scale of 35 items was .93. In the following section, measures of student engagement, interaction, and satisfaction are described in detail.

Table 1. Questionnaire Items by domain.

Domain	Sub-domain	No.	Item
Engagement	Skill	1	Making sure to study on a regular basis.
	Emotion	2	Putting forth effort.
	Skill	3	Looking over class notes before getting online to make sure I understand the material.
	Skill	4	Looking over class notes before getting after to make sure I understand the material.
	Skill	5	Taking good notes over readings, PowerPoints, or video lectures.
	Skill	6	Listening/reading carefully.
	Emotion	7	Finding ways to make the course material relevant to my life.
	Emotion	8	Applying course material to my life.
	Participation	9	Having fun in online chats, discussions or via email with the instructor or other students.
	Participation	10	Participating actively in small-group discussion forums.
	Participation	11	Helping fellow students.
	Performance	12	Getting a good grade.
	Performance	13	Doing well on the tests/quizzes.
	Participation	14	Engaging in conversations online (chat, discussions, email).
	Participation	15	Posting in the discussion forum regularly.
	Participation	16	Getting to know other students in the class.
Interaction	Student-student	17	Students interact with peers through discussions.
	Student-student	18	Students work collaboratively using online communication tools to complete team projects.
	Student-student	19	Students work collaboratively using online communication tools to complete homework.
	Student-student	20	Students work collaboratively using online communication tools to complete problem solving assignments.
	Student-teacher	21	The instructor sends/posts regular announcements or email reminders.
	Student-teacher	22	The instructor provides students with opportunity to contact the instructor with questions about the course.
	Student-teacher	23	The instructor posts a “due date checklist” at the end of each instructional unit.
	Student-teacher	24	The instructor uses various features to interact with students (e.g., polls, emoticons, whiteboard, text, or audio and video chat).
	Student-content	25	Students interact with content in more than one format (e.g., text, image, video, audio).
	Student-content	26	Students search for and select applicable materials (e.g., articles, videos) based on their interests.
Satisfaction	Satisfaction	27	I am satisfied to communicate effectively with my teachers throughout the semester.
	Satisfaction	28	I am satisfied with the support of my teachers in accessing various educational materials related to the course.
	Satisfaction	29	I am satisfied that my teachers are enthusiastic about online learning.
	Satisfaction	30	I am satisfied to receive feedback from my teachers online.
	Satisfaction	31	I am satisfied with the speed of the online system.
	Satisfaction	32	I am satisfied that the online system is easy to use.
	Satisfaction	33	I have learned a great deal in online class.
	Satisfaction	34	Overall, I am satisfied with virtual learning courses.
	Satisfaction	35	The virtual learning courses offered by my school exceed my expectations.

Table 2. Domain, sub-domain, number of items, and Cronbach's alphas per domain.

Domain	Sub-domain	Number of items	Cronbach's alpha
Engagement	Skill	5	.89
	Participation	6	
	Emotion	3	
	Performance	2	
Interaction	Student-student	4	.87
	Student-teacher	4	
	Student-content	2	
Satisfaction	Satisfaction	9	.84
Total		35	.93

Student Engagement

Student engagement was assessed using the modified Online Student Engagement Scale (OSE), which was developed by Dixson (2015). The questionnaire consisted of 16 items designed to assess a participant's level of engagement during online learning. There were four domains, with items comprising 5 items for skills engagement (Cronbach's alpha = .69), 6 items for participation engagement (Cronbach's alpha = .74), 3 items for emotional engagement (Cronbach's alpha = .58), and 2 items for performance engagement (Cronbach's alpha = .66). Each item was rated on a 5-point Likert scale (from 1 = *not at all characteristic of me* to 5 = *very characteristic of me*). The Cronbach's alpha reliability for student engagement was 0.89.

Student Interaction

Interaction was assessed with the modified 10-item Martin and Bolliger (2018) questionnaire, which measures participants' level of engagement across the three sub-domains: student-student, student-teacher, and student-content; 4 items assess student-student interaction (Cronbach's alpha = .67), 4 items assess student-teacher interaction (Cronbach's alpha = .79), and 2 items assess student-content interaction (Cronbach's alpha = .67). All items were rated on a 6-point Likert scale (from 1 = *strongly disagree* to 6 = *strongly agree*). The Cronbach's alpha reliability for student interaction was 0.87.

Student Satisfaction

Satisfaction was evaluated using the adapted Development of Online Course Satisfaction Scale, which is based on the work of Bayrak *et al.,* (2020). The scale included 9 items are designed to assess students' online satisfaction. Participants reported on a 5-point Likert scale ranging (from 1 = *strongly disagree* to 5 = *strongly agree*). To determine reliability of satisfaction for online learning, Cronbach's alpha was computed. The reliability of this scale was .84.

Procedures

The data was collected through a field service company for two reasons. First, instead of isolating one middle or high school with homogenous demographics, a field service company allowed data on a representative sample of secondary students in Seoul to be collected. The second reason is due to convenience sampling: the Korean high school students are on their vacation and the sampling of secondary school students was possible through the field service company. The questionnaire was administered in an individual context, and took approximately 25 to 30 minutes to complete.

Data Analysis

In order to describe the study variables, means, standard deviations, minimums, maximums, skewness, and kurtosis were computed using SPSS Statistics 27 (IBM Corp, 2020). Correlations among all the study variables were also conducted in SPSS Statistics 27. A bootstrapping mediation analysis allowed for the testing of three key hypotheses of the mediation model: (1) the total effect of student engagement on virtual learning environment satisfaction; (2) the direct effect of student engagement on interaction and the direct effect of student interaction on virtual learning environment satisfaction, and (3) the indirect effect of student engagement on virtual learning environment satisfaction via student interaction. As recommended by Preacher and Hayes (2008), all the relationships of the mediation model were tested using a bootstrapping procedure.

Furthermore, sentiment analysis, a powerful machine learning tool in the era of data mining, uses natural language processing, text analysis, and computational linguistics to systematically extract and quantify participants' affective states (Mite-Baidal, *et al.,* 2018; Wankhade, *et al.,* 2022). In the present study, the

Orange Data Mining tool (Demsar *et al.,* 2013) was used to perform the sentiment analysis, which allows the automatic assessment of participants' sentiments or attitudes, opinions, and emotions using survey responses. These sentiments are categorized as positive, negative, or neutral. Of note, participants responded to the open-ended question in their native language (i.e., Korean). Therefore, multilingual sentiment, an approach where Korean language is used for analysis.

Results

Preliminary Analysis

Means, standard deviations, minimums, maximums, skewness, and kurtosis among the main variables are reported in Table 3. The normality of the variables was examined: skewness and kurtosis values fell between -.17 and .01, and 2.82 and 3.69, respectively. These values were in the accepted range of normal distribution, with subsequent analysis conducted using raw values.

Inter-correlations among all study measures are displayed in Table 4. All associations were statistically significant. Specifically, middle and high school students' satisfaction was positive and strongly related to skills, emotion, participation, and performance ($.55 \leq rs \leq .74$). Student satisfaction showed a significantly positive relation to student-student, student-teacher, and student-content interaction ($.33 \leq rs \leq .63$). Overall, student satisfaction showed a strong positive association with engagement ($r = .89$) and interaction ($r = .52$).

The above findings provide support for Research Question 1 in that secondary students who had positive engagement and interaction were linked to their satisfaction in synchronous virtual learning environment. This finding is in line with the results of previous research suggesting the influence of engagement and interaction on students' satisfaction (e.g., Marks, 2000; Vuopala *et al.,* 2016; Baloran *et al.,* 2021; Oraif, and Elyas, 2021).

Table 3. Descriptive statistics of all study variables.

	Engagement	**Interaction**	**Satisfaction**
Mean	3.13	2.78	2.72
SD	.66	.69	.66
Minimum	1	1	1
Maximum	5	5	5
Skewness	.01	-.17	-.06
Kurtosis	3.69	2.82	3.26

Table 4. Correlations of all study variables.

	Domain	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	Skill	1.00									
2	Emotion	.68*	1.00								
3	Participation	.74*	.71*	1.00							
4	Performance	.55*	.53*	.66*	1.00						
5	Student-student	.63*	.57*	.62*	.51*	1.00					
6	Student-teacher	.63*	.57*	.62*	.51*	1.00*	1.00				
7	Student-content	.33*	.29*	.40*	.32*	.52*	.52*	1.00			
8	Engagement	.89*	.83*	.93*	.76*	.69*	.69*	.40*	1.00		
9	Interaction	.52*	.52*	.60*	.46*	.83*	.83*	.83*	.63*	1.00	
10	Satisfaction	.36*	.36*	.50*	.39*	.58*	.58*	.73*	.48*	.81*	1.00
Note: $p < .01$											

Mediation Analysis

To test whether student interaction contributed to increased synchronous student satisfaction, a mediation analysis using bootstrapping was employed, following guidelines from Hayes and Preacher (2014). First, using a 95% confidence interval obtained from 5,000 bootstrap samples, the mediation analysis indicated that although the total effect of engagement on student satisfaction was statistically significant, $c = .30$, SE = .04, $p < .001$, there is no evidence that engagement directly influences student satisfaction, $c' = -.30$, SE = .03, $p = .434$. Second, the path from student engagement to interaction was statistically significant, $a = .41$, SE = .04, $p < .001$. Third, the path from student interaction to synchronous student satisfaction was statistically

significant, b = .80, SE = .05, p < .001. Lastly, the indirect effect of engagement on satisfaction through student interaction was statistically significant, ab = .33, SE = .04, 95% bootstrap CI .25 to .41.

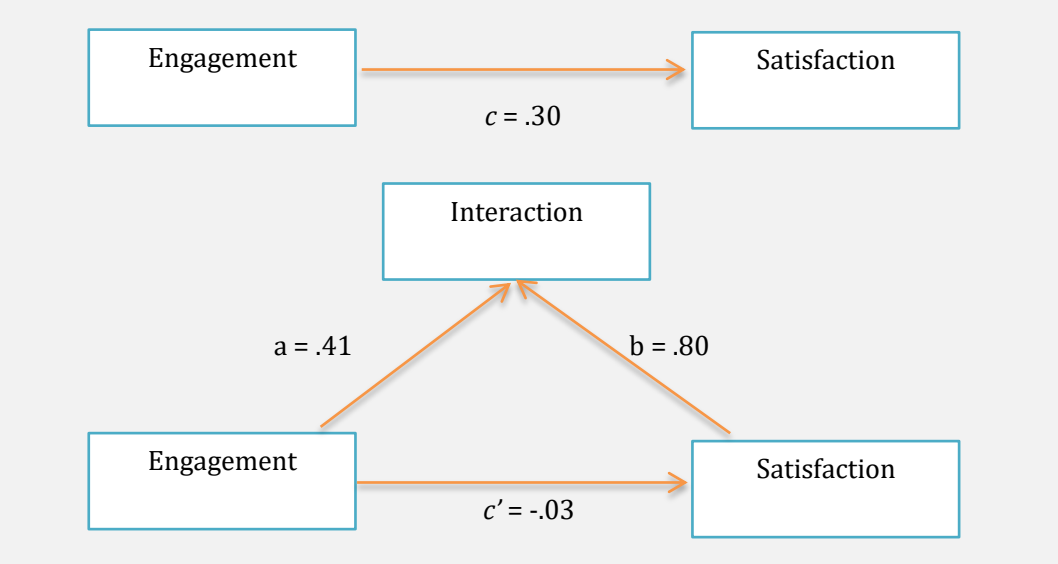

Figure 2. Results of the mediation analysis.

Sentiment Analysis

The sentiment analysis, which focused on evaluating participants' satisfaction with virtual learning environments, observed a wide range of sentiments, as shown in Figure 3. A minority, representing 10% (k = 20) of the participants, expressed negative sentiments about virtual learning. These sentiments likely reflect issues such as lack of engagement, technical difficulties, or general dissatisfaction with the virtual learning experience. Examples of these negative responses include:

Example 1

학교까지 가는 준비시간이 줄어들어 좋았지만 집이다보니 주변에 집중을 방해하는 요소들이 많아 집중이 어려웠다. (학생번호78)

It was nice to have less time to get ready for school, but it was hard to concentrate at home because there were so many distractions. (Student ID78)

Example 2

가끔 연결이 끈어져 수업이 진행되지 않은점과 학생들이 마이크를 키기 싫어하는 편인데 그렇다보니 선생님이 혼자 수업하는 느낌이 들기도 한다. (학생번호60)

Sometimes the connection drops and the class doesn't go on, and students don't like to turn on their microphones, so it feels like you're teaching alone. (Student ID60)

Example 3

사립학교의 학생으로서 사랍학교 특성상 나이가 많은 선생님이 많이 계시는데, 나이가 많으신 선생님들께서는 인터넷 문화가 익숙하지 않으셔서 온라인 수업에 적응하시는데 오랜 시간이 걸리셨고 적응 후에도 갑작스럽게 나타나는 오류나 버그상황에 유연하게 대처하지 못 하셨다. 또한 학교 업무에 최적화된 학교의 컴퓨터 성능으로는 많은 학생들을 관리하기 어려웠고 관리가 된다고 하더라도 학교에서 수업을 듣는 것만큼 집중하기도 어려웠고 소통부분에서도 학교 수업이 더 잘 되는 것 같았다. (학생번호156)

As a student in a private school, there are many older teachers due to the nature of private schools, but older teachers are not familiar with the Internet culture, so it took them a long time to adapt to online classes, and even after they adapted, they could not flexibly cope with errors or bugs that suddenly appeared. In addition, it was difficult to manage many students with the school's computer performance optimized for school work, and even if it was managed, it was difficult to concentrate as much as in school, and it seemed that school classes were better in communication. (Student ID156)

Conversely, the majority of participants, approximately 67% (k = 134), expressed neutral sentiments. This neutrality may suggest a level of ambivalence or moderate acceptance, indicating that while these participants did not find significant flaws in the virtual learning system, they also did not perceive it as particularly beneficial or engaging. Examples of neutral responses include:

Example 4
수업의 관리 및 질이다. 일부 학교는 좋은 자료, 직접 수업 등으로 만족스러운 반면 일부는 EBS를 시청하는 등 불만족스러운 수업이 많아 공교육의 필요성을 저하시켰다. (학생번호10)

The management and quality of classes: Some schools are satisfactory with good materials, in-person classes, etc. while others are unsatisfactory, such as watching EBS, which reduces the need for public education. (Student ID10)

Example 5
비대면 수업으로 하다보니까 친구들과의 소통이 원활하지 않았고, 친해지는데 어려움이 많이 있었다. 선생님과의 소통도 잘안되고 대면보다 수업준비와 수강이 많이 어려웠다. (학생번호53)

I had a hard time communicating with my friends and getting to know them. I couldn't communicate well with my teacher and it was much harder to prepare for and take classes than face-to-face. (Student ID53)

Example 6
만족하는 점은 시간에 쫓기지 않고 집에서 편하게 수업을 들을 수 있는점이고, 불만족하는 점은 아무래도 서버가 튕기거나 불안정할때 수업이 원할하게 진행되지 않는점, 또 학교에서 수업할때보다 집중력이 떨어지는 점 같아요. (학생번호27)

What I like is that I can take classes at home without being pressed for time, and what I don't like is that the classes don't run smoothly when the server is bouncing or unstable, and that I can't concentrate as well as I did in school. (Student ID27)

On the positive side, a significant proportion, 23% (k = 46) of participants expressed favorable sentiments towards their virtual learning experience. This positivity could be linked to factors such as the convenience and flexibility of virtual learning, and a preference for this learning mode over traditional classroom settings. Positive responses included:

Example 7
집에서 편하게 수업할수 있다는 점이 가장 만족스러웠다. (학생번호100)

I was most satisfied with the ability to learn from the comfort of my own home. (Student ID100)

Example 8
집에서 편하게 수업을 들을 수 있다는 부분에서 가장 만족하다. (학생번호89)

Most satisfied with the ability to take classes from the comfort of their own home. (Student ID89)

Example 9
온라인 비대면 수업 "만족" 동영상 시청시, 내가 멈추고 싶을때 멈출 수 있어서 문제를 풀때 유용했다. 집에만 있어서 불규칙적으로 생활할 거 같았는데 온라인 비대면 수업으로 인하여 규칙적인 생활이 가능했다. 집에서 비대면 수업을 한 추억이 생기고 공부하는데 편했다. (학생번호3)

When watching the video, I could stop when I wanted to, which was useful for solving problems. I thought I would have an irregular life because I was only at home, but the online virtual class made it possible to have a regular life. I have fond memories of having a virtual class at home and it was easy to study. (Student ID3)

Overall, these results show a mixed response to virtual learning, with a significant portion of participants remaining neutral, a smaller group expressing dissatisfaction, and a considerable number indicating satisfaction. This diversity in sentiment highlights the complexity of virtual learning experiences and the varied ways in which participants perceive and interact with this virtual mode of education.

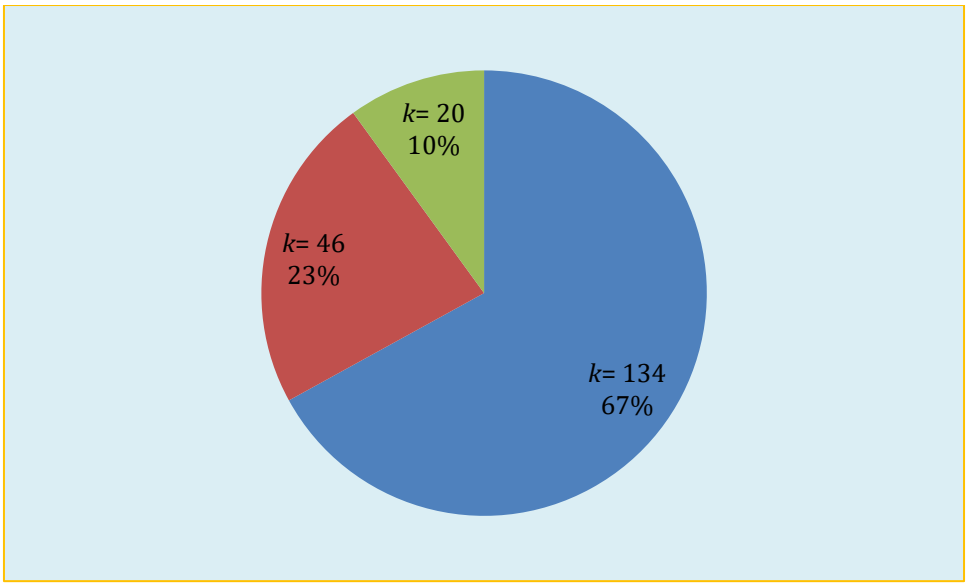

Figure 3. Sentiment analysis.

Note: A small fraction, 10% (k = 20), expressed negative feelings, possibly indicating challenges or unmet expectations associated with virtual learning environments. In contrast, a significant majority, 67% (k = 134), expressed neutral attitudes, suggesting either a satisfactory but unremarkable experience or a balance of positive and negative aspects. On the other hand, 23% (k = 46) of participants expressed positive feelings, possibly reflecting a favorable view of the convenience or flexibility of virtual learning.

Discussion

The findings of the current study illuminate several positive correlations among student engagement, interaction, and satisfaction within a synchronous virtual learning environment. Applying mediation analysis, it was also found that there is a positive relationship between student engagement and satisfaction, with interaction serving as a mediating factor. This suggests that high school students stand to benefit when their teachers strive to keep them engaged.

While these findings align with those of Marks (2000), Baloran *et al.,* (2021) and Oraif and Elyas (2021), who identified positive correlations between engagement and satisfaction, our study diverges in a key area. Contrary to their research, the present study does not demonstrate a direct effect of engagement on satisfaction. Baloran *et al.,* (2021) in particular, illustrated that student engagement positively influences students' level of satisfaction by enhancing their virtual learning skills, emotion, participation, and performance activities. However, our findings do not directly support this assumption regarding student engagement in virtual learning activities. In fact, the direct effect of student engagement on satisfaction was found to be insignificant (c' = -.30, SE = .03, p = .434).

One plausible explanation for the apparent lack of impact of student engagement on virtual learning satisfaction pertains to teacher training. It is conceivable that during the COVID-19 pandemic, classroom teachers may not have received adequate training to effectively boost students' level of engagement and satisfaction. This could mean that the potential benefits of student engagement were not fully realized. Moreover, students may not have had sufficient exposure or experience with the online platform employed by their teachers. These factors may have jointly influenced the findings of our study. Future research is warranted to explore these potential mitigating factors in more detail.

The sentiment analysis conducted to assess participants' attitude with virtual learning environments has yielded insightful findings that warrant a comprehensive discussion. The analysis, as shown in Figure 3, reveals a broad range of sentiments among participants, ranging from negative and neutral to positive, each reflecting unique aspects of the virtual learning experience. A minority of participants expressed negative sentiments. These responses highlighted challenges such as distractions at home, technical issues, and difficulties in adapting to online platforms. For example, Student ID78's comment about difficulty concentrating at home due to distractions underscores a significant challenge in virtual learning environments-the lack of a controlled, distraction-free environment that traditional classrooms provide. Similarly, the experiences of Student ID60 and Student ID156 point to technical difficulties and the struggle

of educators, especially older educators, to adapt to the digital mode of teaching. These findings are consistent with existing literature that emphasizes the importance of a supportive learning environment and the need for robust technical support and digital literacy training for educators in virtual learning environments (e.g., Muilenburg and Berge, 2005).

In contrast, the majority of participants expressed neutral sentiments. This neutrality suggests a level of acceptance of virtual learning, but without strong enthusiasm. In other words, it could indicate a balanced view where the advantages and disadvantages of virtual learning are weighed equally. For example, the comments of Student ID53 and Student ID27 highlight communication challenges and the trade-off between convenience and engagement. This neutrality may suggest that while virtual learning offers flexibility and accessibility, it may not fully replicate the engagement and interactive aspects of traditional classroom settings. This finding is consistent with previous research indicating that while virtual learning offers significant advantages in terms of accessibility and convenience (e.g., Hollister, *et al.,* 2002), it may not always provide the same level of engagement and interaction as traditional classroom settings. This finding suggests that while virtual learning can be effective, there is a need for strategies to increase student engagement and interaction in these environments.

On the positive side, participants expressed positive sentiments. The ability to learn at one's own pace and in the comfort of one's own home was highly valued, as highlighted by Student IDs 100, 89, and 3. This positive sentiment is particularly noteworthy in the context of the ongoing digital transformation of education. It is consistent with the growing recognition of the benefits of virtual learning, such as personalized learning paces and the convenience of learning in one's own environment (e.g., Hollister, *et al.,* 2002). These positive responses also highlight the potential of virtual learning to meet diverse learning needs and preferences, suggesting that virtual learning can be a highly satisfying mode of education. This positive sentiment, while less prevalent, is nonetheless significant as it highlights aspects of virtual learning that are valued by learners and reinforces the need for flexible learning solutions in an increasingly digitized educational landscape.

In conclusion, the sentiment analysis reveals that participants' experiences with virtual learning are varied and complex. While there are challenges related to engagement, interaction, and technical issues, there are also clear benefits in terms of convenience and flexibility. These findings suggest that for virtual learning to be more effective and satisfying for a broader range of learners, it is essential to address the identified challenges while leveraging the advantages.

Limitations

This study has several limitations that should be addressed in future investigations. The first one involves the sample selection. This study's participants were solely high school students from the South Korean educational system, potentially limiting the generalizability of the findings. Future research should include students from different cultural backgrounds and age groups to increase the generalizability of the results.

The second limitation stems from the use of self-reported data to gauge student engagement, interaction, and satisfaction. This is a common approach in empirical research within this field, but it could compromise the study's internal validity due to the potential for self-report bias. To mitigate subjectivity, future research should incorporate diverse measures and novel methods of assessment.

Lastly, this study did not utilize any alternative metrics for measuring engagement, interaction, or satisfaction. Despite utilizing multiple items for each construct, the absence of alternative measures poses a limitation. Therefore, future studies in this area should consider exploring alternative constructs and employ a variety of items for assessing specific classes or types of online learning environments.

Conclusion

Overall, the present study contributes to the growing literature examining students' satisfaction in virtual learning environments. The results of the study suggest that Korean secondary school students' interactions play a pivotal role through which positive engagement relates to satisfaction during virtual learning. These findings provide clear implications for middle and high school teachers: design curriculum and classroom learning activities to further promote students' online interaction. For example, educators are encouraged to develop online activities that are authentic, current, and interesting, facilitating students to interact not only with class materials but also with their teachers and their fellow learners. This study expands previous research by investigating secondary students in virtual learning contexts and confirming the significance and

importance of interaction for pedagogical practices, as positive engagement is linked with students' virtual learning satisfaction.

Declarations

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