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Factors Influencing Active Online Learning in Virtual Live-Streaming: An Empirical Analysis of Chinese College Students

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ABSTRACT

Objective: This research investigates the determinants that affect college students' engagement in active online learning within the context of virtual live-streaming platforms in China. The study specifically explores how core components—including the virtual live-streaming environment, the characteristics of the virtual presenter (avatar), content quality, and real-time interactivity—influence students' perceived usefulness and learning engagement. The theoretical basis for the investigation is grounded in the Technology Acceptance Model (TAM) and the Stimulus-Organism-Response (SOR) framework. **Methodology:** A quantitative methodology was adopted, with data gathered through an online questionnaire administered to 553 university students who had prior experience with learning via virtual live-streaming platforms. The dataset was subjected to statistical analysis using SPSS to examine the interrelationships among the study variables. **Results:** The analysis demonstrated statistically significant positive associations across all examined variables. Improvements in both the technological aspects of the virtual environment and the perceived social presence of the avatar were found to enhance students' propensity for active participation in online learning. Furthermore, content quality and immediate interactivity emerged as primary contributors to sustained learner engagement and the promotion of deeper cognitive outcomes. **Conclusion:** The study concludes that refining the virtual learning environment, strengthening the features of the avatar, and ensuring high-quality content alongside real-time interactions significantly enhance perceived usefulness among learners, ultimately encouraging more active and effective participation in online education. **Implications:** In light of these outcomes, the study offers strategic recommendations for students, developers of virtual live-streaming platforms, and enterprises operating in the virtual reality (VR) sector to refine their approaches and contribute to enriched online educational experiences.

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Introduction

The rapid progression of digital technologies has significantly expanded the potential and appeal of virtual live-streaming as a platform that enables interactive and synchronous communication over the internet. Distinct from traditional live-streaming, this approach blends virtual characters with immersive digital environments, creating a novel form of engagement. Its adoption has surged across multiple sectors, including retail, entertainment, social media, and more recently, educational applications (Chen et al., 2024; Wu et al., 2023; Yan et al., 2021). Within learning environments, virtual live-streaming offers digitally constructed spaces and avatars that mirror real-world scenarios, enabling learners to engage in tailored and inclusive educational experiences free from stereotypical constraints (Y. Chen et al., 2021), as depicted in Figure 1. Additionally, the incorporation of VR into these platforms delivers a fully immersive 360-degree perspective, strengthening learners' sense of presence and promoting higher levels of cognitive and emotional engagement (Gandsas et al., 2023; Petersen et al., 2022).

Figure 1: The Educational Virtual Live-Streaming Rooms

The growing use of virtual live-streaming in education stems from its numerous pedagogical advantages, such as enhanced accessibility, greater flexibility, and more dynamic interaction between instructors and students (Zhao, 2024). In their study, Ho and Song (2021) examined the immersive nature of live-streamed learning and its ability to satisfy students' need for active participation in E-learning. They found that the gratification derived from this medium serves as a motivating factor in improving academic performance. The inclusion of real-time engagement features and visually appealing environments in virtual live-streaming has been identified as essential for maintaining learner attention and stimulating interest, both of which positively influence academic achievement (Zhang & Liu, 2023). The use of avatars as instructional agents also significantly alters learners' expectations, perceptions, and interaction patterns when compared with conventional human-led online learning formats (Pai et al., 2024; Wang et al., 2024). Despite these merits, various obstacles continue to hinder the widespread adoption of virtual live-streaming in education. These include technical limitations such as unstable connections and insufficient bandwidth (Arezoo et al., 2023), along with pressing concerns around privacy—particularly in highly interactive online environments (X. Chen et al., 2021).

To evaluate the effectiveness of online education, it is crucial to examine the concept of active online learning. This refers to learners' sustained involvement, ability to self-direct, and consistent cognitive engagement throughout the learning process (Hoi et al., 2021; Qiu et al., 2023). Empirical evidence indicates that participatory instructional strategies

significantly enhance academic performance and improve the overall quality of online learning experiences (Wang et al., 2021). However, maintaining learner engagement in virtual live-streamed classrooms remains challenging due to the informal structure and potential distractions inherent in digital environments (Y. Chen et al., 2021). During the COVID-19 pandemic, Huang and Zhi (2023) explored the variables and underlying mechanisms influencing students' willingness to participate in online learning settings as a means to enhance educational outcomes.

Current research into the application of virtual live-streaming in academic contexts highlights several benefits, such as improved flexibility, accessibility, and interaction. However, these studies also expose notable shortcomings that require attention. Firstly, most investigations have tended to assess general aspects of online learning without isolating the distinctive interactive components of virtual live-streaming—such as avatar-based communication, immersive digital surroundings, and synchronous engagement. In addition, although considerable research has been conducted on students' adaptation to online education in general, there remains a scarcity of empirical studies specifically focusing on the variables that foster proactive learner engagement within live-streamed environments.

Earlier studies have identified factors such as self-efficacy, interactivity, immersion, content relevance, and teaching strategies as pivotal in shaping learner involvement and the effective use of VR and related digital tools (Bai & Jiang, 2024; Xie et al., 2022). Nevertheless, the particular mechanisms through which these factors impact learners' active participation in virtual live-streamed education are not yet fully understood, revealing a significant gap in existing scholarship. In response to the identified research gaps, the present study is designed to systematically examine and clearly delineate the factors that influence the online learning behaviours of college students within virtual live-streaming environments. The investigation is guided by two primary research questions:

1. Which variables exert a significant and positive influence on the active online learning behaviours of Chinese college students in virtual live-streaming classrooms?
2. How do these variables shape students' overall engagement in learning and their academic outcomes within such digital environments?

Through the provision of targeted empirical data, this research contributes to advancing theoretical understanding in the field of digital learning engagement, while also offering valuable insights for educators, designers of online learning platforms, and other relevant stakeholders involved in virtual education initiatives.

Theoretical Foundation

TAM Theory

Davis (1989) introduced the Technology Acceptance Model (TAM), a widely utilised and frequently cited theoretical framework in academic research. According to the foundational concepts of TAM, Perceived Usefulness (PU) reflects the extent to which an individual believes that employing a particular system will enhance their task efficiency. In contrast, Perceived Ease of Use (PEOU) refers to the degree to which a user considers a technological system to be simple and effortless to operate. The study conducted by X.

Chen et al. (2021) confirms that both PU and PEOU positively influence an individual's Attitude Toward Usage (ATU). The structural relationships among these core constructs are illustrated within the TAM framework (Figure 2).

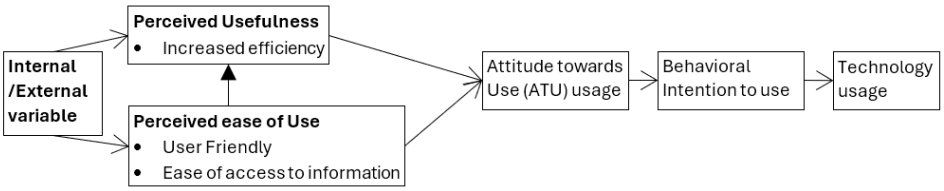

Figure 2: TAM Model

Since its development, TAM has been revised multiple times to broaden its relevance across diverse fields, particularly within education. It is frequently employed in educational research to understand technology adoption in learning environments. Stephanie and Truong (2022) proposed a refined version of TAM that incorporates factors related to the use of VR in educational systems, reinforcing the connection between VR-related variables and student learning processes. Similarly, Bhatt (2021) explored the use of online streaming services through the lens of TAM. In alignment with this approach, the present study investigates how students' perceptions of virtual live-streaming—such as its educational value and user-friendliness—influence their attitudes, motivation to participate, and proactive learning behaviour.

SOR Theory

Originating from psychological research, the SOR model (Figure 3) was initially introduced by Mehrabian and Russell in 1974 (Mehrabian & Russell, 1974). This framework has since been applied extensively across various disciplines, including the educational domain. SOR explains the process by which external environmental factors act as stimuli, influencing an individual's internal psychological state, which in turn leads to observable behavioural outcomes (Pan et al., 2024).

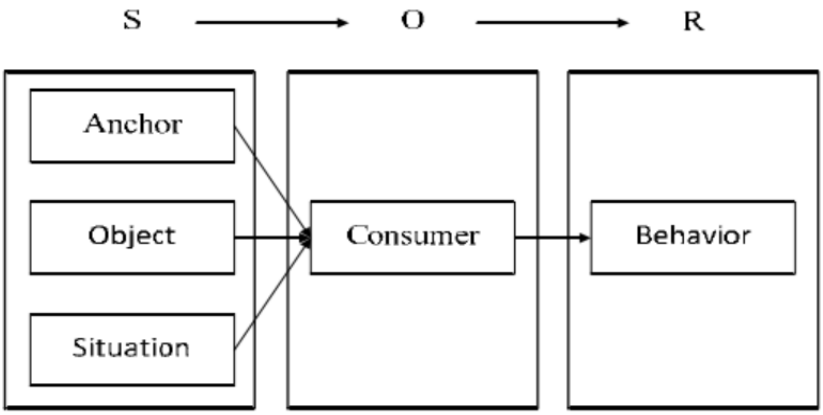

Figure 3: SOR Model

The SOR framework serves as a foundational model for understanding and analysing learning dynamics, and its core concepts have been widely applied and extended within the field of educational research. In the context of online learning, studies using SOR have demonstrated that interactive components—particularly learner-instructor engagement—significantly influence students' perceptions of PU, which in turn affect their academic outcomes and overall learning satisfaction (Hameed et al., 2025; Pan et al., 2024; Zhang & Liu, 2023). In virtual live-streaming classrooms, students are exposed to a variety of compelling stimuli, including immersive avatars, real-time interactive features, and 360-degree virtual environments. Employing the SOR model facilitates the examination of how these stimuli shape internal cognitive and affective responses (such as PU and perceived immersion), which then drive active participation in learning activities (Chang et al., 2023; Erensoy et al., 2024; Gao et al., 2023). The integration of SOR with TAM offers a comprehensive analytical lens by linking environmental design elements with internal cognitive mechanisms and resultant behavioural outcomes.

Research Hypotheses

Theoretical Framework

In this investigation, virtual live-streaming characteristics—including the streaming room environment, virtual streamers, content quality, and real-time interaction—are conceptualised as external stimuli that influence learners' internal assessments, such as PU and immersion. These internal responses shape students' attitudes and intentions to engage, which ultimately lead to active participation and enhanced learning outcomes within virtual classrooms. By combining TAM, which focuses on individual cognitive factors, with SOR, which highlights the influence of environmental design, this dual-theoretical model offers a comprehensive approach to understanding the mechanisms that drive virtual learning. The proposed theoretical framework is illustrated in Figure 4.

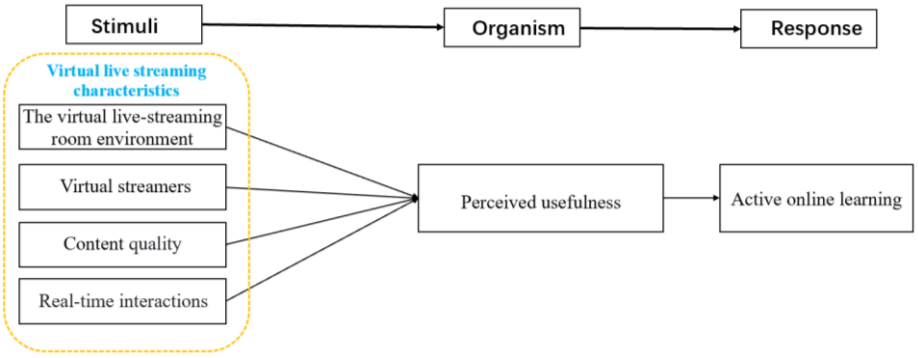

Figure 4: Theoretical Framework

Research Variables

Within the framework of SOR, the stimulus (S) represents external environmental inputs. In the context of this study, these stimuli include virtual live-streaming components

such as virtual streamers (Anchor), content quality (Object), the overall live-streaming setting (Situation), and real-time interaction (also classified as Situation). The organism (O) pertains to an individual's internal interpretations. Here, grounded in TAM, PU is considered a central element that captures the internal evaluations of college students as digital learners. The response (R) refers to the behavioural outcome triggered by external stimuli (Gao et al., 2023). In this research, the students' engagement in active online learning is conceptualised as the behavioural response arising from their exposure to the virtual learning environment. Based on the theoretical model and related constructs, the study categorises the variables into three groups: predictor variables, mediating variables, and outcome variables (Table 1).

Table 1

Categorization of Variables

Module	Variable
Predictor Variable	Virtual Live-Streaming Room Environment, Virtual Streamers, Content Quality, Real-Time Interactions
Intermediate Variable	Perceived Usefulness
Outcome Variable	Active Online Learning

Research Hypotheses

H1: *The virtual live-streaming room environment has a significant and positive impact on the perceived usefulness of Chinese college students.*
H2: *Virtual streamers have a significant and positive effect on the perceived usefulness of Chinese college students.*
H3: *Content quality has a significant and positive effect on the perceived usefulness of college students.*
H4: *Real-time interactions have a significant and positive effect on the perceived usefulness of Chinese college students.*
H5: *Perceived usefulness has a significant and positive effect on Chinese college students' active online learning.*

Research Method

A quantitative research design was adopted for this study, employing a structured survey to obtain detailed insights into participants' perceptions, attitudes, and behaviours (Coe et al., 2021). The data collected through this method were analysed using SPSS version 28.0 to examine the interrelationships among the variables derived from the established theoretical framework.

Measurement

The measurement items, adapted from prior studies and tailored to virtual live-streaming contexts, were rated using a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree) (Table 2).

Table 2

Measurement Items

The Virtual Live-Streaming Room Environment
1. The systems are both intuitive and accessible.
2. The layout is well-organized.
3. The audio quality is clear and without interruptions.
4. The environment is comfortable, engaging and interactive.
5.The technical support is reliable.
Virtual Streamers
6. The virtual streamer is knowledgeable in the subject matter.
7. The virtual streamer express clearly and effectively.
8. The virtual streamer engages with the audience effectively.
9. The virtual streamer responds promptly to questions and comments.
10. The virtual streamer is enthusiastic and motivating.
Content Quality
11. The content delivered is relevant to my studies.
12. The content is up-to-date and accurate.
13. The content is well-structured and easy to follow.
14.The pace of content delivery is appropriate.
15. The learning materials are available for review after lessons.
Real-Time Interactions
16. I can engage with the streamer during the online lesson.
17. I can interact with other students during the virtual live-streaming lesson.
18. Real-time interactions help me understand the content better.
19. Real-time interactions make the learning process more enjoyable.
20. The feedback I receive during the virtual live-streaming lesson is useful and timely.
Perceived Usefulness
21.The knowledge gained is applicable and practical to my studies.
22. The virtual live-streaming lessons help me learn more effectively.
23. I feel more confident about the subject after attending the virtual live-streaming lesson.
24. The virtual live-streaming lessons enhanced my overall learning performance.
25. I prefer virtual live-streaming learning over traditional classroom learning.
Active Online Learning
26. I actively participate in the virtual live-streaming learning process.
27. I collaborate with peers during the virtual live-streaming lessons.
28. I complete assignments and tasks during the virtual live-streaming lessons.
29. I seek additional resources based on the live-streaming content.
30. I apply what I learn the virtual live-streaming lessons to other academic activities.

Data Collection

To evaluate the proposed hypotheses, data were collected using an online questionnaire administered through Wenjuanxing (https://www.wjx.cn/), a widely used survey

platform in China. The questionnaire was organised into three sections. The first section outlined the purpose of the study, assured respondents of the confidentiality and anonymity of their input, and provided contextual information regarding the application of virtual live streaming in educational settings to ensure participants fully understood the background. The second section incorporated a screening question to confirm whether participants had prior experience with educational virtual live streaming. Only individuals who responded positively proceeded to answer items related to the study constructs, with a focus on their most recent experiences in active learning within such environments. The final section gathered demographic data, including information on gender, age, academic status, and income range.

The target population consisted of university students located in Jinan City, Shandong Province, China. A combination of simple random sampling and convenience sampling was applied. Initially, four universities were randomly selected from a pool of 42 institutions in the region. Proportional allocation was then used to determine the appropriate number of participants to be drawn from each selected university. To ensure statistical reliability, the sample was calculated based on a 95% confidence level and a permissible margin of error of 0.05, which required a minimum sample size of:

$$n = \frac{z^2 * p(1-p)}{d^2} = \frac{1.96^2\text{^}0.5\ (1-0.5)}{0.05^2} \approx 384 \text{ (Pesrons)}$$

In total, 553 valid responses were obtained, fulfilling the required minimum sample threshold for statistical analysis. A summary of the participants' demographic characteristics is presented in Table 3.

Table 3

Demographic Information

		Quantity	Percent
Gender	Male	259	46.8
	Female	294	53.2
	Total	553	100.0
Age	23	21	3.8
	22	22	4.0
	21	24	4.3
	20	114	20.6
	19	243	44
	18	129	23.3
	Total	553	100.0
Monthly Living Expenses	Less than ¥ 1,000	81	14.6
	¥ 1,000 - 1,300	223	40.3
	¥ 1300 - 1600	161	29.1
	¥ 1600-1900	28	5
	More than ¥ 1900	60	10.8
	Total	553	100.0

Data Analysis

Reliability and Validity

Validity Analysis of Variables

Factor analysis was conducted to assess the validity and suitability of item groupings. Before this, the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity confirmed the data's adequacy for factor analysis, as the variables showed sufficient intercorrelations (Table 4).

Table 4

Factor Analysis Results

Indicator	Result
KMO Measure of Sampling Adequacy	0.923
Bartlett's Test of Sphericity	$\chi^2(190) = 2950.63, p < .001$
Total Variance Explained	71.26%

Confidence Analysis of Variables

Multiple approaches exist for assessing internal consistency, with Cronbach's alpha being particularly well-suited for evaluating the reliability of Likert-scale instruments. As indicated in Table 5, this study employed SPSS version 26.0 to conduct a reliability assessment using Cronbach's alpha. The results confirm that the questionnaire demonstrates satisfactory internal consistency and meets the reliability standards required for the analysis.

Table 5

Confidence Analysis of Variables

Construct	Item	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
Virtual Live-Streaming Room Environment	1	0.781	0.874	0.89
	2	0.635	0.87	0.89
	3	0.701	0.893	0.89
	4	0.64	0.889	0.89
	5	0.651	0.894	0.89
Virtual Streamers	6	0.777	0.9	0.91
	7	0.787	0.924	0.91
	8	0.793	0.915	0.91
	9	0.696	0.91	0.91
	10	0.688	0.913	0.91
Content Quality	11	0.786	0.892	0.88
	12	0.758	0.868	0.88
	13	0.646	0.881	0.88
	14	0.724	0.897	0.88
	15	0.77	0.863	0.88

Table 5(continued)

Confidence Analysis of Variables

Construct	Item	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
Real-Time Interactions	16	0.736	0.871	0.87
	17	0.622	0.872	0.87
	18	0.607	0.88	0.87
	19	0.638	0.861	0.87
	20	0.769	0.889	0.87
Perceived Usefulness	21	0.67	0.945	0.93
	22	0.791	0.927	0.93
	23	0.666	0.912	0.93
	24	0.643	0.922	0.93
	25	0.65	0.943	0.93
Active Online Learning	26	0.639	0.918	0.9
	27	0.686	0.883	0.9
	28	0.771	0.899	0.9
	29	0.639	0.887	0.9
	30	0.604	0.908	0.9

Results of Data Analysis

Pearson correlation analysis was conducted to examine the strength and direction of associations among the variables, revealing statistically significant relationships. In addition, regression analysis was applied to explore the influence of one or more independent variables on a dependent variable, and to quantify the degree to which these independent variables impact the outcome variable.

The Relationship Between the Virtual Live-Streaming Room Environment and College Students' Perceived Usefulness

The Pearson correlation method was employed to examine the association between the virtual live-streaming room environment and PU among university students (Table 6). The results indicate a statistically significant positive correlation at the 0.01 level between the virtual live-streaming room environment and PU among university students. This finding suggests that enhancements in the virtual live-streaming environment are positively associated with increased perceptions of usefulness within the learning context.

Table 6

Correlation Analysis

	Perceived Usefulness
Virtual Live-Streaming Room Environment	0.762**
Sig. (2-Tailed)	0.000
N	553

As presented in Table 7, the regression analysis reveals a statistically significant positive association between the virtual live-streaming room environment and PU, with $F(1, 551) = 773.65$ and $p < 0.001$. The derived regression model is expressed as:

$$PU = 0.325 + 0.723 \times (\text{Virtual Live-Streaming Room Environment})$$

These results provide empirical support for the hypothesis, confirming that the virtual live-streaming room environment is significantly and positively associated with students' perceptions of usefulness.

Table 7

Regression Analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.762	0.581	0.580	0.652

	Sum of Squares	df	Mean Square	F	Sig.
Regression	328.74	1	328.74	773.65	0.000
Residual	236.73	551	0.430		
Total	565.47	552			

	B	Std. Error	Beta	t	Sig.
(Constant)	0.325	0.110	-	2.96	0.003
Virtual Live-streaming Room Environment	0.723	0.026	0.762	27.82	0.000

The Relationship Between Virtual Streamers and College Students' Perceived Usefulness

Pearson correlation analysis examined the link between virtual streamers and PU among university students (Table 8). A significant positive correlation at the 0.01 level indicates that virtual streamers are positively associated with students' perceptions of usefulness in virtual learning.

Table 8

Correlation Analysis

	Perceived Usefulness
Virtual Streamers	0.690**
Sig. (2-Tailed)	0.000
N	553

As indicated in Table 9, the regression analysis demonstrates a significant positive association between virtual streamers and PU, with $F(1, 551) = 400.41$ and $p < 0.001$. The resulting regression equation is:

$$PU = 1.025 + 0.595 \times (\text{Virtual Streamers})$$

This outcome supports the proposed hypothesis, confirming that virtual streamers are significantly and positively linked to students' perceived usefulness within virtual learning contexts.

Table 9

Regression Analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	0.690	0.476	0.475	0.820		
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Regression		269.25	1	269.25	400.41	0.000
Residual		296.22	551	0.538		
Total		565.47	552			
		B	**Std. Error**	**Beta**	**t**	**Sig.**
(Constant)		1.025	0.112	-	9.15	0.000
Virtual Streamers		0.595	0.030	0.690	20.01	0.000

The Relationship Between Content Quality and College Students' Perceived Usefulness

Pearson correlation analysis was employed to examine the relationship between content quality and PU among university students (Table 10). The findings confirm a statistically significant positive correlation at the 0.01 level between content quality and PU among university students. This suggests that higher content quality is positively associated with students' perceptions of usefulness in virtual live-streaming educational settings

Table 10

Correlation Analysis

	Perceived Usefulness
Content Quality	0.58**
Sig. (2-tailed)	0.000
N	553

As shown in Table 11, the regression analysis reveals a significant positive association between content quality and PU, with $F(1, 551) = 201.85$ and $p < 0.001$. The regression model is expressed as:

$$PU = 1.25 + 0.58 \times (\text{Content Quality})$$

These results support the hypothesis, indicating that content quality is significantly and positively related to university students' perceptions of usefulness.

Table 11

Regression Analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	0.580	0.336	0.334	0.970		
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Regression		189.65	1	189.65	201.85	0.000
Residual		375.82	551	0.682		
Total		565.47	552			
		B	**Std. Error**	**Beta**	**t**	**Sig.**
(Constant)		1.25	0.134	—	9.33	0.000
Content Quality		0.58	0.041	0.580	14.21	0.000

The Relationship Between Real-Time Interactions and College Students' Perceived Usefulness

Pearson correlation analysis was applied to investigate the relationship between real-time interactions and PU among university students (Table 12). The results demonstrate a statistically significant positive correlation at the 0.01 level between real-time interactions and PU among university students. This finding indicates that increased real-time interaction is positively associated with students' perceived usefulness in virtual learning environments.

Table 12

Correlation Analysis

	Perceived Usefulness
Real-Time Interactions	0.65**
Sig. (2-Tailed)	0.000
N	553

As presented in Table 13, the regression analysis identifies a significant positive relationship between real-time interactions and PU, with $F(1, 551) = 351.35$ and $p < 0.001$. The corresponding regression equation is:

$$PU = 1.35 + 0.60 \times (\text{Real-Time Interactions})$$

This outcome supports the hypothesis, confirming that real-time interactions are significantly and positively associated with university students' perceived usefulness.

Table 13

Regression Analysis

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	0.650	0.423	0.421	0.825

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Regression	239.21	1	239.21	351.35	0.000
Residual	326.26	551	0.592		
Total	565.47	552			

	B	**Std. Error**	**Beta**	**t**	**Sig.**
(Constant)	1.35	0.112	—	12.05	0.000
Real-time Interactions	0.60	0.032	0.650	18.75	0.000

The Relationship Between Perceived Usefulness and College Students' Active Online Learning

Pearson correlation analysis was conducted to examine the relationship between PU and students' active participation in online learning (Table 14). The findings reveal a statistically significant positive correlation at the 0.01 level between PU and active online learning among university students. This suggests that higher levels of PU are positively associated with increased student engagement in online learning activities.

Table 14

Correlation Analysis

	Active Online Learning
Perceived Usefulness	0.68**
Sig. (2-Tailed)	0.000
N	553

As reflected in Table 15, the regression analysis demonstrates a significant positive association between PU and active online learning, with $F(1, 551) = 302.14$ and $p < 0.001$. The derived regression equation is:

$$\text{Active Online Learning} = 1.22 + 0.59 \times (\text{PU})$$

These results validate the hypothesis, confirming that PU is significantly and positively associated with university students' active engagement in online learning behaviours.

Table 15

Regression Analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.680	0.462	0.461	0.92

	Sum of Squares	df	Mean Square	F	Sig.
Regression	256.00	1	256.00	302.14	0.000
Residual	297.47	551	0.54		
Total	553.47	552			

	B	Std. Error	Beta	t	Sig.
(Constant)	1.22	0.060	—	20.33	0.000
Perceived Usefulness	0.59	0.034	0.680	17.38	0.000

Conclusion and Recommendations

Conclusions

This research investigates the determinants influencing active learning among university students in China within virtual live-streaming environments, aiming to contribute to the development of innovative online learning approaches and offer fresh perspectives for established educational theories. The key findings are summarised as follows:

H1: *The virtual live-streaming room environment significantly and positively affects the perceived usefulness of college students.*
H2: *Virtual streamers significantly and positively affect the perceived usefulness of college students.*
H3: *Content quality significantly and positively affects the perceived usefulness of college students.*
H4: *Real-time interactions significantly and positively affect the perceived usefulness of college students.*
H5: *Perceived usefulness significantly and positively affects college students' active online learning.*

Recommendations

Recommendations for College Students

First, university students must demonstrate proactive engagement when participating in virtual live-streaming learning environments. Active involvement entails more than simply accessing the platform; it requires students to take the initiative in contributing to discussions, critically reflecting on concepts introduced, and collaboratively exploring ideas with peers and instructors. Such participatory learning facilitates deeper cognitive processing and improves retention, as active contribution promotes meaningful understanding and long-term knowledge acquisition. The dynamism of active learning not only prevents monotonous repetition but also cultivates a more enriched educational experience.

Second, the quality of instructional content remains a pivotal determinant of effective virtual learning. Students are encouraged to enrol in courses that exhibit coherent structure, align with defined learning outcomes, and are delivered by educators who combine subject expertise with engaging teaching methods. High-quality content that is contextually relevant, well-organised, and supported with clear examples and explanations enhances comprehension and strengthens academic relevance. This, in turn, contributes significantly to improved academic performance and renders the learning process more fulfilling.

Finally, the establishment of an optimal virtual learning environment plays an essential role in supporting student success. Learners are advised to create a personalised and distraction-free study space that promotes concentration and cognitive engagement. Minimising environmental disruptions enhances focus and information absorption during live-streamed sessions. Additional physical factors, such as proper lighting, ergonomic seating, and stable internet connectivity, further contribute to sustained attention and learner comfort throughout extended study periods.

Recommendations for Virtual Live-Streaming Platforms

Live-streaming platforms now play a central role within the evolving educational landscape, mediating interactions between learners and instructors. To enhance user satisfaction, it is essential that these platforms prioritise the development of interfaces that are both intuitive and aesthetically engaging. A well-designed and conceptually coherent interface facilitates ease of navigation and maintains users' attention, thereby significantly improving the overall learning experience. This, in turn, increases learners' comfort with VR technologies and positively influences their engagement with the content.

Beyond the provision of high-quality educational material, the opportunity for digital social interaction should also be emphasised. Platforms should equip streamers with comprehensive instructional tools, access to advanced streaming technologies, and effective content management systems. Experienced and technologically adept streamers not only deliver high-impact presentations but also elevate the academic quality of sessions through their pedagogical competence, thereby enriching the students' learning outcomes. Moreover, the availability of a robust and flexible real-time communication system is

critical in fostering interactive learning environments. Features such as live discussions, question-and-answer sessions, and interactive polls contribute to the development of a collaborative virtual learning community. These mechanisms ensure secure, immediate communication between streamers and learners, promoting timely feedback and enhancing engagement. A stimulating and responsive virtual setting further encourages learner motivation and improves attendance and participation in online classes.

Recommendations for Related VR Enterprises

VR enterprises possess a unique opportunity to influence the educational landscape by developing sophisticated VR-based learning applications. Such innovations should aim to transform traditional live-streaming experiences into more immersive and interactive virtual environments. Immersion in VR settings enables students to engage in realistic simulations of complex scenarios, which are often confined to abstract explanations in textbooks or lectures. By virtually experiencing the learning context, students can better comprehend intricate subject matter, enhancing their appreciation of VR's educational value and promoting higher levels of engagement and perceived importance.

Establishing effective partnerships with educational institutions is also a vital component in designing practical and relevant VR solutions. Collaborations between VR providers and universities facilitate the identification of educational requirements and instructional challenges, allowing for the co-creation of tools that are closely aligned with curricular goals. Such partnerships ensure that VR applications are pedagogically sound and directly responsive to the evolving needs of students and educators. In addition, ensuring equitable access to VR technology is essential for its widespread adoption in education. VR companies must adopt inclusive strategies to make their technologies financially accessible to institutions and students with limited resources. This may involve offering flexible payment options, discounted educational packages, or scalable systems that adjust according to institutional budgets. Providing affordable solutions is crucial in narrowing the digital divide and securing broader acceptance of VR-enhanced classrooms.

Ultimately, the responsibility also lies with students to redefine their role within the virtual learning environment by taking ownership of their active participation, engaging critically with content, and optimising their learning space. At the same time, virtual live-streaming platforms should continue refining their user interfaces, supporting the production of high-quality content, and incorporating real-time interactive features. VR companies, in turn, must focus on advancing educational tool development, fostering institutional collaboration, and ensuring their offerings remain accessible and cost-effective. Collectively, these efforts can contribute to the creation of a more engaging and immersive digital learning ecosystem for university students in China.

Limitation and Future Direction

This study acknowledges several limitations that should be addressed in future research. Primarily, the reliance on self-reported survey data to capture students' perceptions of virtual streamers may not fully encapsulate the complexities of actual user interaction. While the survey approach provided meaningful insights, it may not reflect the subtleties of behavioural engagement with virtual streamers. Future investigations could

employ experimental designs that allow for systematic manipulation of streamer attributes, thereby offering a more controlled and precise analysis of their effects on learning outcomes. Another avenue for future research involves exploring additional mediating variables that could influence users' responses to virtual live-streaming features. Constructs such as flow state, perceived uncertainty, and user experience may play critical roles in shaping learners' engagement and attitudes.

To enhance the generalisability and cultural relevance of the findings, future research should examine the proposed theoretical framework across a range of cultural and institutional contexts. This would not only validate the model but could also lead to its refinement, offering a broader and more robust understanding of the factors that shape learning behaviours in virtual environments. Addressing these limitations and expanding the research scope will support continued advancement in the field of digital education and learner interaction with immersive technologies.

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