Metaverse Basic and Applied Research. 2025; 4:199
doi: 10.56294/mr2025199

ORIGINAL

Students receive multi-dimensional discussions on technology in virtual classroom

Los estudiantes reciben discusiones multidimensionales sobre tecnología en el aula virtual

XuBiao Yin[1], Changsheng Yu[1], Jinghong Liu[1]

[1]Multimedia University Faculty of Management, SELANGOR, CYBERJAYA, 63100. Malaysia.

Cite as: Yin X, Yu C, Liu J. Students receive multi-dimensional discussions on technology in virtual classroom. Metaverse Basic and Applied Research. 2025; 4:199. https://doi.org/10.56294/mr2025199

Submitted: 22-08-2024 **Revised:** 17-02-2025 **Accepted:** 10-08-2025 **Published:** 11-08-2025

Editor: PhD. Dra. Yailen Martínez Jiménez

Corresponding author: XuBiao Yin

ABSTRACT

Introduction: virtual learning is becoming increasingly prevalent, and there is a growing need for teaching strategies that enhance student engagement and critical thinking. Multi-dimensional discussions addressing technology from technical, social, and economic perspectives provide an approach for a comprehensive understanding in virtual classrooms.
Objective: this analysis aims to investigate the influence of multidimensional discussions on student engagement, comprehension, critical thinking, retention rate, participation frequency, and student satisfaction in a virtual classroom environment using statistical evaluation.
Method: a six-week program was implemented across four virtual classrooms with 348 students. A different technology-related theme was examined each week through guided, multidimensional discussions that encompassed educational, technical, social, and economic aspects within the context of a structured virtual classroom environment. Quantitative data were collected using pre- and post-session tests, engagement tracking, and peer evaluations. To evaluate improvements in learning outcomes, statistical techniques such as descriptive statistics, paired t-tests, and Pearson correlation analyses were used with IBM SPSS software 26.0.
Results: student engagement levels increased from post-intervention ($p < 0,0001$). Comprehension test scores improved by 13,80 on average (pre = 64,3, post = 78,1, $p < 0,001$). Critical thinking scores and the variety of conversation aspects showed a moderately significant connection ($r = 0,60$). Peer evaluation indicated enhanced argumentation skills and increased confidence in expressing viewpoints.
Conclusion: multi-dimensional discussion in virtual classrooms boosts student engagement and technology comprehension that facilitates learning and critical thinking, an important tool in online education.

Keywords: Virtual Classroom; Multi-Dimensional Discussion; Student Engagement; Critical Thinking; Interactive Learning.

RESUMEN

Introducción: el aprendizaje Virtual es cada vez más frecuente y hay una creciente necesidad de estrategias de enseñanza que mejoren el compromiso de los estudiantes y el pensamiento crítico. Los debates multidimensionales que abordan la tecnología desde perspectivas técnicas, sociales y económicas proporcionan un enfoque para la comprensión integral en aulas virtuales.
Objetivo: este análisis tiene como objetivo investigar la influencia de las discusiones multidimensionales en el compromiso estudiantil, la comprensión, el pensamiento crítico, la tasa de retención, la frecuencia de participación y la satisfacción estudiantil en un ambiente de aula virtual mediante la evaluación estadística.
Método: aulas virtuales apoyadas por plataformas como Google Meet y herramientas digitales integradas,

que proporcionan flexibilidad y accesibilidad y todavía enfrentan limitaciones para mantener la participación activa y el compromiso crítico. Se implementó un programa de seis semanas A través de cuatro aulas virtuales con 348 estudiantes. Cada semana se examinaba un tema diferente relacionado con la tecnología A través de discusiones guiadas y multidimensionales que abarcaban aspectos educativos, técnicos, sociales y económicos en el contexto de un ambiente de aula virtual estructurada. Los datos cuantitativos se recogieron mediante pruebas antes y después de la sesión, seguimiento del compromiso y evaluaciones por pares. Para evaluar las mejoras en los resultados de aprendizaje, se utilizaron técnicas estadísticas como estadística descriptiva, pruebas t parey análisis de correlación de Pearson con el software IBM SPSS 26.0.
Resultados: los resultados indican que los niveles de compromiso estudiantil aumentaron después de la intervención ($p < 0,0001$). Los resultados de la prueba de comprensión mejoraron en un promedio de 13,80 puntos (pre = 64,3, post = 78,1, $p < 0,001$). Las puntude pensamiento crítico y la variedad de aspectos de conversación mostraron una conexión significativa moderada ($r = 0,60$). La evaluación por pares indicó el aumento de las habilidades de argumentación y el aumento de la confianza para expresar puntos de vista.
Conclusiones: las aulas virtuales con debates multidimensionales mejoran la participación de los estudiantes y la comprensión de la tecnología que promueve el aprendizaje y el razonamiento crítico, por lo que es una estrategia valiosa en la educación digital.

Palabras clave: Aula Virtual; Debate Multidimensional; Compromiso Estudiantil; Pensamiento Crítico; Aprendizaje Interactivo.

INTRODUCTION

A rapid rise in virtual learning reshaped the global educational landscape, especially following the widespread adoption of digital tools and online platforms. Virtual classrooms are considered more essential than traditional classroom instruction. It provides unique access, flexibility, and convenience to students and teachers equally.[1] Although virtual classrooms offer flexibility, they have no association and connection found in the traditional classroom. Students remain focused but struggle to find ways to get involved in class or engage in learning when instruction is passive and one-dimensional. Collaborative learning, discussion, and inquiry are a few curricular approaches that help students become interested, capture their attention, and promote deeper learning.[2]

Technology extends as a simple content delivery tool; it serves as a subject of inquiry with broad technical and societal implications. Students are consumers of technology, and they will also be the creators of technology, regulators of technology, and decision-makers within a technology-based society. Providing technology only as a technical concern, it is no longer as robust an approach to inquiry. Understanding these implications assists the students in developing a more knowledgeable and well-formed technological generation.[3] The presence of various points of view (technical, social, and economic) in classroom discourses helps the students have the chance to be engaged in a critical approach to complicated matters. Through these discussions, students are given a chance to critically analyze how technologies give and receive impacts of human interactions and social structures. Students consider the implications of each stance and discuss in an informed and deliberate way to bring out a diversity of perspectives. Multifaceted conversations in a structured manner improve engagement and promote higher-order and thoughtful thinking in virtual environments where students often feel isolated or uninterested.[4]

The online applications such as Google Meet, Microsoft Teams, and Zoom allow meaningful communication, real-time interactions, and collaboration at a distance. Although technology is a key requirement, virtual learning should be aided by efficient pedagogical strategies that encourage dialogue and critical thinking. Facilitators guide the process by helping to make conversations, open spaces to discuss, and, in their actions, which help students with their various points of view get supported by others, as well as inquire respectfully.[5] Student-centered practices that enhance engagement and reflection are more attentive to educational change. One of them is multi-dimensional discussions, through which students can find ways of discussing real-world phenomena of different persecutions. The students want to go beyond mere memorization, which helps them build knowledge with personal meaning. The interdisciplinary thinking and the interaction between students also help in the development of flexible skills that include communication, reasoning, and empathy. This strategy coincides with the more recent educational ambitions concerning the significance of rendering learners unremitting and responsive students in an intricate surrounding. But the online teaching is becoming more mainstream; teachers are also becoming aware of their own set of challenges, specifically those which involve maintaining the students' active, interested, and critically engaged in the learning processes.[6]

In the case of online education, which is still under development, seek a way that not only provides content but also enhances the development of critical thinking and student voice. The ability to access bandwidth and software, among other aspects, is not the most important part of effective digital education, but one of the

teaching methods that enhances the learning process online. Multi-dimensional discussions are a good way to develop further. With teachers affecting more than just one side of the argument by making the online classroom discussion an organized dialogue, the classrooms become an exciting learning process where the students not only think critically but also ask meaningful questions and explore the technology in an impactful manner.[7]

The analysis conducted on the virtual classroom has attracted several aspects of engagement and learning outcomes, with the majority of the studies being scattered in various settings.[8] In the case of online language learning, research has demonstrated that the level of learner attitudes, willingness, and preparedness will have a great impact on motivation and engagement. A survey demonstrated in similar areas revealed that more sophisticated teaching techniques, including the use of knowledgeable tutors, may boost the acquisition of scientific process skills by students.[9] The aggregate effect of these findings is that specific instructional approaches enhance participation, but their applicability is constrained by the limited populations and the limited context.

The research has examined faculty and institutional factors in shaping digital education. Integrated models assessing faculty attitudes toward AI in teaching revealed that expectations and information quality significantly influenced adoption.[10] Structural impediments, instructor effectiveness, and environmental distractions were found to be significant stressors at the student level and negatively affect engagement and academic performance.[11] These works support the opinion that engagement is heavily influenced by instructional design and environmental supports in general, but they remain mostly silent on interactive pedagogical strategies that can support participation in the long term.

The analysis has been enthusiastic about social presence and interaction in online learning.[12] The positive learning results were attributed to co-presence and social richness dimensions, whereas disengagement in second language classrooms was highly attributed to poor instructional design and lack of support.[13] Likewise, the studies of self-efficacy and engagement established that confidence is an important predictor of behavioral, cognitive, and emotional engagement.[14] Social presence was reported to affect learner satisfaction and persistence.[15] These results, combined with those of other researchers, highlight the role of interpersonal issues, though also indicate that the majority of studies are based on self-reporting and single-platform settings and cannot be extrapolated.

Cultural and emotional challenges have also been pointed out through research. Cross-cultural pragmatic failure in English language learning was identified as an imbalance between the teacher and student perception [16], and boredom in foreign language online classes was divided into such categories as classroom, content, and relational.[17] These studies highlight the emotional depth of online learning but are highly relevant to the context, which limits their wider use.

Prior research identifies factors influencing engagement—ranging from motivation, preparedness, and social presence to faculty attitudes and cultural dynamics—but they seldom provide evidence of structured, multi-dimensional approaches to discussion that integrate technical, social, and economic perspectives. This gap forms the basis for the present analysis, which systematically evaluates whether guided, multi-dimensional discussions can enhance engagement, comprehension, critical thinking, and satisfaction in virtual classrooms.

Online classes are flexible and accessible, but there is always a persistent demand for active engagement and critical thinking. The strategies available tend to be typically one-sided or teacher-centered strategies that cannot always result in profound interaction. The previous studies concentrate on the importance of the engagement process but have not found approaches to dealing with the problem in a systematic manner and enhancing comprehension and participation. It suggests multi-dimensional discussions that combine all three technical, social, and economic points of view as a way of enriching learning. Their contribution in virtual setups, however, has not been critically assessed through the use of statistical tools. The lack of obvious evidence concerning their effectiveness makes the effect they have on student performance unclear. This analysis addresses that gap by examining the role of multi-dimensional discussions in improving engagement, comprehension, critical thinking, retention, and satisfaction in virtual classrooms.

The goal of this analysis is to assess the influence of multi-dimensional discussions in virtual classrooms on student engagement, awareness, critical thinking, participation, satisfaction, by examining statistical pre- and post-intervention data to assess the overall effectiveness in improving online learning outcomes.

The objectives of this research are to evaluate the multifaceted conversations as a means to improve the student involvement, engagement, understanding, critical thinking, satisfaction, and retention in an online learning environment.

METHOD

This analysis employed a quantitative research design conducted over a period of six weeks. The intervention was carried out in four virtual classrooms using digital platforms such as Google Meet and integrated online tools, which provided real-time interaction and accessibility.

The study population consisted of college students enrolled in virtual courses. A total of 348 students participated across the four classrooms. The sample was obtained using convenience sampling, based on course availability and willingness to participate. Inclusion criteria required students to be actively enrolled in the course, have stable internet access, and agree to participate in the sessions and assessments. Exclusion criteria applied to students who failed to attend at least four of the six sessions. Exit criteria included voluntary withdrawal from the program or incomplete test participation.

The analysis focused on six primary variables: Student Engagement (SE), Comprehension (CO), Critical Thinking (CT), Student Satisfaction (SS), Participation Frequency (PF), and Retention Rate (RR). These variables were selected to capture both cognitive outcomes and behavioral participation. Student Engagement and Retention Rate served as key behavioral indicators, while Comprehension and Critical Thinking measured cognitive development. Student Satisfaction and Participation Frequency represented attitudinal and interactional dimensions.

Data were collected using three instruments: (a) comprehension tests administered before and after each session to measure knowledge gain; (b) engagement tracking tools embedded in the virtual platforms to monitor frequency and activity levels; and (c) peer evaluation forms to assess communication, collaboration, and critical argumentation. The comprehension tests were adapted from validated online learning assessments in prior research, while the peer evaluation rubric was reviewed to confirm content validity. Engagement tracking was based on platform-recorded metrics, ensuring objectivity in participation measurement.

Data Collection Process

Over the six weeks, each session centered on a different technology-related theme covering educational, technical, ethical, social, and economic aspects. Students engaged in structured discussions guided by facilitators. Pre-tests were conducted at the beginning of each session, while post-tests and peer evaluations were completed at the end. Engagement metrics were captured continuously throughout the sessions.

Data Analysis Process

Collected data were processed using IBM SPSS 26.0. Descriptive statistics were applied to characterize the sample and distribution of variables. Paired t-tests compared pre- and post-test results to measure intervention effects, while Pearson correlation analysis examined relationships among engagement, comprehension, critical thinking, and satisfaction. Figure 1 shows an overview of the methodology flow, illustrating the research design, data collection, and analysis process.

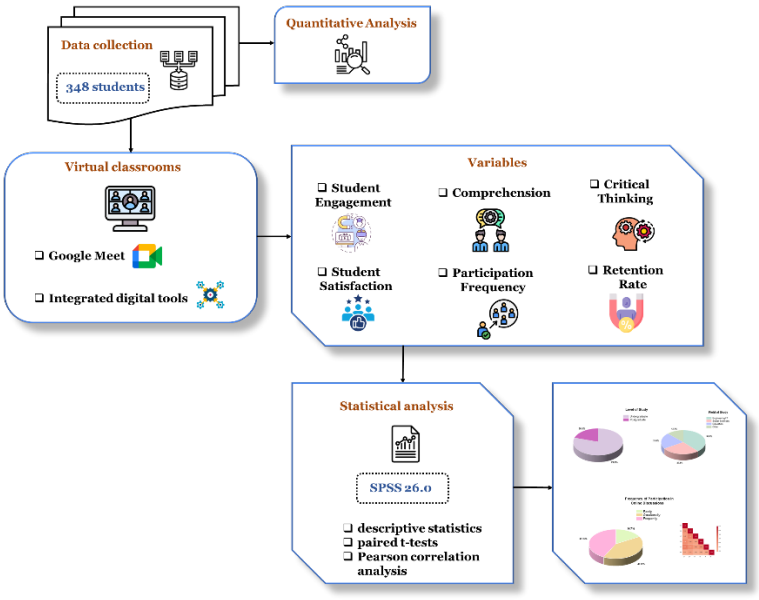

Figure 1. Methodological Flowchart Illustrating the Analytical Framework

Data Collection

A total of 348 students from four virtual classrooms participated in the analysis. The sampling strategy was convenience-based, as participants were drawn from courses that agreed to integrate the intervention during the study period. Students who were enrolled in the program were invited to attend, and only a student who gave informed consent and attended four of six sessions was included in the analysis. Although this method is useful, it can restrict the applicability of the results to large-scale educational settings. The intervention lasted

six weeks, with each week dedicated to one technology-related theme (educational, technical, ethical, social, or economic). In each session, students engaged in guided multi-dimensional conversations. The protocol for these discussions was as follows:

The weekly theme was presented in the form of a brief (10-15 minutes) introduction by the facilitator, followed by guiding questions aimed at exploring multiple viewpoints. The task of the instructor was to facilitate discussion, maintain the balance of participation, and motivate students to relate technical problems to social and economic consequences in a critical manner.The duration of each session was approximately 60 minutes. There was a discussion by students on the given theme in small breakout groups (2530 minutes) and in a group (20 minutes) where the main findings were discussed in a complete discussion in the classroom. The remaining 10 minutes would be spent in reflection and summary led by the instructor. The students had to raise at least one argument or point of view per session, either orally or by the use of the chat program. Participation was recorded on the platform analytics.

The data were gathered by pre- and post-test that comprised 10-15 multiple-choice and short-answer items that measured pre- and post-session understanding. Platform logs were employed to trace the engagement, attendance, frequency of participation, and chat activity. In addition, a structured rubric was used to complete peer assessment, where the learner rated the level of clarity, relevance, and critical thinking of the peer contribution using a scaled critical assessment. Virtual classrooms were conducted using Google Meet and supported with integrated digital tools (e.g., shared documents and polls). These tools enhanced flexibility and accessibility but also posed challenges in maintaining sustained interaction.

The statistical analysis involved characterizing the data using descriptive statistics, paired t-tests, and Pearson correlation. To analyze pre-and post-test data, IBM SPSS 26.0 was utilized to improve the assessment of the effectiveness of multi-dimensional discussions.

Variables

The variables determine core cognitive skills and participation behaviors influencing students' critical thinking and comprehension. It also captures external factors affecting engagement and retention in virtual learning environments.

- Student Engagement (SE): the term SE is characterized by the degree of active participation, attentiveness, and affective involvement of students in the virtual classroom discussion. The SE describes how multi-dimensional technology discussions enhanced the learners' degree of interest, interaction, and engagement, which resulted in an improved understanding of course content, enhanced critical thinking, and ultimately improved effectiveness in the virtual classroom.SE was assessed on a 5-point Likert scale engagement questionnaire that had previously been validated in online learning research, with a supplement to platform analytics on frequency and length of participation.
- Comprehension (CO): variable CO describes the ability of students to recognize and integrate multidimensional discussions of technology in their thinking, including technical, social, and economic aspects. The analysis attempts to assess learning by comparing the merit of learning when coordinating the teaching remotely. It describes the depth of conceptual understanding developed during virtual classroom sessions, with students' understanding assessed through pre- and post-tests of cognitive growth and knowledge retention.CO was assessed by 10-15 multiple-choice and short-answer comprehension questions that were given at baseline and after each session. Two experts in the subject reviewed test items, which guaranteed content validity.
- Critical Thinking (CT): theCT refers to the engagement of students conducting reasoning, forming arguments, and demonstrating reflective judgment, as students engage in pre-defined multi-dimensional discussions on topics related to technology. The CT measurement explained focuses on students' competence in evaluating, analyzing, and synthesizing data based on the perspectives associated with that evidence of a technical, social, and economic nature during the virtual class discussions.CT was assessed on a 4-item peer evaluation rubric (argument clarity, use of evidence, perspective integration, and reflective judgment), rated on a scale of 5. The rubric was pilot-tested and reliable with a small group.
- Student Satisfaction (SS): the termSS indicates the extent to which learners are satisfied with their virtual classroom experience, specifically through the successful use of multi-dimensional discussion on technology. It encompasses perceptions of relevance, engagement, and value from relevant sessions that include technical, social, and economic perspectives, which relate to maximizing significant digital learning.It was assessed using a standardized student satisfaction survey (5-point Likert scale), which was based on validated and reliable online learning survey and assessment instruments.
- Participation Frequency (PF): the PF is the number of times a student takes part in online chat discussions. PF roles in the analysis were to be able to capture how students engaged in multi-facet discourse of technology, which was a gauge of engagement and interaction with key enhanced

understanding, critical analysis, and effective learning in an online environment.PF was determined using system-generated logs of Google Meet, which captured the number of verbal contributions, chat entries, and use of the reaction tool in each session.

- Retention Rate (RR): it indicates the percentage of students who were consistently engaged in the virtual learning program and completed the course. In the analysis, RR tracks the consistency of the students in terms of the effectiveness of multi-dimensional dialogues in sustaining students' engagement, indicating the role of engagement and cognitive stimulation in the degree to which students continued to be engaged in virtual classrooms and how long the learners maintained participation.The percentage of students who attended all six weeks of the program was computed and determined to be the RR based on the attendance logs.

RESULTS

Table 1. Demographic Characteristics for Student Participants

Variable	Category	Frequency(n)	Percentage (%)
Gender	Male	162	46,6
	Female	186	53,4
AgeGroup	18-20	102	29,3
	21-23	163	46,8
	24 above	83	23,9
Level of Study	Undergraduate	278	79,9
	Postgraduate	70	20,1
Field of Study	Engineering/IT	134	38,5
	Social Sciences	96	27,6
	Education	75	21,6
	Other	43	12,3
Previous Online LearningExperience	Yes	302	86,8
	No	46	13,2
Frequency of Participation in Online Discussions	Rarely	58	16,7
	Occasionally	142	40,8
	Frequently	148	42,5
Self-RatedTechnologyProficiency	Low	41	11,8
	Moderate	193	55,5
	High	114	32,7

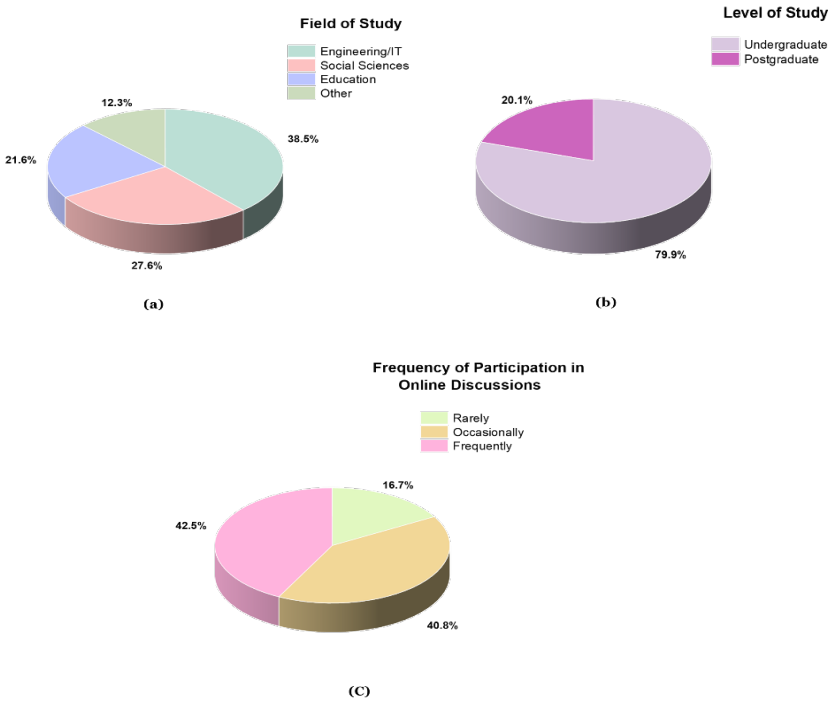

Figure 2. Distribution of participants by (a) Field of Study, (b) Level of Study, (c) Frequency of Participation in Virtual Discussions

Investigating how the multifaceted conversations affect learning results and students' active engagement in online learning settings is the focus of the research. Evaluate the improvements in student involvement, comprehension depth, and critical thinking. The statistical analysis assisted in identifying the observed significant improvements and significant relationships between the key learning variables within the virtual classroom setting. Table 1 shows the students' demographic details. Figure 2 shows participant demographics highlighting (a) academic background, (b) prior online experience, and (c) discussion participation trends.

Descriptive Statistics

The findings show that there are definite improvements in all the major learning variables post-intervention. The SE increased, or rather improved to 4,10, thus demonstrating a rise in student confidence. CO increased significantly by the margin of 64,3 to 78,1, which showed an improvement in peer interaction. There was also an increase in CT and SS, accompanied by better cognitive and interpersonal skills. PF experienced a significant increase between 2,10 and 3,70, indicating more of a real-world problem. Lastly, the RR was improved from 89,7 to 97,4, which showed that there was better retention of knowledge. Table 2 shows the pre- and post-intervention of core learning measures.

Table 2. Descriptive Statistics of Key Learning Variables with Before and After Intervention

Variable	Test	Mean	SD	Minimum	Maximum	Skewness	Kurtosis
SE	Pre	3,20	0,75	1,50	5,00	0,22	0,40
	Post	4,10	0,68	2,50	5,00	0,18	0,45
CO	Pre	64,3	10,2	40,0	85,0	0,10	0,25
	Post	78,1	9,5	55,0	95,0	0,20	0,10
CT	Pre	3,40	0,62	2,00	5,00	0,30	0,38
	Post	4,00	0,55	2,50	5,00	0,12	0,42
SS	Pre	3,60	0,70	2,00	5,00	0,15	0,20
	Post	4,30	0,60	3,00	5,00	0,22	0,30
PF	Pre	2,10	0,90	0,50	4,00	0,35	0,50
	Post	3,70	1,00	1,00	5,00	0,28	0,25
RR	Pre	89,7	2,5	85,0	92,0	0,10	0,15
	Post	97,4	1,8	95,0	100,0	0,12	0,20

Paired t-test

The results indicate that there are positive changes in all variables following the intervention. SE improved 0,90, CO improved 13,80, and CT improved 0,60, which indicated improved confidence, teamwork, and thinking. SS increased by 0,70, and the PF increased significantly by 1,60. RR was also enhanced by 7,70, which shows that it recalls better. The p-values of all of them are less than 0,0001, which proves the outcomes to be significant. These results indicate that multi-dimensional conversation is effective in enhancing virtual learning. Table 3 shows the statistical outcome of the paired t-test measuring educational impacts.

Table 3. Pre and Post Intervention Scores Across Key Learning Variables

Variable	Pre-Mean	Post Mean	Mean Difference	SD	-value	Degree of freedom (DF)	-value
SE	3,20	4,10	0,90	0,72	18,2	347	0,0001
CO	64,3	78,1	13,80	8,30	25,7	347	0,0001
CT	3,40	4,00	0,60	0,65	17,6	347	0,0001
SS	3,60	4,30	0,70	0,60	17,0	347	0,0001
PF	2,10	3,70	1,60	1,10	19,4	347	0,0001
RR	89,7	97,4	7,70	3,20	14,3	347	0,0001

Pearson correlation

The findings demonstrate that there are positive and strong correlations between the defining variables. SS and CO had a moderate positive correlation (r = 0,52), which means that social interaction and collaboration. PF was most correlated with SE (r = 0,62), meaning that problem-based study is strongly correlated with student confidence. RR also had a positive correlation with SE (r = 0,41) and CO (r = 0,45), as well as engagement and retention. All the correlations are significant, which contributes to the fact that the variables are related meaningfully. These results highlight the importance of multi-faceted conversations in the improvement of

virtual learning. Figure 3 shows the interrelationships of learning metrics in the virtual classroom contexts.

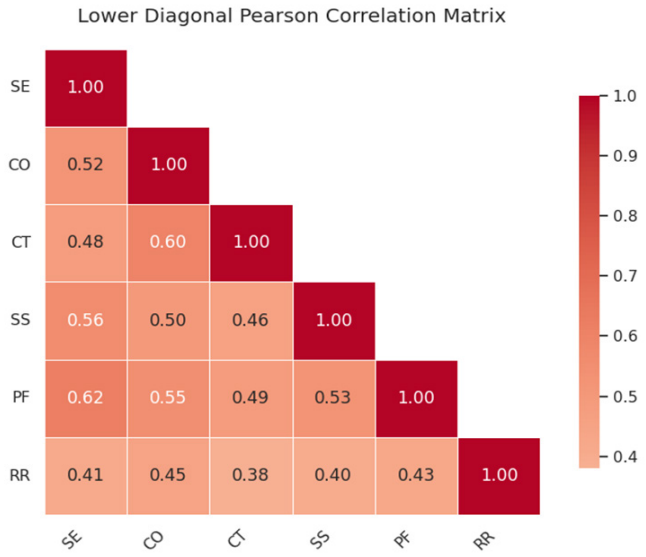

Figure 3. Outcome of Pearson Correlation Analysis

DISCUSSION

The research presented the effects of multi-dimensional conversations on student involvement, understanding, critical thinking, student satisfaction, frequency of participation, and retention in virtual classrooms. Findings showed that there was an improvement in all variables after the intervention. The SE, CO, and CT significantly improved, and the SS and PFalso demonstrated a quantifiable increase. RR was higher, which meant that multi-dimensional discussions enabled long-term participation in online learning. The results are consistent with the global literature that confirms the importance of interactive and collaborative approaches to digital education. As an example, learner preparedness and guided interactions were revealed to enhance motivation and engagement of online learning [11], whereas scenario-oriented, multi-dimensional interventions improved teacher-student interaction.[9] In the same manner, self-efficacy and engagement were also identified to be strongly related in science learning.[14] The high correlations of SE, SS, and PF indicate that interactive discussions enhanced deep learning because they encourage both thinking and interpersonal interactions. This finding confirms the finding that the self-efficacy and science education engagement are closely related, because active dialogues establish a situation in which learners will feel competent and motivated. Mechanically, multi-dimensional conversations seem to offer ways of allowing the students to relate the technical, social, and economic aspects that can improve reflective judgment and critical thinking. The results indicate the efficacy of discussing in multiple dimensions as a means of teaching that enhances learning, develops critical and collaborative skills, and increases retention. Online course design can resolve the issue of disengagement and minimize the chances of dropping out through the incorporation of such methods in online education. Although the results of the study are encouraging, the paper has a number of limitations. First, a convenience sample of 348 students in four classrooms was used, which restricts the external applicability of the findings to larger, more heterogeneous samples. Second, the long-term sustainability of learning gains might not be well reflected in the six weeks of intervention since retention after the intervention is not known. Third, quantitative measures were used to present strong evidence of improvement, but no qualitative insights into the experiences of students were made, and it might have supported the interpretation of the findings. Lastly, the research was based on online platforms (e.g., Google Meet), and the findings can be different in situations when the technological infrastructure is not as solid.

CONCLUSIONS

The analysis shows that integration of multiple perspectives in learning virtual classrooms can empower student engagement, comprehension, and critical thinking, as well as improve participation, satisfaction, and retention. Online learning allows active engagement in learning activities by incorporating technical, social, and economic perspectives into organized activities, which helps break the monotony of basic content delivery and encourages more critical thinking and reflection. The results affirm that interactive student-focused approaches can be used in dealing with the disengagement and critical inquiry issues in the online setting. Nevertheless, the study was limited to a single context and was primarily based on quantitative data, which limits the generalization. This model needs to be tested in a variety of institutions in future studies,

including long-term evaluation, and introduce qualitative information to optimize strategies that can promote meaningful and sustainable online learning.

REFERENCE

1. Zhang J, Pan Q, Zhang D, Meng B, Hwang GJ. Effects of virtual reality-based microteaching training on pre-service teachers' teaching skills from a multi-dimensional perspective. J Educ Comput Res. 2024;62(3):655-83. https://doi.org/10.1177/07356331231226179

2. Pavlidou I, Dragicevic N, Tsui E. A multi-dimensional hybrid learning environment for business education: A knowledge dynamics perspective. Sustainability. 2021;13(7):3889. https://doi.org/10.3390/su13073889

3. Chen Y. The online teacher-student interaction level in the context of a scenario-based multi-dimensional interaction teaching environment. Int J Emerg Technol Learn. 2022;17(12):135-49. https://doi.org/10.1108/IJEM-08-2022-0309

4. Wajid MA, Camacho-Zuñiga C. A multi-dimensional neutrosophic PESTEL approach to assessing the TEC21 educational model. Cogent Educ. 2025;12(1):2527930. https://doi.org/10.1080/2331186X.2025.2527930

5. Lin YC, Chien SY, Hou HT. A multi-dimensional scaffolding-based virtual reality educational board game design framework for service skills training. Educ Inf Technol. 2025;30(8):11251-78. https://doi.org/10.1007/s10639-024-13243-4

6. Li Q, Li Z, Han J, Ma H. Quality assurance for performing arts education: A multi-dimensional analysis approach. Appl Sci. 2022;12(10):4813. https://doi.org/10.3390/app12104813

7. Docter MW, de Vries TN, Nguyen HD, van Keulen H. A proof-of-concept of an Integrated VR and AI application to develop Classroom Management competencies in teachers in Training. Educ Sci. 2024;14(5):540. https://doi.org/10.3390/educsci14050540

8. Jiang L, Zhou N, Yang Y. Student motivation and engagement in online language learning using virtual classrooms: Interrelationships with support, attitude, and learner readiness. Educ Inf Technol. 2024;29(13):17119-43. https://doi.org/10.1007/s10639-024-12514-4

9. Elfeky AIM, Najmi AH, Elbyaly MYH. The impact of advanced organizers in virtual classrooms on the development of integrated science process skills. PeerJ Comput Sci. 2024;10:e1989. https://doi.org/10.7717/peerj-cs.1989

10. Habib FAB. Unveiling the role of educators' attitudes & intention toward artificial intelligence in teaching: A multi-dimensional analysis. Educ Inf Technol. 2025:1-25. https://doi.org/10.1007/s10639-024-13271-0

11. Rabby SM, Akhi AA, Talukder MS, Das S. How does limited student engagement in virtual classrooms affect students' academic performance? A stressor–strain–outcome perspective. Horizon. 2025. https://doi.org/10.1108/OTH-02-2025-0017

12. Yang H, Kim J, Kelly S, Merrill Jr K. Learning in the online classroom: Exploring the unique influence of social presence dimensions. Commun Stud. 2022;73(3):245-62. https://doi.org/10.1080/10510974.2022.2074491

13. Derakhshan A, Gao X. "I Am Excessively Pressed by Classroom Tasks": A Cross-Cultural Study on the Sources and Solutions of Chinese and Iranian EFL Students' Academic Disengagement in Online Classes. Psychol Sch. 2025;62(4):996-1012. https://doi.org/10.1002/pits.23374

14. Lin TJ. Multi-dimensional explorations into the relationships between high school students' science learning self-efficacy and engagement. Int J Sci Educ. 2021;43(8):1193-207. https://doi.org/10.1080/09500693.2021.1904523

15. Guo Q, Zeng Q, Zhang L. What social factors influence learners' continuous intention in online learning? A social presence perspective. Inf Technol People. 2023;36(3):1076-94. https://doi.org/10.1108/ITP-02-2021-0151

16. Savadkouhi ZB, MostafaeiAlaei M. Cross-Cultural Pragmatic Failure in English Language Classrooms: Development of a Multi-Dimensional Model Based on EFL Teachers' and Learners' Perceptions. J Mod Res Engl Lang Stud. 2022;9(3):49-72. https://doi.org/10.30479/jmrels.2022.16141.1962

17. Chen W, Sun P, Yang Z. Understanding Chinese second language learners' foreign language learning boredom in online classes: Its conceptual structure and sources. J Multiling Multicult Dev. 2024;45(8):3291-307. https://doi.org/10.1080/01434632.2022.2093887

FINANCING

The authors did not receive financing for the development of this research.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORSHIP CONTRIBUTION

Data curation: XuBiao Yin.
Formal analysis: Changsheng Yu.
Resources: XuBiao Yin.
Software: Changsheng Yu.
Validation: Jinghong Liu.
Display: Jinghong Liu.
Drafting - original draft: XuBiao Yin.
Writing - proofreading and editing: XuBiao Yin.