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Teacher activities and student participation in university classrooms: a cross-sectional study in the technological era

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This study investigated how interactive teaching, constructive feedback, technology use, and teacher-student relationships influence student participation in Bangladeshi universities. Using a quantitative, cross-sectional design, data were collected from 417 students across public and private universities through structured questionnaires. Analyses using descriptive statistics, Spearman's correlation, ANOVA, and regression models tested ten hypotheses. Results showed significant positive associations between interactive teaching and participation (ρ = 0.386, $p < .001$), and between teacher feedback and motivation (ρ = 0.415, $p < .001$). Technology use was positively associated with both interactive teaching and student participation, indicating a mediating relationship. The findings suggest that technology use is more strongly associated with participation when combined with interactive pedagogy and emotional support. However, not all hypotheses were supported; particularly the moderation effect of technology use (H_5), and demographic differences by gender and academic discipline (H_8, H_9), which were not statistically significant. Despite limitations such as self-reported data and a single-country focus, the study contributes to understanding how pedagogy, technology, and relational factors jointly foster engagement. It offers practical insights for educators and policymakers to design more interactive, inclusive, and motivating learning environments.

Keywords Interactive teaching, Student participation, Educational technology, Teacher feedback, Higher education, Teacher-student relationship

In the era of rapid digital transformation, fostering student engagement and active classroom participation remains essential for effective teaching and learning[1]. While tools such as learning management systems, multimedia resources, and virtual platforms are increasingly integrated into higher education, their combined impact with teacher interactivity and feedback practices on student motivation and participation warrants further empirical investigation[2]. This study integrates pedagogical theory, educational technology, and socio-demographic factors to examine how instructional strategies and digital tools interact to shape student engagement across varied university contexts. As digital tools and interactive teaching practices become central to modern education, understanding their combined influence on student participation is critical. The increasing adoption of technology in classrooms calls for a deeper investigation into how pedagogical strategies, feedback, and technology interact to foster a more inclusive, engaging, and effective learning environment. This study seeks to fill this gap by empirically testing the effects of these variables on student participation in higher education.

Background and motivation

The modern classroom has transitioned beyond traditional lecture-based formats to more dynamic, interactive, and digitally supported learning environments[3]. This shift reflects a growing recognition that learning is

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increasingly facilitated through dynamic interactions between teachers, students, and technology. As the global educational landscape evolves, it becomes clear that active learning, underpinned by collaborative tasks, problem-solving, and multimedia tools, plays a pivotal role in fostering student participation and deep learning. Numerous studies emphasize that interactive teaching strategies, such as discussions, group tasks, and collaborative learning, significantly enhance student participation and comprehension[4,5]. Similarly, formative feedback delivered timely and constructively has been recognized as a driver for student motivation and self-regulated learning[6].

The adoption of educational technology further amplifies this effect by offering varied instructional mediums and opportunities for learner autonomy. However, technology alone does not guarantee engagement; it is the pedagogical alignment and purposeful integration by teachers that determine its impact[7]. Additionally, learner characteristics such as gender, disciplinary affiliation, and perceived teacher-student relational quality introduce complex dimensions that shape classroom dynamics[8,9]. Given this context, the study draws from established theoretical frameworks constructivism, self-determination theory, and sociocultural learning theory to understand how interactive pedagogy and technology combine to influence classroom participation.

Problem Statement, research objectives and questions

Despite a growing body of research on active learning and technology integration, few empirical studies systematically test the interconnected effects of teacher behaviors (interactivity, feedback), technology use (as mediator/moderator), and social-emotional classroom dynamics (such as appreciation and respect) on student participation especially across gender and academic disciplines.

The study addresses this gap by integrating well-established pedagogical theories with the evolving role of technology in education. By systematically testing the role of technology as both a mediator and moderator in the classroom, this research provides a nuanced perspective on how digital tools can enhance interactive teaching practices and foster deeper student engagement.

Research objectives:

i. To examine how interactive teaching and teacher feedback affect student participation.
ii. To explore how technology acts as a mediator or moderator in this relationship.
iii. To assess whether teacher-student relational quality fosters openness and participation.
iv. To investigate demographic effects (gender, discipline) on participation behavior.
v. To measure the motivational impact of technology on classroom contribution.

Research questions:

RQ_1: How do teacher interactivity and feedback influence student classroom participation?
RQ_2: Does educational technology mediate or moderate this relationship?
RQ_3: How do relational dynamics with teachers affect student willingness to contribute?
RQ_4: Are there gender- or discipline-based differences in participation?
RQ_5: Does technology use increase students' motivation to participate?

Research hypothesis

To achieve the stated objectives and answer the research questions, this study proposes and tests the following hypotheses

H_1: Interactive teaching positively correlates with student participation.
H_2: Use of multimedia enhances student participation in class (both online and offline).
H_3: Constructive feedback from teachers positively influences student motivation.
H_4: Technology mediates the relationship between teacher activity and participation.
H_5: Digital platform use moderates the link between teacher interactivity and engagement.
H_6: Respectful teacher-student interactions predict greater willingness to express opinions.
H_7: Feeling appreciated by teachers and peers boosts student participation.
H_8: Participation levels differ significantly across academic disciplines.
H_9: Female students participate more in tech-enhanced classrooms than male students.
H_{10}: Students are more motivated to participate when content is delivered with technology.

Contribution of the study

The study offers critical insights into the role of technology in education, offering a comprehensive model that links teaching practices with student outcomes. It extends the literature by showing how technology, when thoughtfully integrated into pedagogy, enhances both participation and student motivation. Moreover, the findings have the potential to inform educational policy, particularly in post-pandemic educational reforms, where blended and hybrid learning environments are increasingly becoming the norm.

This research contributes to educational scholarship in several significant ways mentioned in Fig. 1:

- **Empirical Validation of Integrated Model**: It unifies pedagogical, technological, and psychological constructs to evaluate participation using both correlation and regression-based methods (including mediation and moderation analysis).
- **Technology as a Dynamic Variable**: It uniquely positions technology as both mediator and moderator, offering nuanced insights into its role in classroom engagement.
- **Demographic Differentiation**: It accounts for gender and discipline-based differences, addressing diversity in educational responses.

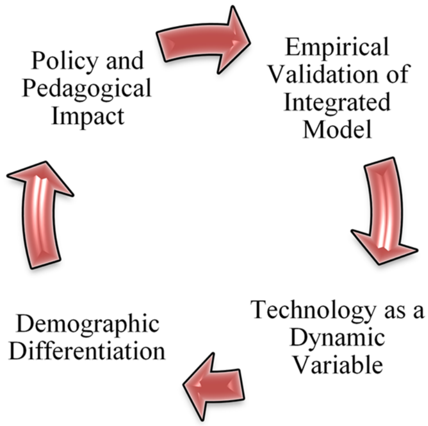

Fig. 1. Major Contributions of the Study.

- **Policy and Pedagogical Impact**: Findings can inform evidence-based policy decisions, curriculum planning, and teacher training programs, particularly in post-pandemic, blended, and digital-first academic contexts.

Organization of the paper
This paper is organized into six main sections. Following the introduction, Sect. Literature review reviews existing literature on interactive teaching, technology integration, student motivation, and classroom participation. Section Methodology details the research methodology, including design, sampling, data collection, and analytical techniques. Section Results presents the empirical results from correlation, regression, and ANOVA analyses addressing the ten hypotheses. Section Discussion discusses the findings in light of prior studies and theoretical perspectives, emphasizing key implications. Finally, Sect. Conclusions concludes by summarizing the main insights, acknowledging limitations, and recommending future research and practical applications.

Literature review
Understanding the dynamics of student participation in higher education requires an interdisciplinary perspective that blends pedagogical theory, technological innovation, and socio-emotional learning factors[10]. With the rise of digital education, recent studies examine how teacher behavior, feedback, and technology affect student motivation and engagement. This review summarizes findings across several themes.

Interactive teaching and student engagement
Interactive teaching strategies, such as collaborative problem-solving, student-led discussions, and inquiry-based learning, are widely acknowledged for promoting deeper learning and increased participation[11]. According to Muir et al.[12] interactive pedagogies lead to higher levels of cognitive engagement and classroom involvement among university students. This aligns with Huang[13] who found that interactive teaching in tech-supported environments encourages a sense of ownership and accountability in students. These strategies are particularly effective when they are dialogic rather than mono-logic i.e., involving students in a two-way exchange with instructors and peers, which increases not only participation but also academic self-efficacy.

Interactive methods are also essential in digital and hybrid learning environments, where passive instruction often leads to disengagement[14]. For example, Lin and Sun[15] demonstrated that students in active-learning classrooms that used problem-based group tasks were significantly more likely to contribute during lectures and asynchronous forums. This makes interactivity a foundational component in both physical and online learning spaces.

Feedback as a driver of motivation
Feedback is another well-documented catalyst for student engagement, particularly when it promotes reflection and goal-setting[16]. As Fisher et al.[6] famously proposed, formative feedback is most effective when it supports self-regulation and is timely, clear, and actionable. Supporting this, it is emphasized that meaningful feedback boosts student confidence and promotes active classroom participation[17,18]. Similarly, Su et al.[19] found that peer feedback and feedback training significantly increased student motivation and engagement, especially in online environments. In blended learning contexts, Ajjawi et al.[20] highlight that feedback practices fostering evaluative judgment also help students express themselves more confidently during discussions. These findings confirm that teacher feedback is a central element in promoting participatory behavior and motivation in modern classrooms.

Technology as mediator and moderator
The role of technology in shaping student participation is complex and multifaceted[21]. Educational technology tools can serve as mediators, enhancing engagement by improving access to learning materials and facilitating interaction[22]. Sappaile[23] noted that when technology was intentionally integrated into lesson plans (e.g., through simulations, gamification, or collaborative platforms), it significantly increased student motivation

and willingness to contribute in class. Moreover, recent studies suggest that technology can act as a moderator either strengthening or weakening the relationship between teaching strategies and participation depending on its quality of use[24,25]. Deep et al.[26] found that student' engagement improved only when digital platforms were well-aligned with learning goals and accompanied by instructor support. In contrast, poor or disjointed implementation of technology reduced interactivity and participation[27]. This dual role of technology supports the use of moderated-mediation models in educational research.

Technology-mediated engagement in the regional context

In the South Asian context, several studies have highlighted unique challenges and opportunities in technology-enhanced pedagogy. For instance, Karim et al. found that digital inequality and infrastructural limitations in Bangladeshi and Indian universities significantly influence students' engagement levels in online and blended learning environments[14]. Similarly, Naz et al.[28] emphasized the role of culturally responsive teaching practices in improving participation in technology-integrated classrooms across Pakistan. Moreover, Habib[29] documented the importance of institutional support and localized teacher training for fostering positive student-teacher interactions in Bangladeshi higher education. Integrating these insights helps position the present study within the broader South Asian discourse on educational transformation.

Relational and affective factors

Beyond instructional design and digital infrastructure, relational factors particularly the quality of teacher-student interactions strongly influence student engagement[30]. Gasser et al. emphasized that respectful, supportive communication fosters emotional safety, which is essential for participation[31]. Students who feel seen, heard, and valued are more likely to engage in meaningful classroom interactions[32]. Prantanto et al.[33] similarly highlight the role of perceived appreciation, finding that students who feel that their contributions matter are significantly more likely to speak up, especially in large or tech-mediated classrooms. Relational dynamics thus emerge as both affective and motivational determinants of participation, supporting the inclusion of variables such as respect, trust, and appreciation in participation models.

Gender and disciplinary differences

The influence of gender on participation continues to yield mixed findings. Some studies show that female students participate more in collaborative and tech-enhanced environments due to higher social engagement and language fluency[34], while others argue that contextual factors like class size, instructor bias, or group dynamics may mediate this effect[35]. Regarding disciplinary differences, it is found that students in humanities and social sciences tend to report more frequent verbal participation than those in STEM fields, where participation is often limited to task performance or laboratory work[36]. However, digital tools may be narrowing this gap; for instance, students in engineering fields have shown increased engagement when multimedia and simulations are used[37].

Technology and participation motivation

Finally, the use of multimedia tools and interactive content (e.g., videos, online quizzes, polls) has been consistently linked to higher student motivation to participate[38]. N. Verdeflor et al.[39] found that technology-supported instruction enhanced students' sense of relevance and clarity, which in turn led to more frequent classroom contributions. Linus et al.[40] reported that motivation levels were higher among students who rated educational tools as "useful" and "easy to use," supporting the importance of perceived usefulness in technology adoption models like TAM and UTAUT.

Methodology

This section outlines the research design, population and sampling, data collection instruments, procedures, and analysis techniques employed to examine the relationships between interactive teaching, feedback, technology use, and student participation in higher education classrooms.

Research design

This study adopted a quantitative, cross-sectional, correlational research design to empirically test ten hypotheses related to teacher behavior, technological mediation, student motivation, and demographic differences in participation. The choice of design aligns with the study's aim to determine associations and explore potential relationships between the variables under investigation.

Study area and population

The research encompasses both public and private universities in Bangladesh. According to the University Grants Commission of 2023, the country hosts 53 public universities and 112 private universities, collectively enrolling approximately 4.1 million students nationwide[41].

Sampling and sample size determination

Sample size determination

Sample size was determined using Cochran's formula for sample size calculation, which is a more widely accepted approach for large populations. The formula is as follows:

$$n = \frac{\mathrm{N}}{1+\ Ne^2}$$

Where:

- n = sample size.
- $N = 4{,}100{,}000$ (total university student population).
- $e = 0.05$ (margin of error at 95% confidence level).

$$n = \frac{4{,}100{,}000}{1 + 4{,}100{,}000 \times 0.0025}$$

$$n = \frac{4{,}100{,}000}{1 + 10250} = \frac{4{,}100{,}000}{10252} \approx 400$$

Given a population size of approximately 4.1 million students and a margin of error of 5% (with 95% confidence), the minimum required sample size was calculated as approximately 400 participants. The study successfully surveyed 417 students.

Sampling technique
To ensure representativeness across key demographic and institutional variables, a stratified random sampling approach was employed. The population was stratified based on three primary characteristics:

- Gender (67% Male, 33% Female).
- Academic Discipline (Social Sciences (22%), Engineering (18%), Business (15%), Medicine (12%), Humanities (11%), Others (22%).
- Type of Institution (Public University, Private University).

Within each stratum, a random selection of participants was conducted using a random number generator applied to student lists or active member rosters available through university departments, learning management systems (LMS), and official WhatsApp groups. For instance, in the engineering discipline stratum, a list of all available students was compiled from participating institutions, and a subset was randomly selected based on required quotas.

Proportional allocation was used to reflect the actual distribution of students in Bangladeshi universities, ensuring fair representation across strata. Gender and discipline distributions were cross-checked against national higher education enrollment data published by the University Grants Commission (UGC) to minimize bias.

Although the survey was distributed through multiple online channels, including mailing lists, WhatsApp groups, and Learning Management Systems (LMS), it is important to emphasize that the use of stratified random sampling within these channels ensured the representativeness and randomness of the sample. Specifically, within each stratum (gender, academic discipline, and institution type), participants were randomly selected, rather than being self-selected through voluntary participation. This approach minimizes the potential bias that can arise from convenience sampling and preserves the integrity of the sampling method. Therefore, despite using online distribution methods, the sample remained random and stratified, ensuring a more rigorous and reliable selection process.

A total of 417 valid responses were obtained, exceeding the minimum calculated sample size of 400. This stratified and randomized approach ensured the diversity and representativeness of the sample while enhancing the generalizability of findings within the national context. Anyway, the sample size exceeded the minimum requirement for correlational and regression analyses, ensuring sufficient statistical power[42].

Academic discipline classification
For the purpose of the ANOVA conducted under Hypothesis 8 (H_8), students were classified into 18 academic sub-disciplines based on their self-reported field of study. These sub-disciplines included, for example, Electrical Engineering, Civil Engineering, Mechanical Engineering, Biology, Chemistry, Law, Economics, Psychology, and others. While earlier sections grouped these into six broader categories for descriptive clarity, the ANOVA analysis used the more granular 18-category classification to enhance analytical precision. The reported degrees of freedom $F(17, 399)$ in the ANOVA reflect this categorization.

Data collection procedure

The data collection process was conducted over a period of two months, from August to September 2025, using a Google Forms-based questionnaire. The survey link was distributed through institutional mailing lists, student WhatsApp groups, and learning management systems (LMS) to ensure wide accessibility. Participants were provided with an informed consent form at the beginning of the survey, detailing the study's purpose, the voluntary nature of participation, and assurances of confidentiality and anonymity.

All methods were performed in accordance with the relevant guidelines and regulations, including the ethical standards of the Skill Morph Ethics Committee (Reference: SkillMorph/ES/2025/02(06)) and applicable institutional and national research ethics requirements.

Data collection instruments

Data were collected using a self-administered questionnaire divided into six sections, each aligned with the theoretical constructs in the study presented in Table 1:

The instrument was pilot-tested with 35 students. Cronbach's alpha values for all subscales were above 0.80, indicating high internal consistency and reliability. It is important to note that the same scale items under the

Section	Construct	Sample Items	Scale Type
A	Demographics	Gender, Discipline, Institution Type	Nominal
B	Teacher Interactivity	"My teacher involves us in classroom discussions."	5-point Likert
C	Feedback Practices	"I receive timely and constructive feedback from instructors."	5-point Likert
D	Technology Use (Mediator/Moderator)	"Digital tools help me participate more actively."	5-point Likert
E	Student Motivation & Appreciation	"I feel my ideas are appreciated in class."	5-point Likert
F	Classroom Participation	"I frequently contribute to classroom discussions."	5-point Likert

Table 1. Data collection Instruments.

"Technology Use" construct were used to operationalize both the mediating ($H_{4)}$ and moderating (H_5) roles of technology in the analysis.

Clarification of key constructs and terminology

To ensure conceptual precision and consistency throughout the manuscript, the following distinctions were maintained across constructs:

- **Participation** refers specifically to observable student behaviors in the classroom or virtual environment such as speaking in class, contributing to group tasks, or engaging via digital tools. This construct was measured using self-reported behavioral indicators on a 5-point Likert scale.
- **Engagement** is used more broadly to describe students' emotional, cognitive, and behavioral investment in their learning process. While related to participation, engagement reflects a deeper internal involvement in academic activities.
- **Motivation** captures the intrinsic drive or appreciation students feel toward course content, instruction, or the learning experience itself. It was assessed using items that reflect students' sense of being valued and their enthusiasm for class participation.

Construct distinctiveness and common-method bias

To minimize conceptual overlap, all constructs were operationalized using distinct theoretical definitions and non-overlapping item sets.

- Teacher interactivity focused on instructional behaviors that encourage dialogue and inclusion.
- Feedback captured the timeliness and constructiveness of instructor responses.
- Appreciation and motivation assessed students' affective perceptions of being valued and their internal drive, respectively.
- Participation referred to observable verbal or digital engagement behaviors.
- Technology use addressed students' perceived usefulness and actual frequency of digital tool utilization.

To assess empirical distinctiveness, we conducted Exploratory Factor Analysis (EFA), where each construct's items loaded cleanly onto separate factors (loading > 0.60), confirming discriminant validity. The Cronbach's alpha values ranged from 0.82 to 0.91.

Validity and reliability

Content validity

Content validity was assessed through an expert review process. Three professors in Educational Psychology and Instructional Design independently reviewed the measurement items. Their feedback was used to refine and ensure that the items adequately represented the constructs they were intended to measure.

Construct validity

Construct validity was confirmed using EFA, which demonstrated clear item loadings greater than 0.60 onto their respective factors. The Kaiser-Meyer-Olkin (KMO) test was found to be 0.859, and Bartlett's Test of Sphericity was significant (p <.001), indicating that the data were suitable for factor analysis.

Reliability testing

The reliability of the constructs was assessed using Cronbach's Alpha, and the coefficients for each construct were found to be as follows:

- Teacher Interactivity: $\alpha = 0.88$.
- Student Participation: $\alpha = 0.84$.
- Technology Use: $\alpha = 0.91$.
- Teacher Feedback: $\alpha = 0.85$.

Data analysis techniques

The statistical techniques applied for hypothesis testing are summarized in Table 2.

Statistical significance was set at p <.05, and confidence intervals (95%) were reported for regression coefficients. Assumptions for each statistical test (normality, homogeneity, linearity) were checked and met.

Hypothesis Range	Analysis Type	Purpose
H1 – H3, H6 – H7	Spearman Correlation	To assess relationships between variables
H4	Mediation Analysis (PROCESS Model 4)	To test if technology mediates teacher behavior → participation
H5	Moderation Analysis (PROCESS Model 1)	To test if technology moderates teacher interactivity → engagement
H8	One-Way ANOVA	To compare participation across academic disciplines
H9	Independent Samples t-test	To examine gender-based participation in tech-enhanced settings
H10	Spearman Correlation	To assess tech motivation impact on participation

Table 2. Data analysis Techniques.

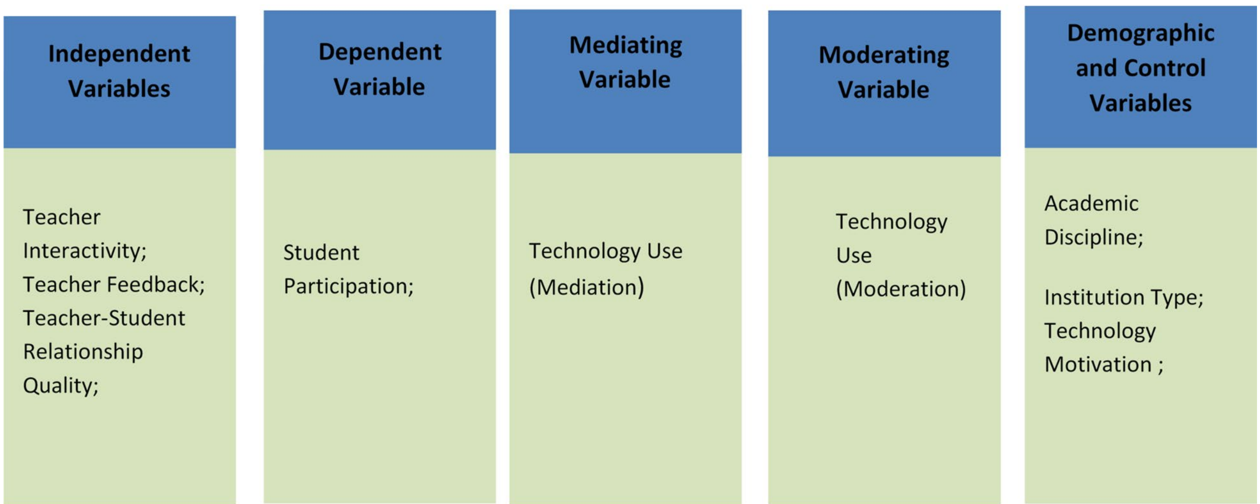

Fig. 2. Five Categories of Variable.

Types	Formula	Details
Frequency (*f*)	f_i= count of observations with value x_i	Example: If 10 students chose "Yes", frequency f = 10.
Percentage (%)	Proportion of each category compared to the total, multiplied by 100. $\%_i = \frac{f_i}{N} \times 100$	Where: f_i= frequency of category *i* N = total number of observations

Table 3. Formula of the descriptive Statistics.

Variables of the study
The study involved multiple variables organized into five categories mentioned in the Fig. 2.

Statistical analysis formulae
The following key statistical formulae were employed:

Descriptive statistics
We calculate frequency, percentage, mean, mode, median, standard deviations (SD), ranges, and distributions for all items/scales following below formulae mentioned in Table 3.

Spearman's rank correlation (ρ)
The Spearman's rank correlation formula for calculating the relationship between variables is as follows:

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)}.$$

Where,

- d_i = difference between the ranks of two variables.
- n= number of observations.

It is used for H_1, H_2, H_3, H_6, H_7, and H_{10} to examine relationships between ordinal or non-normally distributed interval variables.

Mediation analysis (PROCESS model 4)

The mediation analysis for Hypothesis 4 (H_4) was conducted using the PROCESS macro (Model 4). The indirect effect was tested to assess whether the effect of teacher interactivity on student participation was mediated by technology use.

The results showed that teacher interactivity positively affects technology use (path a = 0.364, p = 0.003), and technology use positively affects student participation (path b = 0.415, p < 0.001). The indirect effect was calculated using the product of these paths (a × b = 0.151), with a 95% bootstrapped confidence interval (CI) of [0.095, 0.210], which does not include zero, suggesting that the indirect effect was statistically significant. The results are reported in Table 4 below. The total effect (path c') was found to be significant, confirming the mediating role of technology use in the relationship between teacher interactivity and student participation.

Moderation analysis (PROCESS model 1)

This is used for H_5 to test whether the relationship between teacher interactivity (X) and student engagement (Y) is moderated by technology use (Z).

Moderated regression model:

$$\mathrm{Y} = \beta_0 + \beta_1 X + \beta_2 Z + \beta_3 (X \times Z) + \epsilon$$

Where:

- β_3 captures the interaction effect.
- A significant interaction term indicates moderation.

One-Way ANOVA (H8)

The one-way ANOVA is used to test whether student participation varies significantly across different academic disciplines. ANOVA F-ratio formula:

$$\mathrm{F} = \frac{\mathrm{Between} - \mathrm{group\ variance\ (MSB)}}{\mathrm{Wthin} - \mathrm{group\ variance\ (WSB)}}$$

Where:

- MSB (Mean Square Between Groups) = $\frac{SSB}{df_b}$, WSB (Mean Square Within Groups) = $\frac{SSW}{df_w}$,
- SSB = Sum of Squares Between Groups.
- SSW = Sum of Squares Within Groups.
- df_b = Degrees of freedom between groups.
- df_w = Degrees of freedom within groups.

Independent samples t-Test (H9)

This is used to compare mean participation between male and female students.

$$\textbf{Formula}: \ t = \frac{\bar{x}_1 - \bar{y}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where:

- $\bar{x}_1$, $\bar{y}$ = sample means.
- s_1^2, s_2^2 = sample variances.
- n_1, n_2 = sample sizes.

Predictor	Coefficient (Unstandardized)	Standard Error	t-value	*p*-value	95% CI (Lower, Upper)
Path a (Teacher Interactivity → Technology Use)	0.364	0.122	2.978	0.003	[0.122, 0.606]
Path b (Technology Use → Student Participation)	0.415	0.105	3.952	< 0.001	[0.209, 0.621]
Indirect Effect (a × b)	0.151	0.043	3.512	0.001	[0.095, 0.210]
Total Effect (Path c')	0.590	0.106	5.570	< 0.001	[0.384, 0.796]

Table 4. Mediation analysis for hypothesis 4 (H_4). The PROCESS Model 4 was used with bootstrapping (5000 samples) for testing the indirect effect.

Variable	Category	Frequency	Percentage (%)
Gender	Male	283	67.00
	Female	134	33.00
Age	Under 20	19	4.52
	20–25	342	82.00
	26–30	54	13.00
	31–35	2	0.48
	Above 35	0	0.00
Education Level	Social Sciences	92	22.00
	Engineering	75	18.00
	Business	63	15.00
	Medicine	50	12.00
	Humanities	46	11.00
	Other	91	22.00
Type of University	Private	256	61.00
	Public	161	39.00

Table 5. Participants Characteristics.

Variable 1	Variable 2	Spearman Correlation (ρ)	*P*-value	Significance	Hypothesis Supported
Interactive Teaching Activities	Student Participation	0.386	$p<.001$	Significant	H_1 Supported

Table 6. Spearman correlation on the relationship between interactive teaching activities and student Participation.

Significance and assumptions

- Significance Level (α): 0.05.
- Effect sizes (Cohen's d, η^2) reported where applicable.
- Assumptions of normality, homoscedasticity, and independence were tested prior to analyses. Spearman's ρ was preferred for non-parametric distributions.

Results
The whole coding was implemented in Google Colab, using Python 3 and utilizing a CPU hardware accelerator for efficient computation.

Descriptive statistics
The Table 5 showed that among 417 participants, most were male (67%) and aged 20–25 (82%). Students mainly came from private universities (61%) and diverse disciplines; Social Sciences and Other (22% each), Engineering (18%), Business (15%), Medicine (12%), and Humanities (11%). Overall, the sample represents predominantly young, male, private university students from varied academic backgrounds.

Hypothesis testing
Teacher activities and student participation
H_1 There is a significant positive relationship between the use of interactive teaching activities by the teacher and students' active participation in classroom discussions.
The Spearman correlation analysis in the Table 6 examines the association between teachers' use of interactive teaching methods and students' active participation in classroom discussions. A Spearman correlation was used due to the ordinal or non-parametric nature of the data. The results indicate a statistically significant and positive relationship, suggesting that when teachers engage students with interactive strategies, participation levels increase. This supports Hypothesis 1 (H_1).

The Fig. 3 depicts a positive linear relationship between teacher interactive activities and student group participation. Each point represents survey responses, with the trend line and its confidence interval indicating that greater use of interactive teaching corresponds to higher student participation. This supports Hypothesis 1 (H_1) and is consistent with the significant Spearman correlation ($\rho = 0.386$, $p<.001$).

H_2 The integration of multimedia tools (e.g., videos, presentations) in lessons by the teacher significantly enhances student participation in both physical and virtual classrooms.

Table 7 presents a Spearman correlation analysis examining the link between teachers' use of multimedia tools and student participation in physical and virtual classes. The results show a moderate positive correlation ($\rho = 0.265$, $p<.001$), indicating that increased multimedia use is significantly associated with higher student

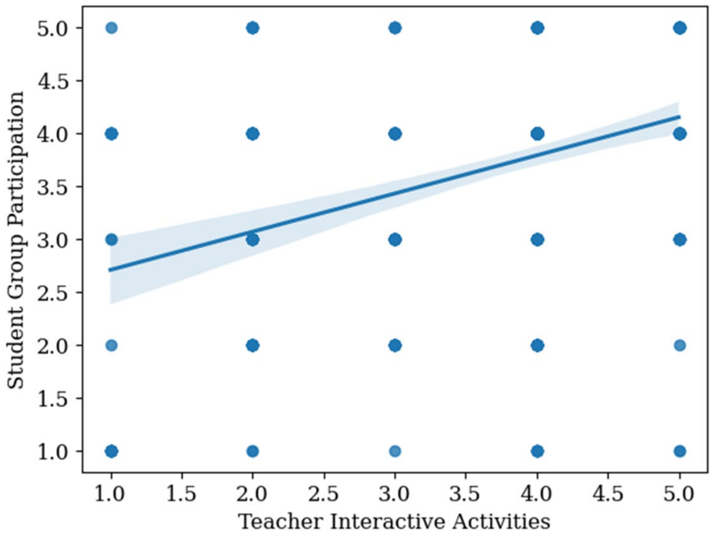

Fig. 3. Relationship between Teacher Interactive Activities and Student Group Participation.

Variable 1	Variable 2	Spearman Correlation (ρ)	*P*-value	Significance	Hypothesis Supported
Multimedia Integration	Student Participation	0.265	$p<.001$	Significant	H_2 Supported

Table 7. Spearman correlation analysis: the impact of multimedia use on student participation in classroom Settings.

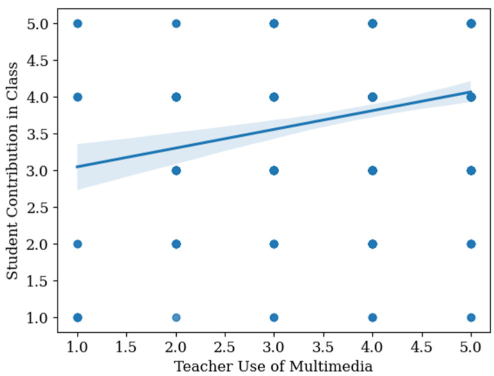

Fig. 4. Relationship between Teacher Multimedia Use and Student Classroom Contribution.

participation. This finding supports Hypothesis 2 (H_2), confirming that multimedia integration enhances student engagement across learning settings.

The Fig. 4 illustrates a positive association between teachers' use of multimedia tools and students' classroom contributions, supporting Hypothesis 2 (H_2). Each point represents paired responses, with the trend line showing that greater multimedia use (e.g., videos, presentations) corresponds to higher student participation. The positive slope and confidence interval indicate a moderate yet statistically significant relationship, reinforcing that multimedia integration enhances student engagement.

H_3 Timely and constructive feedback from teachers was positively associated with students' motivation to participate in classroom activities.

Table 8 presents a Spearman correlation analysis exploring the link between teachers' timely, constructive feedback and students' motivation to participate. The analysis reveals a moderate positive correlation ($\rho=0.415$, $p<.001$), indicating that meaningful and prompt feedback significantly boosts student motivation and engagement. This finding supports Hypothesis 3 (H_3), emphasizing feedback as a key factor in fostering active classroom participation.

Variable 1	Variable 2	Spearman Correlation (ρ)	*P*-value	Significance	Hypothesis Supported
Timely Feedback	Student Motivation to Participate	0.415	$p<.001$	Significant	H_3 Supported

Table 8. Spearman correlation analysis: the influence of timely feedback on student motivation to Participate.

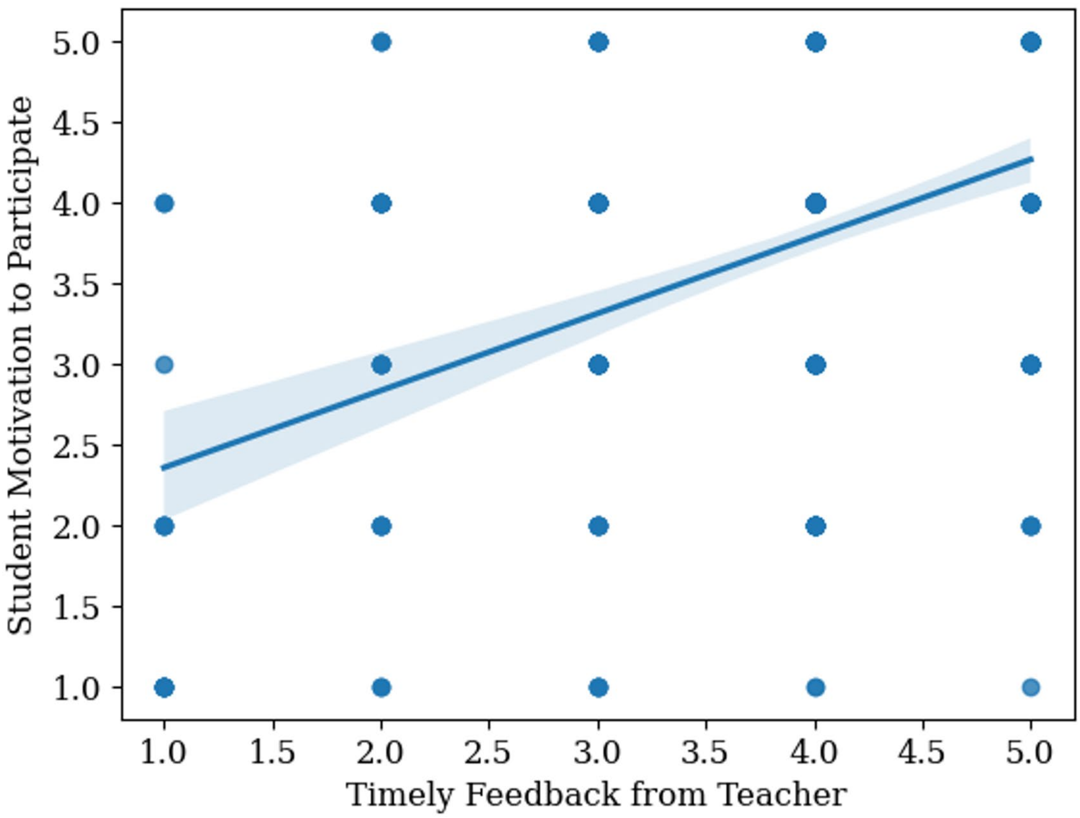

Fig. 5. Teacher Feedback and Student Motivation to Participate.

Model	Predictor	β (Beta Coefficient)	Std. Error	t-value	*p*-value	Significance
Path a & b (Direct + Mediation)	Teacher Interactivity → Tech Use	0.236	0.048	4.932	$p<.001$	Significant
	Tech Use → Participation	0.198	0.045	4.391	$p<.001$	Significant
	Interactivity (Direct Effect) → Participation	0.287	0.053	5.104	$p<.001$	Significant
Total Effect Path (c)	Teacher Interactivity → Participation	0.366	0.048	7.578	$p<.001$	Significant

Table 9. OLS regression results for mediation analysis (H_4).

The Fig. 5 illustrates a moderate positive relationship between teachers' timely feedback and students' motivation to participate, supporting Hypothesis 3 (H_3). Each point represents student responses, with the upward trend line showing that prompt and constructive feedback enhances students' enthusiasm and engagement in class. This visual pattern aligns with the Spearman correlation result ($\rho = 0.415$, $p<.001$), reinforcing the significance of effective feedback in promoting active participation.

Technology use as mediator/moderator

H_4 The relationship between teacher activities and student participation is mediated by the effective use of technology in the classroom.

Table 9 presents the mediation analysis for Hypothesis 4 (H_4) using Ordinary Least Squares (OLS) regression. Results indicate that teacher interactivity significantly predicts technology use ($\beta = 0.236$, $p<.001$), and technology use, in turn, significantly predicts student participation ($\beta = 0.198$, $p<.001$). The total effect of teacher interactivity on student participation ($\beta = 0.366$, $p<.001$) decreases when technology use is introduced, confirming partial mediation. Thus, H_4 is supported, suggesting that technology use partly explains how interactive teaching enhances student participation.

Predictor	Coefficient (β)	Std. Error	t-value	*p*-value	Significance
Intercept	1.996	0.406	4.909	0.000	Significant
Teacher Interactivity (X)	0.364	0.122	2.978	0.003	Significant
Platform Use (Z)	0.136	0.119	1.139	0.255	Not Significant
Interaction Term (X × Z)	−0.011	0.013	−0.345	0.730	Not Significant

Table 10. Moderation regression results for H_5.

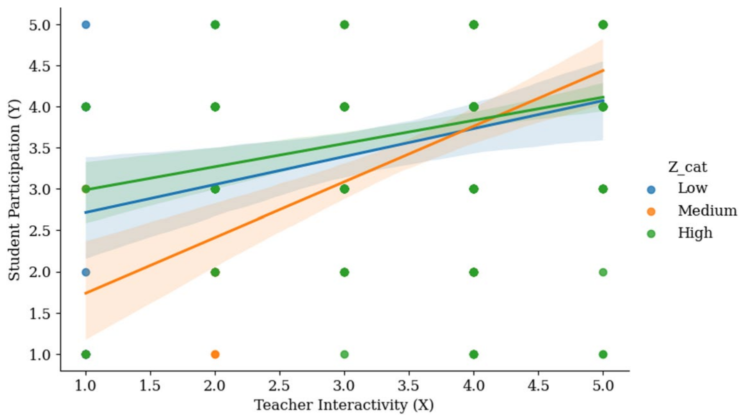

Fig. 6. Visual Illustration of Technology Use and Teacher Interactivity Interaction.

Variable 1	Variable 2	Spearman Correlation (ρ)	*P*-value	Significance	Hypothesis Supported
Teacher-Student Relationship	Willingness to Share Opinions	0.314	$p<.001$	Significant	H_6 Supported

Table 11. Spearman correlation results for H_6.

H_5 The use of digital platforms (e.g., LMS, discussion boards) by teachers moderates the relationship between teacher interactivity and student engagement; strengthening it when used effectively.

Table 10 presents the regression analysis for Hypothesis 5 (H5). The results show that while teacher interactivity significantly predicts engagement ($\beta=0.364$, $p=.003$), neither platform use ($p=.255$) nor the interaction term (β = −0.011, $p=.730$) were statistically significant. This indicates no moderating effect of platform use on the relationship between teacher interactivity and student engagement.

The Fig. 6 illustrates the moderation analysis for Hypothesis 5 (H_5), depicting the relationship between teacher interactivity and student participation across low, medium, and high levels of technology use. Although all lines show a positive association, the visual variation in slope does not reflect a statistically meaningful trend. As confirmed by the regression results mentioned in Table 10, the interaction effect was not statistically significant ($p=.730$). Therefore, H_5 is not supported, and technology use does not significantly moderate the relationship between teacher interactivity and student participation.

Teacher-student relationship quality

H_6 Positive and respectful teacher-student interactions significantly predict higher levels of student willingness to express opinions during classroom discussions.

Table 11 presents the Spearman correlation analysis for Hypothesis 6 (H_6), examining the link between the quality of teacher-student interactions and students' willingness to share opinions in class. The results show a significant positive correlation ($\rho=0.314$, $p<.001$), suggesting that respectful and supportive teacher-student relationships encourage students to express their views more freely. This finding supports H_6, emphasizing the role of positive interaction in promoting student voice and participation.

The Fig. 7 depicts a positive relationship between respectful teacher interactions and students' comfort in expressing opinions, supporting Hypothesis 6 (H_6). Each point represents student responses, with the upward trend line indicating that improved teacher-student interaction quality fosters greater confidence in sharing views. The shaded 95% confidence interval reinforces the reliability of this trend, aligning with the significant Spearman correlation ($\rho=0.314$, $p<.001$) and confirming that supportive teaching enhances student voice.

H_7 Students who perceive their contributions as appreciated by teachers and peers are more likely to participate in class activities.

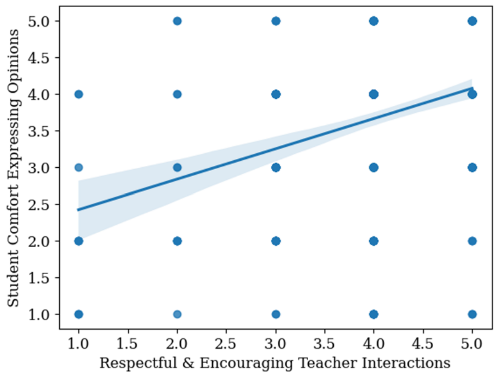

Fig. 7. Respectful Teacher Interaction vs. Student Comfort in Expressing Opinions.

Variable 1	Variable 2	Spearman Correlation (ρ)	*P*-value	Significance	Hypothesis Supported
Perceived Appreciation	Student Class Participation	0.458	$p<.001$	Significant	H_7 Supported

Table 12. Spearman correlation results for H_7.

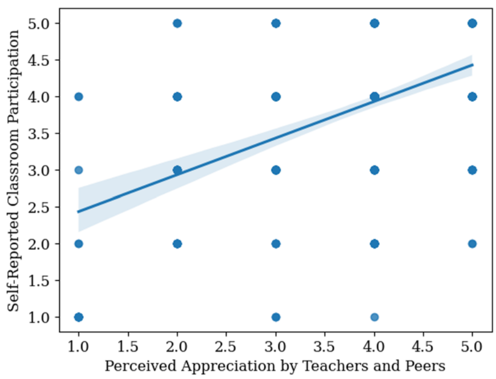

Fig. 8. Perceived Appreciation vs. Student Participation in Classroom Activities.

Table 12 presents the Spearman correlation analysis for Hypothesis 7 (H_7), examining the association between students' sense of appreciation and their class participation. The results reveal a moderate, statistically significant positive correlation ($\rho=0.458$, $p<.001$), showing that students who feel valued by teachers and peers tend to engage more actively. This finding supports H_7 and underscores the importance of cultivating an appreciative and inclusive classroom environment to promote student engagement.

This scatter plot in Fig. 8 illustrates the positive relationship between students' perceived appreciation and their participation in class activities, supporting Hypothesis 7 (H_7). Each point represents individual responses, with the upward regression line showing that students who feel valued by teachers and peers tend to participate more actively. The shaded confidence band confirms the reliability of this upward trend, consistent with the significant Spearman correlation ($\rho=0.458$, $p<.001$), reinforcing that appreciation meaningfully enhances student engagement.

Demographic influence

H_8 There is a significant difference in student participation levels across different academic disciplines (e.g., Engineering vs. Social Sciences).

Table 13 presents the one-way ANOVA results for Hypothesis 8 (H_8), which examined whether student participation differs across academic disciplines. Students were classified into 18 sub-disciplinary categories (e.g., Electrical Engineering, Psychology, Economics) based on their field of study. This finer classification allowed for more detailed analysis and corresponds to the degrees of freedom reported in the ANOVA: $F(17, 399)=0.896$, $p=.578$. The results indicate no statistically significant variation in participation scores across disciplines. This suggests that student engagement levels are relatively consistent across academic fields, and thus, H_8 is not supported.

Source	Sum of Squares	df	F-value	*p*-value	Significance	Hypothesis Supported
Discipline	13.831	17	0.896	0.578	Not Significant	H_8 Not Supported
Residual	362.188	399	—	—	—	—

Table 13. One-Way ANOVA results for H_8.

Group	*N*	Mean Participation	Standard Deviation (SD)	
Female	134	3.58	0.92	
Male	283	3.52	0.89	

Test	t-Value	df	p-value	Significance	Hypothesis Supported
Independent Samples t-test	−0.62	417	0.538	Not Significance	H_9 Not Supported

Table 14. Independent samples t-Test results for Gender-Based participation (H_9). Effect Size, Cohen's d- 0.07 (small).

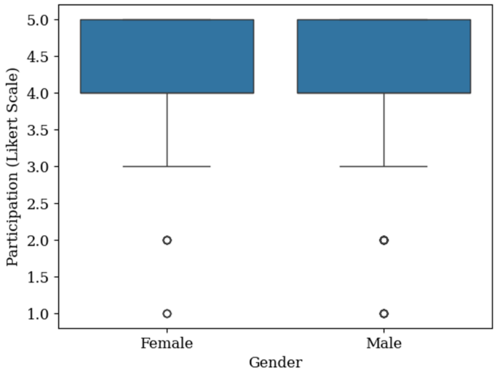

Fig. 9. Gender Differences in Tech-Driven Classroom Participation.

H_9 Female students report higher levels of class participation in technology-enhanced classrooms compared to male students.

Table 14 presents the results of an independent samples t-test conducted to examine gender-based differences in classroom participation. The mean participation scores for female (M = 3.58, SD = 0.92) and male students (M = 3.52, SD = 0.89) were nearly identical. The test statistic (t (415) = −0.62, p=.538) indicates that this difference is not statistically significant. These findings confirm that gender does not have a meaningful effect on student participation in technology-enhanced university classrooms. Besides, The calculated effect size (Cohen's d = 0.07) further confirms that the difference in participation between male and female students is negligible, indicating a practically small effect.

This boxplot in the Fig. 9 presents a boxplot comparing male and female students' participation levels in technology-enhanced classrooms, corresponding to Hypothesis 9 (H_9). Participation scores, measured on a Likert scale, show similar medians and interquartile ranges for both genders, with a few outliers in each group. The nearly identical distributions suggest no notable gender-based difference in technology-driven participation. Without further statistical confirmation (e.g., Mann–Whitney U or t-test), this visual evidence alone does not support H_9.

Technology motivation effect

H_{10} Students are more likely to participate in classroom discussions when digital tools are used to present content, compared to when traditional methods are used.

In the Table 15 presents the Spearman correlation analysis for Hypothesis 10 (H_{10}), which examined whether digital tools in content delivery enhance student participation. The results show a significant moderate positive correlation (ρ = 0.432, p<.001), indicating that students engage more actively when learning materials are delivered through technologies such as videos, simulations, or digital presentations. This finding supports H_{10}, highlighting technology's role as a key driver of improved classroom interaction.

The Fig. 10 illustrates the positive relationship between students' perception of technology's role in enhancing understanding and their motivation to participate, supporting Hypothesis 10 (H_{10}). The scatter plot shows a clear upward trend, with the regression line indicating that greater perceived usefulness of technology corresponds to higher participation motivation. The shaded confidence band affirms the reliability of this

Variable 1	Variable 2	Spearman Correlation (ρ)	*P*-value	Significance	Hypothesis Supported
Use of Technology Tools	Student Participation	0.432	$p<.001$	Significant	H_{10} Supported

Table 15. Spearman correlation results for H_{10}.

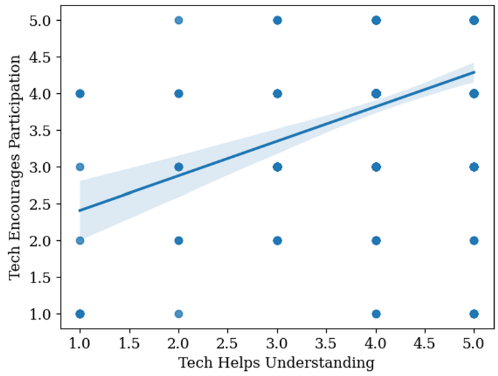

Fig. 10. Relationship between Technology-Assisted Understanding and Participation Motivation.

relationship. Consistent with the statistical finding (Spearman's $\rho = 0.432$, $p<.001$), this visual evidence confirms that technology enhances both comprehension and engagement, thereby supporting H_{10}.

So, it is said that, the analysis for Hypothesis 10 (H_{10}) examined the correlation between students' perceptions of how technology aids their understanding and how it influences their participation in class.

Discussion

The findings of this study provide compelling empirical support for the argument that interactive teaching strategies significantly enhance student participation in university classrooms. The positive correlation observed between teacher interactivity and student engagement aligns with contemporary literature emphasizing dialogic pedagogy as a catalyst for deeper learning[43–45]. Interactive environments, particularly those that emphasize two-way exchanges between instructors and students, foster greater cognitive investment and a sense of ownership over learning[46,47]. This result reinforces the view that student-centered teaching marked by questions, discussions, and collaborative tasks continues to be a strong predictor of student voice and agency in both traditional and tech-supported settings.

Similarly, the study confirms that the integration of multimedia and digital tools positively influences classroom participation, albeit to a moderate degree. The positive correlation between multimedia use and participation aligns with prior findings that underscore the motivational potential of visual and interactive technologies[48]. Interactive media not only enriches content delivery but also provides multimodal entry points for learners with diverse cognitive styles[49]. Importantly, students in digitally-enhanced environments reported higher willingness to engage when technology was perceived as relevant, interactive, and user-friendly echoing the principles of the Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT) frameworks[50,51]. This reinforces the importance of intentional, pedagogically-aligned integration of technology rather than merely technological presence in classrooms. As with the rest of the study, it is important to clarify that participation is based on self-reported measures, which may differ from actual behavior observed in classroom settings.

Feedback emerged as another strong predictor of student motivation and participation. The results demonstrate that timely and constructive feedback from instructors is significantly associated with increased student motivation to contribute in classroom discussions. This supports existing research which positions feedback not just as a performance indicator, but as a relational and emotional process that fosters trust, competence, and student self-efficacy. However, it should be noted that the participation measured in this study is based on self-reported data, and may not fully reflect actual classroom behavior or participation[52]. Moreover, feedback that encourages reflection and offers actionable suggestions has been found to activate self-regulatory behaviors, enhancing student autonomy and long-term engagement[53]. The evidence from this study reinforces the notion that feedback when consistent, personal, and dialogic is central to sustaining student engagement, especially in blended learning environments.

The role of technology as a mediator between teaching strategies and student participation is particularly noteworthy. The results reveal that the effect of interactive teaching on participation is partially mediated by technology use, implying that technology can enhance the effectiveness of pedagogical strategies when meaningfully integrated. Recent research has highlighted the growing importance of aligning technology with pedagogical strategies to achieve meaningful learning outcomes, further supporting the idea that technology, when used purposefully, can enhance engagement and academic performance[54]. It echoes the recent work by Kovari[55], who reported that digital tools amplify the effects of instructional design by enabling real-time collaboration, simulation, and immediate feedback. At the same time, the lack of support for the moderating role of platform use suggests that technology alone does not automatically enhance participation unless embedded within active, teacher-guided learning practices. This insight emphasizes that digital platforms function best as pedagogical amplifiers, not substitutes for meaningful teaching presence. Additionally, our findings align with recent research that emphasizes the role of cognitive flexibility and interdisciplinary learning in enhancing student engagement. For example, Honra[56] discusses how biomimetic projects in biology education foster transdisciplinary thinking, which enhances students' cognitive flexibility and contributes to deeper learning. This aligns with the notion that interactive teaching methods, when paired with technology, offer similar opportunities for students to engage in critical thinking and cross-disciplinary problem-solving. Moreover, Honra and Monterola[57] found that problem-based learning, moderated by transdisciplinary thinking, plays a critical role in developing cognitive flexibility, reinforcing the idea that pedagogical methods integrating technology can nurture students' adaptability and problem-solving skills.

Another critical contribution of this study lies in its analysis of the relational quality between students and teachers. The statistically significant association between respectful teacher-student interaction and students' willingness to express opinions supports sociocultural learning theories, which position learning as a socially mediated process[58]. Respectful communication fosters a psychologically safe classroom climate, enabling students to take intellectual risks and engage in deeper dialogue[59]. Moreover, the study's confirmation of appreciation as a motivational driver aligns with research emphasizing recognition as a critical component of classroom participation, particularly in large or digitally mediated learning contexts[60]. Students who perceive that their contributions are valued demonstrate not only higher rates of participation but also increased emotional attachment to learning tasks.

Unlike some past research, this study did not find big differences in participation based on gender or academic discipline. This may be because technology allows more flexible ways to communicate, like chats, polls, and group work. These digital features give all students a chance to participate, even if they are shy or come from different academic backgrounds. This supports the idea that technology can create more equal learning environments[61,62].

Finally, the motivational power of technology is affirmed through strong statistical evidence showing that students are more likely to participate when content is delivered via digital tools. Students' perception of technology as useful, clear, and engaging correlates with higher participation rates, reinforcing the importance of usability and perceived relevance in ed-tech deployment[63,64]. These results reflect growing trends in higher education where hybrid and blended learning models are not only adopted for convenience but also embraced for their capacity to motivate students, particularly when enhanced by interactivity and multimedia.

Conclusions

This study explored how interactive teaching methods, teacher feedback, technology use, and teacher-student relationships affect student participation in university classrooms. Based on the empirical data from students across Bangladeshi private and public universities, the findings clearly show that when teachers involve students in discussions, provide timely and supportive feedback, and create a respectful classroom environment, students are more motivated and confident to participate. The use of multimedia and digital tools also had a positive effect, especially when technology was used purposefully to support learning. Students reported greater willingness to contribute when they felt appreciated and when the content was delivered in a more engaging, tech-supported way. However, the study's findings reflect self-reported participation, which may not always align with actual behaviors in the classroom.

Despite its encouraging findings, this study has several limitations. First, the data were collected only from university students, limiting the generalizability of the results to other educational levels or international contexts. Additionally, while the study used regression and mediation analyses, future research could benefit from applying Structural Equation Modelling (SEM) to validate and extend the analytical approach, particularly to capture more complex relationships between pedagogical practices, technology use, and student outcomes[65]. Second, the use of a cross-sectional design and self-reported data restricts causal interpretation, as responses may reflect social desirability rather than actual experiences. Thirdly, the study did not examine in depth the specific types or quality of technology used, which may have influenced the observed outcomes. Lastly, an important limitation concerns the measurement of the technology construct. The same scale was used to represent technology use in both mediating and moderating roles. While this ensured consistency in the statistical model, it may have constrained the ability to capture interaction-specific nuances necessary for moderation effects. For example, platform-specific engagement, technological readiness, or digital literacy could have offered a more differentiated construct better suited for testing moderation. Future studies are encouraged to develop and validate separate instruments when examining technology's multiple functional roles in educational settings.

Despite these limitations, this research opens the door for future studies. Researchers can expand on this work by using a larger and more diverse sample, involving universities from other regions or countries, and using different research methods such as interviews or classroom observations. Future studies could also explore changes over time by following students through a full semester or academic year. Moreover, comparing results across different cultural or academic settings would help understand how teaching styles and local context influence participation.

In practical terms, this study offers several important suggestions for educators and institutions. Teachers are encouraged to use interactive methods and provide constructive feedback that supports student growth. They should also build positive relationships with students, as feeling respected and appreciated increases student involvement. At the same time, universities should provide professional development to help teachers integrate technology effectively into their lessons. Investing in digital platforms that are easy to use and aligned with course goals will also support student engagement. Overall, the findings suggest that a supportive, interactive, and technology-enhanced learning environment can significantly improve student participation in university classrooms.

Data availability

The data used and analyzed during this study are available from the corresponding author upon reasonable request.

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Author contributions

- Farhana Yasmin: Conceptualization, Research Design, Data Collection Supervision, Formal Analysis, Writing – Original Draft Preparation, and Overall Project Administration.- Sabina Akter: Data Curation, Literature Review, Instrument Development, Data Curation, Methodology, and Writing – Review & Editing.- Md. Touhiduzzaman: Methodology, Data Curation, Statistical Analysis, Visualization, and Validation of Findings.- Md. Waresul Zannat Razu: Data Interpretation, Methodology Refinement, and Critical Review of the Manuscript.- Md. Alamgir Hossain: Data Curation, Theoretical Framework Development, Expert Guidance, Formal Analysis and Final Manuscript Revision for Intellectual Content.

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Conflict of interest

The authors declare no conflicts of interest related to financial, personal, or professional matters that could have influenced the findings reported in this manuscript.

Ethical approval

All procedures performed in this study involving human participants were conducted in accordance with the ethical standards of the institutional research committees, as well as with the 1964 Declaration of Helsinki and its subsequent amendments. Ethical approval for the study was obtained from the Skill Morph Ethics Committee, Dhaka, Bangladesh (Approval Reference: SkillMorph/ES/2025/02(06)). All methods were carried out in accordance with the relevant institutional guidelines and regulations. Prior to participation, informed consent was obtained from all participants, ensuring that their involvement was voluntary and based on a clear understanding of the study's purpose and procedures.

Additional information

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