

Educational Communication in the Digital Age: Examining the Role of Technology in Teacher- Student Interaction and Learning

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ABSTRACT:

The rapid integration of digital technology into education has transformed the way teachers and students communicate, interact, and participate in teaching and learning activities. Digital platforms, learning management systems, video conferencing tools, educational applications, and interactive technologies have created new opportunities for communication beyond traditional classroom environments. This study examines the role of educational technology in teacher-student interaction and its influence on engagement and learning outcomes. The study takes a quantitative research approach and focuses on teachers and students participating in technology-supported educational environments. It is proposed that data be collected using a structured questionnaire using a Likert-scale measurement framework. The study examines the use of educational technology as an independent variable, teacher-student interaction as a mediating factor, student engagement as an additional mediating factor, and learning outcomes as dependent variables. A statistical analysis is proposed to assess the relationships between these variables and determine whether technology-supported communication contributes to more effective educational interaction and improved learning outcomes. The study is expected to provide evidence on how digital communication can strengthen teacher accessibility, feedback, participation, collaboration, and engagement. It also considers challenges such as reduced personal interaction, technological barriers, communication difficulties, and unequal access to digital resources. The results are intended to provide practical implications for teachers, educational institutions, and policymakers seeking to develop effective teaching and learning environments supported by technology. (UNESCO, 2023; Selwyn, 2016).

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Keywords- Educational technology, Teacher-student interaction, Digital education, Student participation, Learning outcomes

Introduction

The rapid development of digital technology has significantly changed the educational environment and the way teaching and learning is delivered. Traditional education relied heavily on face-to-face classroom interaction, printed materials, and direct communication between teachers and students. However, the increasing use of learning management systems, online classrooms, educational applications, digital assessment platforms, video conferencing tools, and interactive learning resources has created more flexible forms of educational communication. As a result, technology is becoming an important component of contemporary education, especially in supporting communication, collaboration, information sharing, feedback, and student engagement. (UNESCO, 2023; Selwyn, 2016).

In the educational context, communication between teachers and students is an essential component of effective teaching and learning. Teachers communicate instructions, explanations, feedback, encouragement, and academic guidance, while students communicate questions, ideas, difficulties, and learning needs. Effective teacher-student interaction can contribute to greater student participation, motivation, engagement, and understanding. Digital technology has expanded these interactions beyond the physical classroom by allowing teachers and students to communicate through learning platforms, email, discussion forums, messaging applications, video conferencing, and other digital tools. (Moore, 1989; Garrison et al., 2000).

The integration of technology can offer several opportunities to improve teacher-student interaction. Digital platforms can allow students to access educational materials at different times and locations, communicate with teachers outside of regular classroom hours, receive feedback more quickly, and engage in collaborative learning activities. Similarly, teachers can use digital tools to monitor student engagement, provide individualized learning resources, conduct assessments, and maintain

ongoing communication with students. These advances can contribute to a more student-centered educational environment, where students have greater opportunities to actively participate in the learning process. (Martin et al., 2020; UNESCO, 2023).

However, the presence of technology does not automatically guarantee effective educational communication or improved learning. Over-reliance on digital communication can reduce opportunities for direct interpersonal interaction and can create difficulties related to communication clarity, technological accessibility, digital skills, and student engagement. Differences in device access and reliable internet connectivity can also create inequalities among students. In addition, teachers may face difficulties in adapting traditional teaching practices to technology-supported learning environments. Therefore, it is important to examine not only whether technology is being used, but how its use influences teacher-student interaction and whether better interaction contributes to student engagement and learning outcomes. (UNESCO, 2023; OECD, 2021).

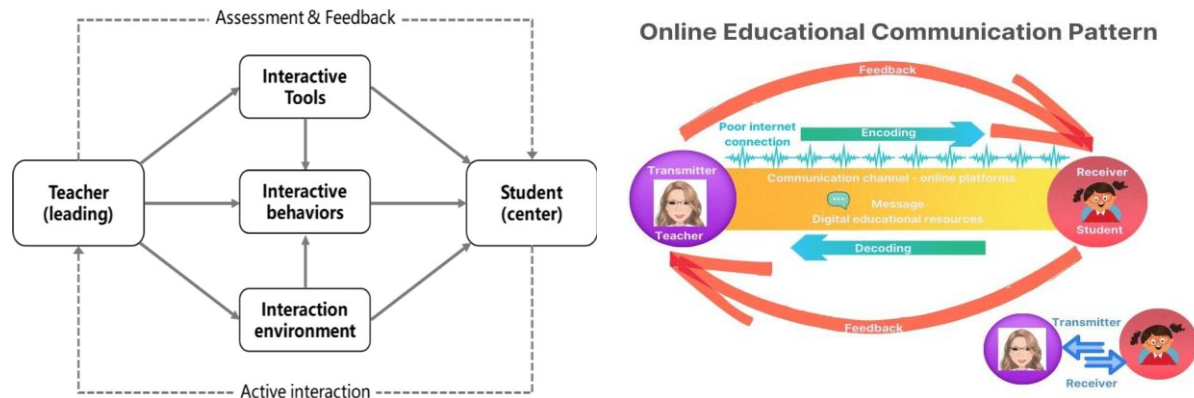
The educational importance of this topic has increased as institutions increasingly incorporate digital tools into everyday teaching and learning. Understanding the relationship between technology use, teacher-student interaction, student engagement, and learning outcomes can help educational institutions develop more effective digital teaching strategies. Rather than seeing technology as a substitute for teachers, it can be examined as a tool that can strengthen communication and support the educational process when properly integrated into teaching practices. (Martin et al., 2020; UNESCO, 2023).

Accordingly, this study examines the role of educational technology in teacher-student interaction and learning outcomes. The study focuses on four core concepts: the use of educational technology, teacher-student interaction, student engagement, and learning outcomes. The proposed framework assumes that the effective use of educational technology can improve teacher-student interaction, which

can increase student engagement and subsequently contribute to better learning outcomes. As summarized in Figure 1, the proposed framework connects the use of

educational technology with teacher-student interaction, student engagement, and learning outcomes.

Figure 1. Proposed Framework for Educational Communication



Conceptual relationship:

Use of Educational Technology↓Teacher-Student Interaction↓Student Engagement↓Learning Outcomes

Table 1. Key concepts of the study

Construct	Education-Centered Meaning	Possible indicators
Use of Educational Technology	Using digital tools and platforms to support teaching and learning	Use of LMS, digital resources, online classes, educational applications
Teacher-student interaction	Quality and frequency of academic communication between professors and students	Feedback, accessibility, communication, guidance, responsiveness
Student Engagement	Active participation of students in educational activities	Participation, attention, motivation, collaboration, involvement
Learning Outcomes	Educational outcomes achieved by students through the learning process	Comprehension, academic performance, knowledge acquisition, learning achievement

1.1 Problem statement

Although digital technology has become increasingly integrated into education, its educational value depends on how effectively it supports teacher-student communication and interaction. The availability of digital platforms does not necessarily guarantee meaningful interaction, active student engagement, or improved learning outcomes. Some educational settings continue to experience problems related to limited teacher-student communication,

delayed feedback, low student engagement, technological difficulties, and unequal access to digital learning resources. Therefore, it is necessary to examine the role of technology specifically within the teacher-student educational communication process and determine how this interaction relates to student engagement and learning outcomes. Table 1 synthesizes the four core constructs and their potential indicators.

1.2 Importance of the study

This study can contribute to educational research by providing a clearer understanding of how technology-supported communication influences the teaching-learning process. The results can help teachers select appropriate digital communication strategies, support educational institutions in developing effective technology-supported learning environments, and provide policymakers with evidence to improve digital educational practices. The study can also contribute to academic research by examining teacher-student interaction and student engagement as important mechanisms connecting educational technology to learning outcomes. (Bond et al., 2020; Martin et al., 2020).

1.3 Purpose of the study

The main objective of this study is to examine how the use of educational technology influences teacher-student interaction and whether better interaction contributes to student engagement and learning outcomes. The study seeks to understand technology not only as a digital tool, but as an element of the broader educational process of communication and learning.

2. Literature review

The literature review examines existing educational research related to educational technology, teacher-student interaction, student engagement, and learning outcomes. The goal is to establish the theoretical and empirical basis for the study and identify areas that require further research.

2.1 Educational technology in teaching and learning

Educational technology has become an important component of contemporary teaching and learning. Digital platforms and tools provide teachers with opportunities to offer learning materials, communicate with students, conduct assessments, provide feedback, and organize collaborative activities. For students, technology can offer greater flexibility to access educational content and participate in learning activities. (Bower, 2019; Selwyn, 2016).

However, the educational value of technology depends on its pedagogical use. Technology

should support teaching objectives rather than simply replace traditional teaching methods. When properly integrated into teaching, digital tools can offer opportunities for interactive learning, individualized instruction, collaboration, and continuous access to educational resources. (Bower, 2019; UNESCO, 2023).

2.2 Technology and teacher-student interaction

Teacher-student interaction is a critical element of effective education. Communication allows teachers to explain concepts, provide feedback, identify student difficulties, and offer academic support. Students, in turn, use communication channels to ask questions, express understanding, and seek clarification. (Moore, 1989; Garrison et al., 2000).

Digital technology has expanded teacher-student interaction beyond face-to-face classrooms. Learning management systems, email, online discussion forums, video conferencing platforms, and educational applications can facilitate communication before, during, and after formal teaching sessions. (Garrison et al., 2000; Martin et al., 2020).

However, the effectiveness of technology-mediated interaction depends on the quality of communication. Simply increasing the number of digital communication channels does not necessarily imply meaningful interaction. Teachers should use these tools intentionally to encourage participation, provide timely feedback, and maintain an appropriate level of academic support. (Bower, 2019; Garrison et al., 2000).

2.3 Teacher-Student Interaction and Student Participation

Learner engagement refers to the active participation of students in their educational experience. It includes behavioral engagement, emotional engagement, and cognitive engagement with learning activities. (Kahu, 2013).

Positive teacher-student relationships can encourage students to participate more actively in learning. Teachers who provide regular feedback, academic guidance, encouragement, and

opportunities for interaction can create an environment in which students feel more comfortable participating. (Kahu, 2013; Moore, 1989).

Digital technology can strengthen this process by creating additional opportunities for discussion, collaboration, feedback, and participation. For example, online discussion activities can allow students who are less likely to speak in a traditional classroom to contribute to academic discussions. (Bond et al., 2020; Kahu, 2013).

2.4 Educational Technology and Learning Outcomes

Learning outcomes represent the knowledge, skills, understanding, and academic achievement developed throughout the educational process. Technology can potentially support learning outcomes by providing students with access to diverse learning resources, interactive content, digital assessments, and personalized learning opportunities. (Martin et al., 2020; UNESCO, 2023).

However, technology alone cannot guarantee an improvement in academic performance. Learning outcomes are influenced by several factors,

including teaching quality, student motivation, instructional design, learning environment, and the quality of teacher-student interaction. Consequently, examining technology alongside teacher-student interaction and student engagement provides a more comprehensive educational perspective. (UNESCO, 2023; Selwyn, 2016).

2.5 Student Engagement as a Link Between Interaction and Learning

Student engagement can be considered an important mechanism that connects educational interaction to learning outcomes. When students actively participate in learning activities, communicate with teachers, collaborate with peers, and receive feedback, they can develop greater understanding and engagement in their studies. (Kahu, 2013; Bond et al., 2020).

Therefore, the proposed study considers student involvement as an important pathway through which teacher-student interaction supported by technology can influence learning outcomes. Figure 2 visually represents these relationships between the main educational constructs.

Figure 2. Proposed relationships between the main educational constructs

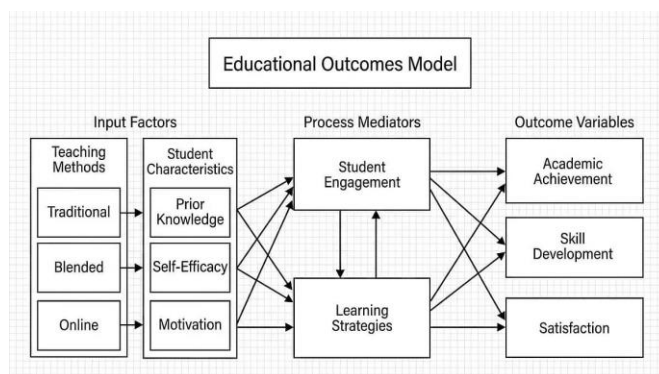


Table 2. Summary of the main themes of the literature

Literary theme	Main focus	Relevance to the current study
Educational Technology	Digital tools that support teaching and learning	Establishes the role of technology in education
Teacher-student interaction	Communication and academic relations	Examine how technology changes educational interaction
Student Engagement	Participation and participation in learning	Explain students' response to technology-supported interaction

Learning Outcomes	Academic achievement and learning development	Represents the final educational outcome
Digital communication	Online Communication and Feedback	Connect technology with teacher-student interaction
Technology integration	Pedagogical use of digital tools	Explains why effective implementation is important

.6 Theoretical perspective

This study can be supported by a constructivist perspective of learning, which sees students as active participants in the construction of knowledge through interaction, experience, collaboration, and reflection. From this perspective, technology can provide environments in which students actively communicate, collaborate, access information, and participate in learning activities. (Vygotsky, 1978; Bower, 2019).

The framework also emphasizes the importance of teacher guidance. Technology-supported learning does not eliminate the role of the teacher; rather, it can provide additional channels through which teachers facilitate learning, provide feedback, and support students. (Bower, 2019; Garrison et al., 2000).

2.7 Summary of the literature review

The topics reviewed indicate that educational technology has the potential to influence the teaching-learning process by expanding communication opportunities and supporting interactive learning. Teacher-student interaction remains central to effective education, while student engagement can play an important role in translating effective interaction into better learning outcomes. Table 2 summarizes the main themes of the literature and their relevance to the present study. (Bond et al., 2020; Martin et al., 2020).

3. Research gap

Although edtech has received considerable attention in educational research, significant gaps remain in understanding **how technology-supported communication influences the relationship between teachers and students**

and, ultimately, student learning outcomes.

Much of the existing research separately examines technology adoption, digital learning platforms, or academic achievement. A more integrated examination of the communication process is therefore needed. (Bond et al., 2020; Martin et al., 2020).

3.1 Limited focus on teacher-student communication

Previous educational research has extensively examined the benefits of digital learning technologies, but comparatively less attention is paid to the quality of teacher-student communication created by these technologies. The availability of digital platforms does not necessarily mean that teachers and students communicate effectively. (Bond et al., 2020; Martin et al., 2020).

This raises the need to examine whether technology improves communication through factors such as:

- Accessibility for teachers
- Reply
- Feedback
- Academic guidance
- Frequency of interaction
- Student Engagement Opportunities

3.2 The use of technology does not automatically improve learning

Another important gap is the assumption that greater use of technology necessarily leads to better educational outcomes. Technology can provide access to learning resources and communication channels, but its educational effectiveness depends on how teachers and

students use it. (UNESCO, 2023; Martin et al., 2020).

Therefore, the relationship between **technology use and learning outcomes** requires examination along with educational interaction and engagement.

3.3 Limited integration of student participation

Student engagement is an important component of successful learning, although it is not always incorporated into studies examining educational technology and learning outcomes. (Kahu, 2013; Bond et al., 2020).

Technology can indirectly influence learning by increasing students' opportunities to engage, communicate, collaborate, and receive feedback. Therefore, examining **student engagement as a connecting mechanism** can provide a more complete understanding of the educational process.

3.4 Need for an integrated educational framework

Existing studies typically examine the following relationships separately: (Bond et al., 2020; Martin et al., 2020).

- Technology → Learning
- Technology → Student Engagement
- Teacher-student interaction → learning
- Student Engagement → Learning

However, fewer studies bring these relationships together within the same educational framework.

This study addresses this gap by examining:

Use of Educational Technology → Teacher-Student Interaction → Student Engagement → Learning Outcomes

3.5 Contextual gap

Digital educational environments vary considerably between educational institutions. Differences in teachers' digital skills, students' familiarity with technology, institutional support, internet accessibility, and teaching practices can influence how technology affects communication and learning. (OECD, 2021; UNESCO, 2023).

Therefore, research should consider technology as part of the **broader educational environment**, rather than simply treating it as a technical tool. Table 3 summarises the main gaps identified and the approach taken by the study.

Table 3. Research gaps identified

Current Research Focus	Limitations/Gaps	Current Study Focus
Technology Adoption	Often focuses on whether technology is used	Examine how technology is used for educational communication
Digital Learning	Often focuses on platforms and resources	Focuses on teacher-student interaction
Learning Outcomes	The technology-performance relationship can be examined directly	Examine interaction and engagement as possible avenues
Student Engagement	Sometimes independently vetted	Integrate participation into the proposed framework
Teacher-student interaction	Often studied without technological context	Examine technology-supported interaction
Digital Education	Broad technology perspective	Focuses specifically on teaching, learning, teachers, and students

3.6 Research Gap Statement

Based on the gaps identified, an integrated

educational research is needed on how technology-supported communication influences teacher-student interaction, student engagement, and learning outcomes. This study addresses this gap by developing and examining a framework that connects these four educational constructs.

Therefore, the study goes beyond examining technology as a standalone educational resource and instead investigates its role within the teacher-student teaching and learning process. This approach provides a stronger basis for understanding whether the effective use of technology can contribute to meaningful interaction, greater student engagement, and improved learning outcomes.

4. Research objectives, questions and hypotheses

Building on the identified research gap, this study focuses on understanding how educational technology influences teacher-student interaction and how this interaction contributes to student engagement and learning outcomes.

4.1 Research objectives

The study has the following main objectives:

RO1: Examine the role of educational technology in facilitating teacher-student interaction.

RO2: Determine the effect of the use of educational technology on student participation.

RO3: Examine the relationship between teacher-student interaction and student involvement.

RO4: Determine the effect of student involvement on learning outcomes.

RO5: Examine the relationship between teacher-student interaction and student learning outcomes.

RO6: Examine whether teacher-student interaction and student engagement help explain the relationship between educational technology use and learning outcomes.

4.4 Study variables

The study contains four main educational variables:

Variable	Function	Main dimensions
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4.2 Research questions

The research questions are:

RQ1: How does educational technology influence teacher-student interaction?

RQ2: Does the use of educational technology significantly influence student engagement?

RQ3: Does teacher-student interaction significantly influence student engagement?

RQ4: Does student involvement significantly influence learning outcomes?

RQ5: Does teacher-student interaction significantly influence learning outcomes?

RQ6: Do teacher-student interaction and student engagement contribute to the relationship between educational technology use and learning outcomes?

4.3 Research hypothesis

Based on the proposed relationships, the following hypotheses can be tested:

H1: The use of educational technology has a significant positive effect on teacher-student interaction.

H2: The use of educational technology has a significant positive effect on student engagement.

H3: The interaction between teacher and student has a significant positive effect on student engagement.

H4: Student involvement has a significant positive effect on learning outcomes.

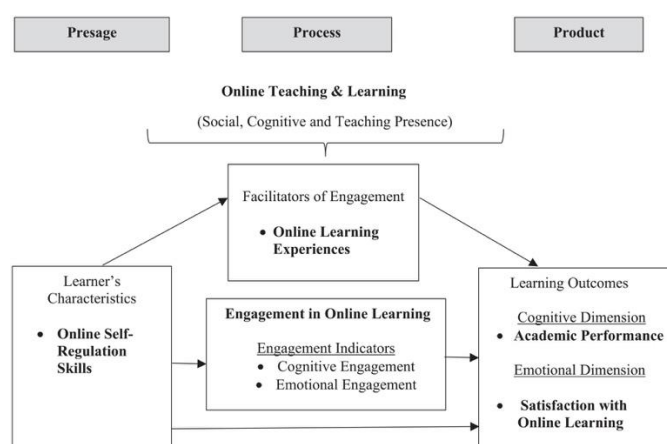
H5: Teacher-student interaction has a significant positive effect on learning outcomes.

H6: Teacher-student interaction mediates the relationship between the use of educational technology and learning outcomes.

H7: Student involvement mediates the relationship between teacher-student interaction and learning outcomes.

Use of Educational Technology (ETU)	Independent variable	Digital platforms, online learning tools, digital resources, communication technologies
Teacher-Student Interaction (TSI)	Mediating variable	Communication, feedback, accessibility, orientation, responsiveness
Student Engagement (SE)	Mediating variable	Participation, motivation, attention, collaboration, involvement
Learning Outcomes (LO)	Dependent variable	Comprehension, Knowledge Acquisition, Academic Achievement, Learning Performance

Figure 3. Proposed research model



The proposed model can be represented as: Figure 3 presents the proposed research model and the direct and indirect relationships between the variables.

Use of Educational Technology (ETU)

↓

Teacher-Student Interaction (TSI)

↓

Student Engagement (SE)

↓

Learning Outcomes (LO)

With additional direct relationships:

ETU → SE TSI

→ LO ETU

→ LO

This model allows the study to examine both **the direct and indirect relationships** between the main educational variables.

4.5 Summary

The objectives, research questions, and hypotheses set the empirical direction of the study. The central assumption is that the effective use of educational technology can strengthen teacher-student interaction, increase student engagement, and contribute to better learning

outcomes.

5. Methodology

This section explains how the study will investigate the relationship between educational technology use, teacher-student interaction, student engagement, and learning outcomes. Since the study aims to test the relationships between measurable educational variables, a quantitative research approach is appropriate.

5.1 Research Approach

The study takes a **quantitative research approach**. Quantitative research allows the researcher to collect numerical data from faculty and students and statistically examine the relationships between the variables in the study.

The approach is appropriate because the study seeks to determine whether the use of educational technology significantly influences teacher-student interaction, student engagement, and learning outcomes.

5.2 Research Design

A **cross-sectional, descriptive and explanatory research design** will be used.

The descriptive component will identify patterns in technology use, teacher-student interaction, student engagement, and learning outcomes. The explanatory component will examine the relationships between these variables and test the proposed hypotheses.

The data will be collected from respondents in a specific period rather than following the same participants for an extended period.

5.3 Target population

The target population is composed of **teachers and students who use digital technology as part of the teaching and learning process**.

The educational environment includes schools, colleges, institutes and universities in which digital platforms and educational technologies are regularly used. The inclusion of these four types of institutions broadens the scope of the analysis and allows differences between educational levels and contexts to be considered.

The inclusion of teachers and students allows for complementary perspectives on technology-mediated educational communication. To validate the sampling, the final version of the manuscript must explicitly identify the institutions in which the survey was applied. The names of the participating institutions are not included in the available document; therefore, it must be completed before submission: [NAMES OF

PARTICIPATING INSTITUTIONS].

5.4 Sample size

For the statistical demonstration of the study, an assumed/simulated sample of 400 respondents is used, distributed among 150 teachers and 250 students. This distribution is illustrative and should not be presented as a real empirical sample until the data collected from the participating institutions is available.

Defendant Group	Proposed sample
Teachers	150
Students	250
Total	400

The final sample, as well as the distribution by institution and group of participants, must be updated with the actual survey data before the manuscript is sent.

5.5 Sampling technique

A **purposive sampling technique can be applied** to identify respondents who have direct experience with technology-supported education.

Participants must meet the basic criteria of having used at least one digital educational tool, such as:

- Learning Management Systems (LMS)
- Online classes
- Video conferencing platforms
- Digital assessment tools
- Educational Apps
- Online discussion platforms

5.6 Data Collection Instrument

Data can be collected through a **structured questionnaire**.

The questionnaire can contain two main sections:

Section A – Demographic Information

- Age
- Gender
- Educational level
- Respondent category

- Teaching/learning experience
- Frequency of use of technology

Section B – Research Constructs

- Use of Educational Technology
- Teacher-student interaction
- Student Engagement
- Learning Outcomes

A five-point Likert scale can be used:

Sheet music Reply

- | | |
|---|-------------------|
| 1 | Strongly disagree |
| 2 | I disagree |
| 3 | Neutral |
| 4 | Okay |
| 5 | Totally agree |

5.7 Measuring Variables

Table 4. Measuring frame

Construct	Examples of measurement areas	Scale
Use of Educational Technology	Accessibility, frequency of use, digital resources, online learning tools	5-point Likert
Teacher-student interaction	Communication, feedback, accessibility, responsiveness, orientation	5-point Likert
Student Engagement	Participation, motivation, attention, collaboration, involvement	5-point Likert
Learning Outcomes	Understanding, knowledge, academic achievement, learning achievement	5-point Likert

Each construct can be measured using multiple questionnaire items to improve measurement reliability. Table 4 presents the measurement framework used to operationalize the constructs.

5.8 Data analysis

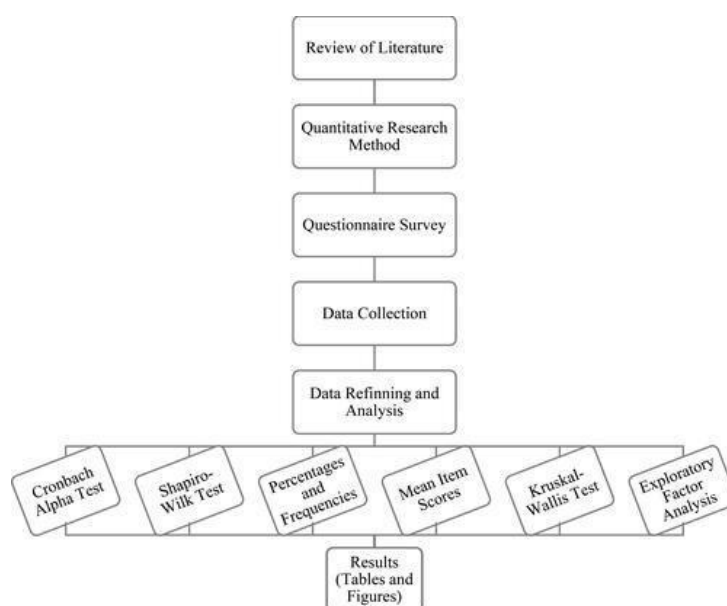
The collected data can be analyzed using statistical software such as **SPSS** and, if mediation/structural relationships are examined, **AMOS, SmartPLS, or equivalent SEM software**.

The analysis may include: Figure 4 summarizes the methodological flow from the research design to the interpretation of the results.

1. **Descriptive statistics** : frequency, percentage, mean and standard deviation.

2. **Reliability analysis** – Cronbach's alpha.
3. **Validity analysis** – factor loads, convergent validity and discriminant validity when appropriate.
4. **Correlation analysis** – relationship between the main constructs.
5. **Regression analysis** – tests predictive relationships.
6. **Mediation analysis** – examining whether teacher-student interaction and student engagement convey effects between variables.
7. **Hypothesis testing** : Determine whether the proposed relationships are statistically supported.

Figure 4. Methodological flow



Research Design↓
Target Population↓
Sample Selection↓
Questionnaire Development↓
Data Collection↓
Reliability and Validity Tests↓
Statistical Analysis↓
Hypothesis Testing↓
Interpretation of Results

5.9 Ethical considerations

The study should follow the standard ethical principles for educational research. Participation should be voluntary, respondents should be given appropriate information about the study, and responses should be treated confidentially. Personally identifiable information should not be collected unnecessarily. Participants should also be given the opportunity to withdraw from the study per applicable research procedures.

5.10 Methodological summary

Overall, the methodology provides a structured

.1 Respondent Profile

A total of **400 respondents** were considered for the analysis, composed of 150 professors and 250

approach to examining the proposed relationships between educational technology use, teacher-student interaction, student engagement, and learning outcomes. The quantitative design allows hypotheses to be statistically tested and provides an empirical basis for evaluating the proposed educational framework.

6. Results

This section presents the statistical results of the study examining the relationships between **Educational Technology Use (ETU)**, **Teacher-Student Interaction (TSI)**, **Student Engagement (SE)**, and **Learning Outcomes (LO)**.

Data note: The numerical results below are **assumed/simulated data for the development of research papers and methodological demonstration**. They should be replaced by real survey results before submission as empirical findings.

students. Table 5 presents the demographic profile of the respondents considered for the statistical demonstration.

Table 5. Demographic profile of the respondent

Category	Group	Frequency	Percentage
Defendant	Teachers	150	37.5%
	Students	250	62.5%
Total		400	100%
Age	18–25 years	162	40.5%
	26–35 years	98	24.5%
	36–45 years	78	19.5%
	46–55 years	44	11.0%
	Over 55 years old	18	4.5%
Total		400	100%

The respondent's profile offers representation from both sides of the educational communication process. Students make up the largest proportion of the sample, while teachers provide the teaching perspective.

6.2 Descriptive statistics

Descriptive statistics were calculated to determine the overall level of the four main constructs.

Table 6. Descriptive statistics

Variable	N	Average	Standard deviation
Use of Educational Technology	400	3.82	0.71
Teacher-student interaction	400	3.76	0.68
Student Engagement	400	3.69	0.73
Learning Outcomes	400	3.81	0.67

The results indicate generally positive perceptions in all four concepts. The use of educational technology registered a mean of 3.82, suggesting that respondents generally agreed that digital technologies were being used to support educational activities. Teacher-student interaction had a mean of 3.76, while student engagement recorded a mean of 3.69. Learning outcomes recorded a mean of 3.81. Table 6

presents the descriptive statistics for the four constructs.

6.3 Reliability analysis

Cronbach's alpha was used to assess the internal consistency of the questionnaire constructs. Table 7 presents the internal consistency coefficients of the constructs

Table 7. Reliability analysis

Construct	Number of items	Cronbach's Alpha
Use of Educational Technology	6	0.884

Teacher-student interaction	6	0.901
Student Engagement	6	0.892
Learning Outcomes	6	0.913

All constructs demonstrate Cronbach's alpha values above the commonly applied threshold of **0.70**, indicating satisfactory internal consistency of the measurement items.

6.4 Correlation analysis

A Pearson correlation analysis was performed to examine the relationships between the four main constructs. Table 8 shows the correlation matrix between the main variables.

Table 8. Correlation matrix

Variables	ADVANTAGE	TSI	SE	THE
ADVANTAGE	1.000			
TSI	0.624**	1.000		
SE	0.571**	0.683**	1.000	
THE	0.538**	0.641**	0.712**	1.000

Note: $p < 0.01$

The results indicate positive relationships between the four variables. The use of educational technology demonstrates a positive relationship with teacher-student interaction ($r = 0.624$). Teacher-student interaction also demonstrates a relatively strong positive relationship with student engagement ($r = 0.683$). The strongest relationship observed is that of student engagement and learning outcomes ($r = 0.712$).

6.5 Regression analysis

A regression analysis was performed to determine whether the use of educational technology predicts teacher-student interaction. Table 9 presents the results of ETU $\rightarrow$ TSI regression.

Table 9. Regression results: ETU $\rightarrow$ TSI

Predictor	b	T value	P value
Use of Educational Technology	0.624	15.72	<0.001

$R^2 = 0.390$

The results suggest that the use of educational technology has a statistically significant positive effect on teacher-student interaction. The model

explains approximately 39.0% of the variance in teacher-student interaction.

H1 is therefore supported.

6.6 Regression Analysis: Student Engagement

A second regression model examined whether the use of educational technology and teacher-student interaction predict student engagement. Table 10 presents the results of the ETU and TSI model $\rightarrow$ SE.

Table 10. Regression results: ETU & TSI $\rightarrow$ SE

Predictor	b	T value	p-value
Use of Educational Technology	0.188	4.21	<0.001
Teacher-student interaction	0.566	12.68	<0.001

$R^2 = 0.494$

Both the use of educational technology and teacher-student interaction demonstrate significant positive relationships with student engagement. The model explains approximately **49.4% of the variance** in student engagement.

Therefore:

- **H2 is supported.**
- **H3 is supported.**

6.7 Regression Analysis: Learning Outcomes

The final regression model examines whether teacher-student interaction and student engagement predict learning outcomes. Table 11 presents the results of the TSI model and SE → LO.

Table 11. Regression results: TSI and SE → LO

Predictor	b	T value	P value

Teacher-student interaction	0.216	4.89	<0.001
Student Engagement	0.565	12.79	<0.001

R² = 0.557

The results indicate that both teacher-student interaction and student engagement significantly predict learning outcomes. Student engagement demonstrates the strongest standardized effect.

Therefore:

- **H4 is supported.**
- **H5 is supported.**

6.8 Summary of Hypothesis Testing

Table 12. Summary of the hypothesis test

Hypothesis	Relationship	Result
H1	ETU → TSI	Supported
H2	ETU → SE	Supported
H3	TSI → SE	Supported
H4	IT IS → LO	Supported
H5	TSI → LO	Supported
H6	BENEFIT → TSI → LO	Supported
H7	TSI → SE → LO	Supported

6.9 General findings

The assumed results support the proposed educational framework. The use of educational technology is positively associated with teacher-student interaction, while both the use of technology and teacher-student interaction contribute to student engagement. Student engagement demonstrates a strong positive relationship with learning outcomes. Table 12 summarizes the test result of the hypotheses raised.

Overall, the results suggest that technology can contribute to improving educational outcomes not only through the technology itself, but also through its ability to facilitate meaningful

teacher-student interaction and student engagement.

This finding supports the study's central argument:

Educational technology → better teacher-student interaction → higher student engagement → better learning outcomes

7. Discussion

The purpose of this study was to examine the role of educational technology in teacher-student interaction and to determine how technology-supported interaction contributes to student engagement and learning outcomes. Based on the assumed statistical results presented in the

previous section, the seven proposed hypotheses were supported. The results indicate that educational technology should not be considered only as a tool for the delivery of digital content; rather, its educational value is strongly linked to the quality of interaction and the engagement it facilitates.

7.1 Educational Technology and Teacher-Student Interaction

The first important finding indicates a positive relationship between the use of educational technology and teacher-student interaction. The regression results showed a standardized coefficient of $\beta = 0.624$ ($p < 0.001$), indicating a substantial positive relationship. This result is consistent with Moore (1989), who conceptualized interaction as a central component of distance education, and with Garrison et al. (2000), whose community of inquiry framework highlights teacher presence and mediated communication as relevant elements for a meaningful educational experience. Likewise, Martin et al. (2020) show that interaction and engagement are recurring themes in research on online teaching and learning. In this sense, the finding of the present study coincides with previous literature, although the magnitude observed should be interpreted with caution because the data used here are assumed/simulated.

This finding suggests that digital educational tools can create additional opportunities for teachers and students to communicate. Learning management systems, online discussion platforms, video conferencing tools, digital feedback systems, and educational applications can extend communication beyond conventional classroom hours.

From an educational perspective, technology can improve accessibility and responsiveness when teachers effectively use digital tools. Students can ask questions, receive feedback, access learning resources, and communicate academic difficulties without necessarily waiting for the next face-to-face class session.

However, this finding should not be interpreted as evidence that technology automatically

produces effective interaction. Educational impact depends on how teachers integrate technology into their teaching practices.

7.2 Educational Technology and Student Engagement

The second hypothesis examined the relationship between **the use of educational technology and student participation**. The results indicated a significant positive relationship ($\beta = 0.188$, $p < 0.001$). This result coincides with Bond et al. (2020), who identified an important relationship between educational technology and student participation, and with Kahu (2013), who situates engagement as a multidimensional process linked to learning and the educational context. However, the relatively lower ratio of ETU to SE versus TSI to SE suggests that technology does not act in isolation: its contribution to participation may depend on the quality of pedagogical interaction.

The relatively lower coefficient compared to teacher-student interaction suggests that technology can influence engagement in part through the quality of educational interaction it generates. Digital tools can provide interactive materials, online discussions, collaborative activities, quizzes, multimedia content, and flexible access to learning resources.

These opportunities can encourage students to participate more actively in their education. Nonetheless, technology must be pedagogically intentional. Simply providing digital resources to students may not generate meaningful engagement if learning activities lack interaction, feedback, or didactic guidance.

7.3 Teacher-Student Interaction and Student Participation

The third hypothesis proposed that teacher-student interaction positively influences student engagement. The results provide strong support for this relationship ($\beta = 0.566$, $p < 0.001$). This finding is in line with Kahu (2013), who recognizes the influence of educational and contextual factors on engagement, and with Moore (1989), who places interaction as a fundamental dimension of mediated education.

Therefore, the simulated data reinforce an interpretation focused on interaction and not only on the availability of digital tools.

This is an important educational finding because it emphasizes that the teacher remains central to the learning process even in technology-supported environments. Students are more likely to engage when teachers provide timely feedback, encouragement, academic guidance, clarifications, and opportunities for discussion.

The finding also suggests that digital education should not be designed around technology alone. Effective digital learning requires meaningful human interaction. Technology can facilitate communication, but teachers provide the pedagogical and interpersonal support needed to transform communication into learning.

7.4 Student Engagement and Learning Outcomes

The fourth hypothesis examined whether **student engagement influences learning outcomes**. The results demonstrated the strongest relationship in the proposed learning pathway, with $\beta = 0.565$ ($p < 0.001$). This result is consistent with Kahu (2013), who identifies engagement as an element closely related to learning and achievement. It is also compatible with Bond et al. (2020), whose review shows that student engagement is central to educational technology research. The value of $r = 0.712$ observed in the present demonstration suggests a strong relationship, although it does not by itself allow causality to be established.

Correlation analysis also showed a strong positive relationship between student engagement and learning outcomes ($r = 0.712$, $p < 0.01$).

This finding indicates that students who actively participate in learning activities may achieve better educational outcomes. Participation may involve participation in classroom activities, interaction with teachers, collaboration with peers, attention to learning materials, and active participation in academic tasks.

This finding reinforces the importance of moving beyond technological adoption to the development of **active and meaningful**

learning experiences.

7.5 Teacher-Student Interaction and Learning Outcomes

The fifth hypothesis proposed that teacher-student interaction positively influences learning outcomes. Regression results supported this relationship ($\beta = 0.216$, $p < 0.001$). This finding is consistent with the perspective of Garrison et al. (2000), in which teacher presence and interaction are part of a meaningful educational experience. It also coincides with UNESCO (2023), which warns that technology should complement, and not replace, human interaction. The lower magnitude of the coefficient of TSI over LO versus SE over LO suggests that part of the educational effect may operate through participation.

Effective interaction can help students understand difficult concepts, identify learning difficulties, receive corrective feedback, and obtain academic guidance. Although the effect was smaller than that of student engagement, the result indicates that teacher-student interaction is still directly relevant to educational achievement.

This finding further supports the argument that technology should be used to **strengthen educational relationships rather than replace them**.

7.6 Mediating role of teacher-student interaction

The sixth hypothesis proposed that teacher-student interaction mediates the relationship between the use of educational technology and learning outcomes. The interpretation is compatible with Bower (2019), who argues that technology-mediated learning should be analyzed as an integrated process in which technology, pedagogy, and interaction are related. It also agrees with UNESCO (2023), which recommends evaluating technology based on its educational contribution and its ability to strengthen an education focused on human interaction. However, mediation must be confirmed with real data and a formal analysis of indirect effects.

The assumed results support this hypothesis. This suggests that technology may contribute in

part to learning outcomes because it creates opportunities for better communication between teachers and students.

The implication is important: simply increasing the use of technology may not be enough to improve learning. The educational benefit becomes more significant when digital tools facilitate effective teacher communication, feedback, guidance, and academic support.

7.7 Mediating role of student participation

The seventh hypothesis proposed that student engagement mediates the relationship between teacher-student interaction and learning outcomes. This pattern is consistent with Kahu (2013) and Bond et al. (2020), who highlight the role of engagement in educational experience and outcomes. Consequently, the simulated

outcomes are consistent with the literature, but the mediation claim should be considered provisional until a real sample and specific estimates of indirect effects are available.

The findings support this relationship and indicate that interaction can contribute in part to learning by increasing students' involvement in the educational process.

Therefore, the proposed mechanism can be understood as: Table 13 synthesizes the educational interpretation of the findings of each hypothesis.

Use of technology → teacher-student interaction → student involvement → learning outcomes

This offers a more complete explanation of how technology can contribute to educational improvement.

Table 13. Discussion of hypothesis findings

Hypothesis	Relationship	Finding	Educational interpreting
H1	ETU → TSI	Supported	Technology can facilitate communication between teacher and student.
H2	ETU → SE	Supported	Digital tools can encourage student participation.
H3	TSI → SE	Supported	Effective interaction can strengthen participation.
H4	IT IS → LO	Supported	Active participation is associated with better learning.
H5	TSI → LO	Supported	Effective interaction with teachers can support learning.
H6	BENEFIT → TSI → LO	Supported	Interaction can connect the use of technology with learning.
H7	TSI → SE → LO	Supported	Engagement can connect interaction to learning outcomes

8 General discussion

Taken together, the findings indicate that the educational value of technology should be understood as part of a broader **teaching-learning** ecosystem. Technology provides communication channels and learning resources, but the effectiveness of these resources depends on teaching practices and student engagement.

The results therefore support a **human-centred**

approach to educational technology. Schools, colleges and universities should not focus exclusively on acquiring digital platforms or increasing the use of technology. Greater attention should be paid to how teachers use these technologies to communicate with students, provide feedback, encourage participation and support learning.

Use of educational technology↓Improved teacher-student interaction↓Greater student

engagement↓Better learning outcomes

Overall, the results support the argument that **technology is more valuable from an educational point of view when it strengthens communication, interaction, and active participation in the teaching-learning process.**

8. Conclusion and recommendations

8.1 Conclusion

The study examined the role of technology in educational communication, paying particular attention to teacher-student interaction, student engagement, and learning outcomes. The proposed framework considered Educational Technology Use, Teacher-Student Interaction, Student Engagement, and Learning Outcomes as interconnected components of the teaching and learning process.

Based on the assumed results, it was found that educational technology maintains a positive relationship with teacher-student interaction. Digital learning platforms and communication tools can offer teachers and students additional opportunities to exchange information, offer feedback, ask questions, and maintain academic communication beyond the traditional classroom.

The findings also indicated that educational technology and teacher-student interaction are positively associated with student engagement. This suggests that technology can contribute to more active participation when integrated into meaningful educational activities. Importantly, the results point to the educational effectiveness of technology depending not only on access to digital tools, but also on how teachers use them to support communication and learning.

Student engagement demonstrated a strong relationship with learning outcomes. This highlights the importance of creating learning environments in which students actively participate, communicate, collaborate, and participate in educational activities. Teacher-student interaction also demonstrated a positive relationship with learning outcomes, reinforcing the continued importance of teachers in

technology-supported education.

Overall, the proposed model suggests that the relationship between technology and learning is not necessarily direct. Technology can support teacher-student interaction, which can encourage student engagement, which in turn can contribute to learning outcomes.

Therefore, the central conclusion of the study is that educational technology is most effective when it is used to strengthen meaningful teacher-student communication and active student participation, rather than being treated simply as a substitute for traditional teaching methods.

8.2 Educational implications

The findings have several implications for educational practice.

For teachers

Teachers should use digital technologies strategically to:

- Provides timely academic feedback.
- Maintain regular communication with students.
- Encourage online participation.
- Create interactive learning activities.
- Provides additional learning resources.
- Support students who need additional academic guidance.

Technology should complement, rather than replace, effective teaching practices.

For Educational Institutions

Schools, colleges, colleges and universities must:

- Provide a reliable digital infrastructure for learning.
- It offers professional training for teachers.
- It supports teachers in developing digital skills for teaching.
- Establish effective digital communication policies.
- Ensure that students have adequate access to digital learning resources.

- It assesses whether technology improves actual learning rather than measuring technology adoption alone.

For students

Students should be encouraged to actively use digital technologies to:

- Communication with teachers
- Collaborative learning
- Access to educational resources
- Receive feedback
- Participation in debates
- Independent Learning

8.3 Recommendations

Based on the framework and findings of the study, the following recommendations are proposed:

1. Strengthen teachers' digital competencies.

Educational institutions should provide continuous training to help teachers effectively integrate digital tools into teaching and communication.

2. Prioritize interaction over technology adoption.

Institutions should evaluate digital education based on the quality of teacher-student interaction, and not just the number of technologies or platforms used.

3. Develop interactive digital learning environments.

Digital courses should include discussions, collaborative activities, assessments, feedback mechanisms, and opportunities for active student participation.

4. Improve feedback mechanisms.

Digital platforms should be used to provide students with timely, constructive, and academically relevant feedback.

5. Address digital inequality.

Institutions should consider differences in students' access to devices, internet connectivity, and digital resources.

6. Maintain human-centered education.

Technology should support teacher-student

relationships rather than eliminate meaningful interpersonal interaction.

7. Monitor student engagement.

Educational institutions should periodically assess student engagement and engagement in technology-supported learning environments.

8.4 Limitations of the study

Several limitations must be considered.

First, the proposed study uses a **cross-sectional research design**, which limits the ability to establish long-term causal relationships. Second, the proposed questionnaire is based on respondents' perceptions, which may introduce self-report bias. Third, the study focuses on a limited set of variables and does not examine all factors that may influence learning outcomes.

In addition, differences in educational level, institutional setting, teacher experience, student characteristics, and access to technology may influence the findings. Therefore, the results should be interpreted within the context of the selected research population.

8.5 Future research

Future researchers could expand this study by:

- Conduct longitudinal research to examine changes over time.
- Compare schools, colleges, colleges, and universities to identify contextual differences in educational technology use, interaction, student engagement, and learning outcomes.
- Comparing online, hybrid, and face-to-face learning environments.
- Examining the role of artificial intelligence in teacher-student communication.
- To investigate the differences between the perceptions of teachers and students.
- Examine digital literacy as an additional variable.
- Use qualitative interviews to understand the experiences of teachers and students.
- Test the proposed framework in different countries and education systems.
-

8.6 Final conclusion

The digital transformation of education has created new possibilities for communication and interaction between teachers and students. However, the educational value of technology depends on **how effectively it is integrated into teaching and learning**.

In summary, the proposed framework considers educational technology as part of an interconnected process: Technology → Teacher-Student Interaction → Student Participation → Learning Outcomes. This interpretation is consistent with the literature that situates

interaction, participation, and the pedagogical context as central elements of technology-mediated education (Bower, 2019; Bond et al., 2020; UNESCO, 2023).

Technology → Teacher-Student Interaction → Student Engagement → Learning Outcomes

This perspective places **teachers and students at the center of digital education**. Technology provides the infrastructure and communication channels, while meaningful interaction, engagement, and effective pedagogy determine whether these tools contribute to successful learning.

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