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RESEARCH PAPER

Digital Inquiry-Based Teaching and Student Engagement Exploring Technology-Enhanced Learning Environments

Mahmood Ahmed Dool*[1] Kamran Hyder Malik[2] Muhammad Imran[3]

1. Assistant Professor, Department of Education, Sukkur IBA University, Sukkur, Sindh, Pakistan
2. Lecturer, Department of Education, Sukkur IBA University, Sukkur, Sindh, Pakistan
3. PhD. Scholar, Department of Education, SZABIST University, Karachi, Sindh, Pakistan

***Corresponding Author:** mahmood.dool@iba-suk.edu.pk

ABSTRACT

This study examined the relationship between digital inquiry-based teaching and student engagement in technology-enhanced learning environments among undergraduate students. The study adopted a quantitative research design using a cross-sectional survey method. Data were collected from 250 undergraduate students from public and private universities through a structured questionnaire based on a five-point Likert scale. The collected data were analyzed using SPSS through descriptive statistics, Pearson correlation, and regression analysis. The findings revealed that digital inquiry-based teaching significantly improved student engagement, participation, and collaborative learning experiences. Technology-enhanced learning environments also positively influenced students' motivation, interaction, and active participation in learning activities. The study further found strong positive relationships between digital inquiry practices and student engagement. The findings highlighted the importance of integrating inquiry-oriented digital teaching strategies and interactive technologies into higher education classrooms. The study concluded that technology-supported inquiry learning environments play a significant role in improving students' engagement and overall learning experiences in modern education.

KEYWORDS Collaborative Learning, Digital Inquiry-Based Teaching, Digital Pedagogy, Educational Technology, Higher Education, Inquiry Learning, Student Engagement, Technology-Enhanced Learning

Introduction

Digital learning environments have made a significant shift in the educational landscape around the world. In contemporary classrooms, teachers utilize technology, such as learning management systems, virtual classrooms, multimedia applications and collaborative online platforms to facilitate learning and teaching activities (Schindler et al., 2017). The ubiquity of technology in society has led to the creation of educational spaces which seek to enhance accessibility, interaction, flexibility and student-centered learning. In response, digital transformation has become a must in the teaching and learning process.

Concurrently, inquiry-based learning has become a significant pedagogical strategy which encourages active learning by asking questions, exploring concepts, working together and solving problems. Inquiry-based learning allows students to build their own knowledge and helps them learn to think and analyze (Lazonder & Harmsen, 2016). Digital technologies also provide additional opportunities for interactive learning and meaningful student engagement when combined with inquiry based teaching. Technology-supported inquiry activities such as online discussions, virtual experiments, simulations, and collaborative research tasks can increase students' engagement and motivation in the learning process.

In technology-supported learning environments, student engagement is regarded as one of the key measures for successful learning outcomes. Digital inquiry-based teaching supports behavioral, emotional, and cognitive engagement by encouraging active

participation and collaboration among learners (Balalle et al., 2024). The research reports that technology-enhanced inquiry learning has positively impacted students in terms of motivation, learning outcomes, and critical thinking skills (Chen & Chen, 2024). Thus, the digitalization of education places a strong emphasis on comprehending the influence of digital inquiry-based teaching on students' learning engagement in contemporary classroom.

Although educational technology has improved, there are still some classroom environments that have low student involvement because of the passive educational techniques of the teachers and the teaching oriented instruction. Students are not usually motivated, do not usually interact or take part in traditional classroom activities. Digital inquiry-based teaching allows teachers to improve student engagement, but there are challenges in its implementation, such as limited technology facilities, lack of teacher staff training, and management issues in digital learning environment (Chen & Chen, 2024).

In addition, the linkage between digital inquiry-based teaching and student engagement in technology-enhanced learning environment is still to be explored. Understanding this relationship is necessary to improve teaching strategies and maximize the educational benefits of digital technologies.

The study is significant for teachers and educational organizations because of the insights it offers regarding effective ways to enhance student engagement by using digital inquiry-based teaching. The study also extends the work in the field of digital pedagogy by investigating the impact of technology-enriched inquiry strategies on students' learning. Previous research suggested that using educational technologies and inquiry-based digital investigations could be very effective in enhancing student participation, collaboration, and engagement in higher education settings (Bedenlier et al., 2020; Huang et al., 2024). Further, the results could be useful for curriculum planners to create more interactive and student-centered learning materials. The study can also help policymakers formulate education policies that facilitate the implementation of good technology integration in contemporary classrooms and innovative teaching.

Literature Review

Inquiry-based teaching is a student-centered pedagogical method that allows students to develop knowledge by using student-centered questions, investigating problems and building knowledge. Inquiry learning is a process of investigation, critical thinking, collaboration and problem solving that enables students to gain conceptual understanding (Lazonder and Harmsen 2016). Questioning, exploration, evidence-based reasoning and reflective learning are the key elements of inquiry-based teaching. Recent research also highlighted the advantages of inquiry-based learning for enhancing scientific literacy, active engagement in learning, and learners' participation in learning programs (Utami, 2024; Sotiriou, Lazoudis, & Bogner, 2020).

The idea of inquiry-based learning was developed from the philosophy of education of John Dewey, who believed in experiential learning and in active participation of the learner. Inquiry learning in science and technology education was widely accepted as a teaching method that fosters meaningful learning experiences and encourages independent thinking over the years. In the 21st century, inquiry learning is recognized as a vital method to cultivate the skills of creativity, communication, collaboration, and critical thinking (Pedaste et al., 2015). Inquiry approaches are being adopted more and more in classrooms and schools to equip students to thrive in more complex digital and global contexts. Recent literature also reported that incorporating digital technologies into inquiry-based learning enhances students' engagement and promotes higher-order thinking skills (Lee, 2023; Hinostroza, Armstrong-Gallegos & Villafaena, 2024).

Digital Inquiry-Based Teaching

Digital inquiry-based teaching is a combination of digital technology with the principles of inquiry-based learning so as to form a teaching-learning process that is interactive and collaborative. Technology-supported inquiry learning allows students to gain access to information on the web and to engage in online investigations and collaborate online. Digital inquiry-based learning increases the participation of students by fostering collaborative problem-solving and simulations, and active participation in online discussions (Chen & Chen, 2024). Recent research also showed that digital inquiry learning environments positively affect students' behavioural engagement, self-regulated learning and scientific literacy (Mamun & Lawrie, 2023; Aidoo et al., 2024).

Collaborative learning is an important part of digital inquiry teaching, which has been carried out online.Online collaborative learning has been an important part of digital inquiry teaching. Students participate in learning through communication technologies (discussion forums, video conferencing, collaborative tools, etc.) and build knowledge together. Sung, Chang, and Liu (2016) determined that collaborative learning with technology has a positive influence on students' learning performance and engagement. Likewise, Carroll, Lang, and Connolly (2024) highlighted how the digital collaborative inquiry frameworks enhance student interactions and online learning.

The use of digital tools like Learning Management Systems (LMS), virtual laboratories, multimedia applications, and AI-powered educational platforms also enhances the support of inquiry-based learning. These technologies enable students to research and analyze information and engage in interactive learning tasks. Using multimedia and digital resources leads to flexible and student-centered learning environments, which improve inquiry learning experiences. Lee (2023) and Hinostroza et al. (2024) also found that digital technologies are effective in facilitating good practices in inquiry-based learning in educational settings.

Technology-Enhanced Learning Environments

In a technology enhanced learning environment, digital technologies are used in the educational process to enhance educational outcomes. The setting provides for communication, collaboration, individualization, and access to instructional material. Schindler et al. (2017) found that technology-supported learning environments allow for greater involvement of students and increase participation through interactive and flexible forms of instruction. Recent research also showed that technology-enhanced environments enhanced engagement, collaborative learning, and academic achievement in digital learning environments (Duterte, 2024; Aljehani, 2024).

In educational institutions, Learning Management Systems (LMS) like Moodle, Blackboard, and Google Classroom are commonly utilized for the management of online learning activities, evaluations, and communication. LMS offers space for students and teachers to collaborate in learning, discuss, and give each other feedback continuously. Ong and Quek (2023) also concluded that the technology-enhanced online learning space has the capacity to enhance teachers' and students' interaction and engagement in digital learning settings.

In recent years, digital education has been further revolutionized through the use of AI tools, multimedia resources, and interactive platforms. Adaptive learning systems and intelligent tutoring systems are examples of AI applications that tailor the learning experience to each student's needs and learning approaches. Using multimedia such as videos, animation and simulations enhances students' understanding and enthusiasm by making learning more lively and interactive. Additionally, Shi et al. (2019) found that active

learning environments using technology have a positive impact on students' cognitive learning outcomes and academic performance.

Student Engagement

Student engagement is a measure of students' involvement, interest, and dedication in learning activities. Engagement is typically measured in three components: behavioral, emotional, and cognitive. Behavioral engagement is manifested through students' involvement in class, attendance and task completion. Emotional engagement involves students' emotions, attitudes, and motivation to learn, whereas cognitive engagement involves critical thinking, self-regulation, and investment in learning tasks (Fredricks, Blumenfeld, & Paris, 2004). Nkomo, Daniel, and Butson (2021) and Bond et al. (2020) also highlighted that digital technologies have a strong impact on students' behavioral, emotional and cognitive involvement in higher education settings.

The use of technology in learning environments positively impacts these dimensions of engagement. Digital inquiry-based teaching promotes problem-solving activities and involves students in discussions and collaboration. Balalle, Rubach, and Lazarides (2024) found that technology-enhanced learning spaces can boost behavioral and cognitive engagement through their interactive nature and their ability to facilitate independent learning. Similarly, Ahshan (2021) pointed out that online and remote learning methods can help to foster active student participation in the digital classroom.

Relationship between Digital Inquiry Teaching and Student Engagement

Some previous research has shown that students' engagement is strongly correlated with digital inquiry-based teaching. Technology supported inquiry learning enhances participation and motivation as students are actively involved in learning process and not passive receivers of information. Using digital activities, students are prompted to ask questions, research problems, and work together with others. Utami (2024) and Mamun and Lawrie (2023) also found that the digital learning environment of inquiry learning can improve student learning engagement and participation.

Digital inquiry teaching also promotes active learning and critical thinking. Hwang and Chiu (2013) suggested that inquiry-based digital learning environments can improve students' analytical and problem solving skills via collaboration and experiential learning. In addition, digital technologies enable the learner autonomy by enabling students to manage the pace, place and direction of their learning. Self-directed learning opportunities enhance motivation and overall engagement. Aidoo et al. (2024) and Sotiriou et al. (2020) also found that digital inquiry-based learning had beneficial effects on motivation, self-regulated learning, and engagement.

Hypotheses

H1 Digital inquiry-based teaching has a significant positive effect on student engagement.

H2Technology-enhanced learning environments significantly improve student participation.

H3 Digital inquiry practices are positively associated with collaborative learning experiences

Theoretical Framework

The study is supported by several theories of learning which are summarized below. According to the Constructivist Learning Theory, learning is a process that occurs when

students actively construct knowledge, experience, and interaction. Digital inquiry-based learning is consistent with the principles of constructivism as students explore, collaborate, and construct knowledge with the help of technology. The findings of the studies by Hinostroza et al. (2024) and Carroll et al. (2024) support the findings that collaborative and tech-assisted inquiry learning contexts positively impact meaningful learning experiences.

Inquiry Based Learning Theory emphasizes the questioning process, investigation and discovery as a basis for learning. In the digital learning environment, the theory that underlies the application of inquiry activities is to solve a problem and develop critical thinking skills. The importance of inquiry-based digital learning in increasing engagement and scientific literacy was also highlighted by Utami (2024), and Lee (2023).

Fred Davis (1989) has developed a model named the Technology Acceptance Model (TAM) that describes the factors that affect technology uptake by users, namely the perception of the technology's usefulness and ease-of-use. TAM in the Educational Context offers explanations for students' and teachers' acceptance of a digital tools and technology enhanced inquiry learning environment. Aljehani (2024) also found that there was a correlation between perceptions of usefulness and support in instruction and integration of technology.

Empirical Review of Previous Studies

International research has repeatedly shown that digital inquiry-based teaching is beneficial for students. Schindler et al. (2017) found via their study that the use of computer-based technologies leads to significant increase in students' participation, motivation, and collaboration. Similarly, Chen and Chen (2024) concluded that technology-based collaborative inquiry has a positive effect on critical thinking and engagement in the K–12 setting. Subsequent systematic reviews by Bond et al. (2020) and Nkomo et al. (2021) found that the effect of educational technologies on students' engagement and collaborative learning outcomes were equally significant in Higher Education settings.

In addition, a few regional studies in Pakistan also highlight the growing importance of digital learning environments. Gupta (2024) concluded that technology facilitates learning in higher education institutions in Pakistan leading to increased motivation of learners. However, in many schools there are still major obstacles to overcome, such as lack of infrastructure, teacher training and access to technology. Recent research also indicated that the effective integration and leadership in the use of technology in learning environments are crucial factors influencing student engagement and learning outcomes (Duterte, 2024; Aljehani, 2024).

Though there are existing studies, the research gaps still exist in the understanding of the impact of digital inquiry-based teaching on the engagement of students in technology-enhanced learning environment, especially in developing countries such as Pakistan. Therefore, further research is required to explore how effective it is to adopt the digital teaching method based on inquiry learning to boost student engagement, motivation and learning achievement.

Conceptual Framework of the Study

This study's conceptual framework shows the relationship between digital inquiry-based teaching and student engagement in technology enhanced learning environments. Guided by this, digital inquiry-based teaching is an independent variable, and student engagement is a dependent variable (Figure 1). Digital inquiry-based teaching centers on technology-based teaching methods that enable students to investigate, collaborate, solve problems and participate in learning (Lazonder & Harmsen, 2016).

Ancillary variables such as technology support for learning, collaborative learning and student involvement are also included in the framework. Technology-enhanced learning environments are digital platforms, the use of multimedia, Learning Management System (LMS), and interactive tools designed to enhance learning experiences and facilitate inquiry-based learning (Schindler et al., 2017). Collaborative learning involves students sharing their ideas, communicating and collaborating with each other through the use of digital technologies which helps in strengthening their engagement and critical thinking skills (Sung, Chang, & Liu, 2016). Similarly, more behavioral, emotional and cognitive engagement when students engage in discussion, problem solving and online interactions. The conceptual framework presented in this research indicates that supporting the development of digital learning environments and collaborative learning practices can positively impact student engagement if it is implemented in effective ways in digital inquiry-based teaching, as shown in Figure 1.

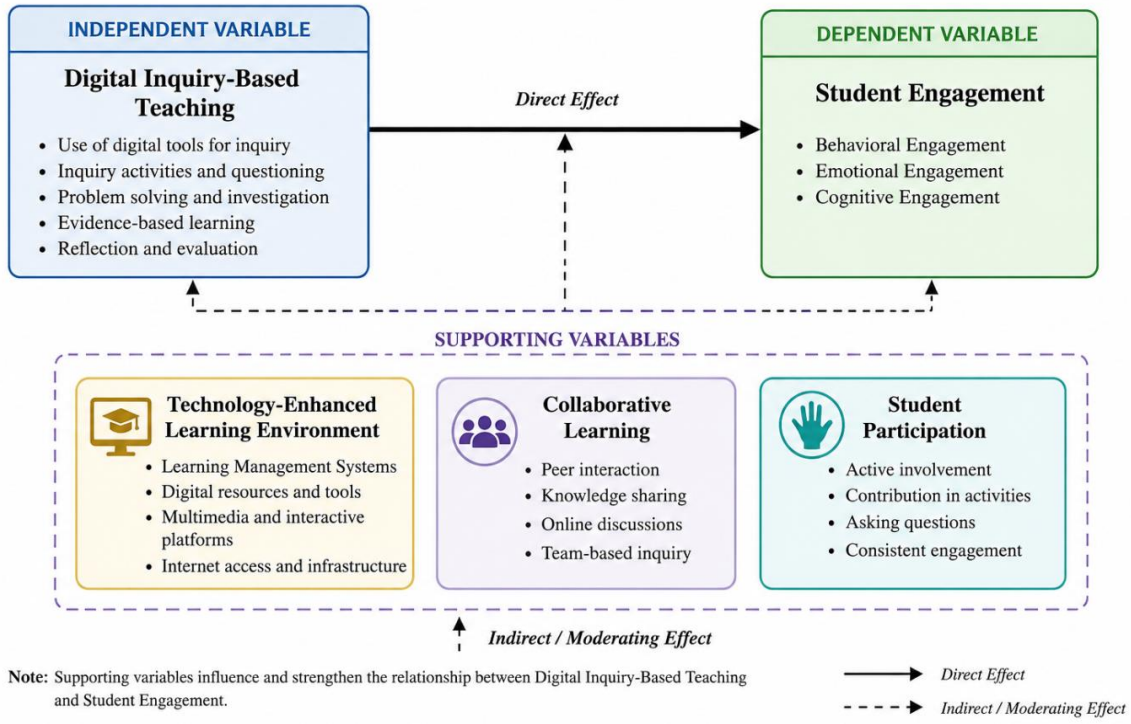

Figure 1: Conceptual Framework of the Study Showing the Relationship between Digital Inquiry-Based Teaching and Student Engagement in Technology-Enhanced Learning Environments.

Material and Methods

The study adopted quantitative research design to investigate the relationship between digital inquiry-based teaching and student engagement in technology enhanced learning. The quantitative research design was found to be appropriate since it enabled the researcher to gather quantitative data and the relationships between variables in the study could be examined using statistics. The study adopted a cross-sectional survey design which involved respondents at one particular time. Cross section surveys are suitable for investigating attitudes, perceptions and behavior in a given population according to Creswell and Creswell (2017).

The research method adopted was positivist research method which emphasized on the measurement, observable facts and on statistical analysis. The positivist approach focused on measurement of data and hypothesis testing in order to explain the relationship between variables. According to Saunders, Lewis, and Thornhill (2011), positivism is

suitable for research that aims to discover cause and effect relationships that can be seen from the facts and using basic structures of data collection.

Population

The study population was composed of public and private university students using digital learning platforms and technology-enhanced learning environments in their university studies. These students were familiar with online learning systems and activities using a learning approach based on inquiry, virtual classrooms, and digital learning tools. The target population was chosen since the study was concerned about students' experiences and engagement in technology-supported learning environments.

Sample and Sampling Technique

The total sample for this study was 250 undergraduate students. Stratified random sampling was used in order to ensure the proper representation of students with different academic backgrounds and institutions. Stratified random sampling was used in which the population was subdivided into groups and random sampling was used within each group. The use of this sampling technique enhanced the representativeness and reliability of the data.

Research Instrument

The data collection tool used was a structured questionnaire. The questionnaire included closed questions with a 5-point Likert scale between strongly disagree and strongly agree. The questionnaire was divided into four parts: Demographic information, Digital inquiry based teaching practices, Scale of student engagement, Technology enhanced learning environment. The questions from the questionnaire were based on existing research on the subject of digital learning and student engagement. According to Joshi et al (2015) that Likert scale questionnaires are good instruments for measuring attitudes, opinions and perceptions in educational research.

Validity and Reliability

The questionnaire was checked by experts in the educational field and research methodology to ensure its validity. The questionnaire items were improved with the help of expert validation for their clarity, relevance and appropriateness. A pilot testing was also done among 30 undergraduate students prior to the main data collection process. The aim of the pilot testing was to detect the problems regarding the structure and wording of the questionnaire. The internal consistency of the questionnaire scales was tested using Cronbach's Alpha reliability test. Taber (2017) suggested that a Cronbach's alpha coefficient of greater than 0.70 is an acceptable level of reliability.

Data Collection Procedure

The data collection process began after obtaining permission from the concerned academic authorities. The questionnaires were sent out via the internet and physically to ensure that more students responded. The participants were given information on the goals and the purpose of the study before filling out the questionnaire. Care was taken to observe ethical principles during research. Each respondent signed informed consent and the participants' confidentiality and anonymity was ensured.

Data Analysis Techniques

Data collected were analyzed with the aid of Statistical Package for Social Sciences (SPSS) software. Demographic information and research variables were summarized using descriptive statistical measures (frequency, percentage, mean and standard deviation). Pearson correlation analysis was used to explore the correlation between digital inquiry-based teaching and students' engagement. Student engagement of technology-enhanced learning environment was also analyzed using linear regression to learn the prediction of digital inquiry-based teaching. Hypothesis testing was carried out to determine the significance of the relationships among variables.

Results and Discussion

Table 1
Gender of Respondents

Gender	Frequency	Percentage
Male	132	52.8%
Female	118	47.2%
Total	250	100%

Table 1 presents the results by gender. 132 of 250 (52.8%) participants were male, while the remaining 118 were female. Overall, the study was able to achieve adequate coverage of both genders, and as a result, it was able to address male and female opinions and perspectives regarding digital inquiry-based teaching and student engagement.

Table 2
Age of Respondents

Age Group	Frequency	Percentage
18–20 Years	94	37.6%
21–23 Years	121	48.4%
24–26 Years	35	14.0%
Total	250	100%

Table 2 shows the age distribution of respondents. 121 (48.4%) students were aged 21-23, 94 (37.6%) of students were 18-20, and only 35 (14.0%) respondents were 24-26. The majority of respondents were undergraduate students interested in learning technology.

Table 3
Academic Discipline of Respondents

Academic Discipline	Frequency	Percentage
Education	72	28.8%
Social Sciences	61	24.4%
Business Studies	57	22.8%
Computer Science	60	24.0%
Total	250	100%

Table 3 shows student sample representation from different disciplines. Education had the largest sample size at 72 (28.8%) with Social Sciences having 61 (24.4%) students. Business studies had 57 (22.8%) students. Computer Science had 60 (24.0%) students. The study involved students from a variety of academic disciplines.

Table 4
Semester/Year of Study

Semester/Year	Frequency	Percentage
1st Year	56	22.4%
2nd Year	71	28.4%
3rd Year	68	27.2%
4th Year	55	22.0%
Total	250	100%

According to the results in Table 4, the highest number of respondents was comprised of 2nd year respondents who were represented by (28.4%) 71 respondents while the 3rd year respondents followed with (27.2%) 68 respondents. Including respondents from all the academic years allowed us to gain comprehensive perceptions regarding digital inquiry based learning practices.

Table 5
Mean and Standard Deviation of Study Variables

Variables	Mean	Standard Deviation
Digital Inquiry-Based Teaching	4.12	0.61
Technology-Enhanced Learning Environment	4.05	0.65
Student Engagement	4.18	0.58
Student Participation	4.09	0.63
Collaborative Learning Experiences	4.14	0.60

The descriptive statistics of the study variables are presented in Table 5. The results show that the mean score of the Digital Inquiry-Based Teaching (M = 4.12, SD = 0.61) is high, indicating that students have positive perceptions of the digital teaching techniques of inquiry. The mean score (M = 4.18, SD = 0.58) for Student Engagement was the highest, indicating high levels of student engagement in the use of technology in learning environments. The other responses of the participants were also positive— Technology-Enhanced Learning Environment (M = 4.05, SD = 0.65), Student Participation (M = 4.09, SD = 0.63), and Collaborative Learning Experiences (M = 4.14, SD = 0.60). In conclusion, the results reveal students' learning environment was conducive to learning, as digital inquiry-based teaching practices were found to be effective.

Overview of Digital Inquiry Teaching Practices

The descriptive results show that the use of digital inquiry-based teaching methods was high in technology-enriched classrooms. Students said they actively engaged with online discussions, collaborative activity, digital investigations, and problem-solving activities. Students' high mean scores indicate that digital technologies enabled interactive learning experiences, and motivated students to be active participants in learning course content.

Overview of Student Engagement Levels

The findings also indicated that students are very engaged in digital learning environments. Students demonstrated behavioral engagement through participation in classroom activities, emotional engagement through motivation and interest in learning, and cognitive engagement through critical thinking and self-regulated learning practices. The results indicated that digital inquiry-based teaching has its positive effect on students' involvement and learning experiences.

Table 6
Correlation Analysis among Variables

Variables	1	2	3	4
1. Digital Inquiry-Based Teaching	1			
2. Technology-Enhanced Learning Environment	.684**	1		
3. Student Engagement	.742**	.701**	1	
4. Student Participation	.655**	.718**	.736**	1

Correlation is significant at the 0.01 level (2-tailed).

Table 6 presents the Pearson correlation analysis among the study variables. The results showed that there was a significant positive correlation between Digital Inquiry-Based Teaching and Student Engagement ($r = .742$, $p<0.01$). The finding implies that if

inquiry-based digital teaching is used more and more, the level of student involvement will be greatly improved.

Similarly, Technology-Enhanced Learning Environment showed a strong positive relationship with Student Participation ($r = .718$, $p < .01$), indicating that digital learning environments encourage active student involvement. The findings indicate strong positive correlations between all study variables, thereby supporting the positive impacts of digital inquiry teaching and technology-supported learning environment on engagement and participation.

Table 7
Regression Analysis: Effect of Digital Inquiry-Based Teaching on Student Engagement

Variables	B	Std. Error	Beta	t	Sig.
Constant	1.214	0.241		5.038	.000
Digital Inquiry-Based Teaching	0.721	0.056	0.742	12.875	.000

Model Summary

R	R^2	Adjusted R^2	F	Sig.
.742	.551	.548	165.76	.000

Table 7 includes regression analysis of the impact that Digital Inquiry-Based Teaching has on Student Engagement. Digital Inquiry-Based Teaching positively identified Student Engagement at ($\beta = .742$, $p < .001$). The R^2 value of .551 shows that Digital Inquiry-Based Teaching accounts for approximately 55.1% of the variance of Student Engagement.

The regression coefficient also indicates that student engagement levels increased significantly with each unit of increase of Digital Inquiry-Based Teaching. Therefore, the results substantiate that the use of digital inquiry teaching strategies results in a higher level of student engagement within the context of technology-based teaching and learning environments.

Table 8
Regression Analysis: Predictive Role of Technology-Enhanced Learning Environment on Student Participation

Variables	B	Std. Error	Beta	t	Sig.
Constant	1.102	0.233		4.730	.000
Technology-Enhanced Learning Environment	0.695	0.052	0.718	13.365	.000

Model Summary

R	R^2	Adjusted R^2	F	Sig.
.718	.516	.512	178.62	.000

Table 8 shows that Technology-Enhanced Learning Environment was a strong predictor for Student Participation ($\beta = .718$, $p < .001$). The R^2 value of .516 indicates that technology-enhanced learning environments explain around 51.6% of the variance in student participation.

The findings indicate that teaching technology and learning technology integrated with digital platforms, multimedia, and interactive technologies play a crucial role in student participation in educational activities. Students who have been in technology-enhanced learning environments have demonstrated high levels of participation and engagement in the learning activities.

Table 9
Hypotheses Testing

Hypotheses	Results	Decision
H1: Digital inquiry-based teaching has a significant positive effect on student engagement.	Supported ($\beta = .742$, $p < .001$)	Accepted

H2: Technology-enhanced learning environments significantly improve student participation.	Supported ($\beta = .718$, $p < .001$)	Accepted
H3: Digital inquiry practices are positively associated with collaborative learning experiences.	Supported ($r = .655$, $p < .01$)	Accepted

The results of the hypothesis testing suggested that all described assumptions were accepted. It was shown that the introduction of digital inquiry teaching improved student engagement. Also, teaching in a technology-enhanced learning environment positively affected student participation. In addition, the use of digital inquiry positively impacted the collaborative learning experience. These assumptions further confirm the theoretical framework and earlier studies on the impact of technology-enriched learning environments on inquiry-based learning.

This study analyzed undergraduate students' learning engagement in technology-enhanced learning environments and the effects of digital inquiry-based teaching on their learning engagement. The demographic results showed that the students participating in the study were in an even balance with respect to their gender, academic discipline, and academic year.

High levels of digital inquiry-based teaching practices, student engagement, collaborative learning and technology supported participation were indicated in the descriptive statistics of the study. The results of the correlation analysis found that digital inquiry teaching and technology enhanced learning environment were positively and significantly correlated with student engagement and student participation.

The results of regression analysis indicated that digital inquiry-based teaching significantly explained the students' engagement and technology-enhanced learning environments significantly affected the student participation. The results show that the use of QR code technology in instruction stimulates students to learn actively, collaborate, be motivated and engaged in learning behavior.

In summary, the authors of the study found that the use of technology-based inquiry learning environments has a significant effect on improving students' learning experiences, learning participation and learning engagement in higher education environments.

Discussion

The results of this research showed a significant increase in engagement, participation, and collaborative learning in digital learning environments for students in DQL. Results of the correlation and regression analyses showed that the digital inquiry practices were significantly positively correlated with students' engagement. The results of this study align with the research results of previous studies conducted by Schindler et al. (2017), Bond et al. (2020) and Chen and Chen (2024), which showed that technology-supported inquiry learning positively affected students' motivation, interaction and academic participation. Based on a similar premise, Mamun and Lawrie (2023) concluded that digital inquiry-based activities have a positive effect on the self-regulated learning and behavioral involvement of students.

Results can also be explained using Constructivist Learning Theory and Inquiry Based Learning Theory. All of these theories stress active learning, collaboration, construction of knowledge, and problem-solving with meaningful interaction. The results confirm a theoretical prediction that students can be engaged more when actively involved in digital investigations and collaborative inquiries activities, as proposed by Lazonder & Harmsen (2016). Moreover, the Technology Acceptance Model (TAM) also attributes students' positive perceptions of the usefulness of digital learning tools to increased engagement and participation in learning activities (Aljehani, 2024).

Digital Inquiry Teaching and Student Engagement

Results indicated that the digital inquiry-based teaching had a positive impact on students' participation and collaboration. Pupils were actively participating in on-line discussions, group work, problem-solving tasks and collaborative digital investigations. The findings corroborate the studies conducted by Utami (2024) and Aidoo et al. (2024) which found that the use of Inquiry-based Digital Learning Environments (IBDLE) significantly enhances participation, communication and collaborative learning experiences.

In addition, the digital inquiry teaching enhanced the students' critical thinking, motivation and independent learning skills. Inquiry-based activities prompted students to scrutinize information, ask questions and solve problems with active learning. Moreover, Hwang and Chiu (2013) also noted that technology-based inquiry learning can improve learners' analytical thinking and cognitive involvement.

Technology-Enhanced Learning Environments

The technology enhanced learning environment offered a number of educational benefits, such as flexibility, accessibility, interactive learning and constant communication between teacher and student. Using digital platforms including Learning Management Systems (LMS), multimedia and collaborative online resources, supported learning environments were fostered that facilitated learners' active involvement and engagement. The findings coincide with the findings of Schindler et al. (2017) and Ong and Quek (2023) that digital learning technologies enhance interaction and student-centred learning experiences.

While this study highlights the various advantages of technology enhanced learning environments, there are also a number of challenges identified, such as limited technological infrastructure, problems with the internet and a lack of teacher training. Duterte (2024) and Gupta (2024) noted the lack of institutional support can impact the implementation of digital learning.

Implications for Educational Practice

The results of this study have implications for educational practice. First, teacher professional development courses in the use of digital tools and in the development of inquiry-based teaching should be offered in schools. The teachers should have enough technological knowledge and teaching methods to implement DIL in the classroom properly.

Second, the design of curriculum materials and resources should be more interactive, student-oriented and the use of technology to stimulate enquiry, collaboration and critical thinking. Digital inquiry activities can be integrated into curriculum design to enhance students' motivation and engagement in learning.

Finally, institutions need to make technological infrastructure robust and ensure proper support to facilitate digital learning environments. Access to reliable internet, digital devices, and educational technologies is necessary to maximize the effectiveness of technology-enhanced inquiry-based learning in higher education settings.

Conclusion

This study examined the relationship between digital inquiry-based teaching and student engagement in technology-enhanced learning environments among undergraduate students. The results indicated that digital inquiry-based teaching had a significant effect on student engagement, participation and collaborative learning. Descriptive, correlation and regression analysis results showed that inquiry-oriented digital teaching practices are positively correlated with the students' behavioral, emotional and cognitive engagement. Likewise, technology integrated learning environments enabled active learning,

communication, collaboration and critical thinking using digital platforms and interactive learning tools.

All the research goals of the study were accomplished. First, it focused on the positive impact of digital inquiry-based teaching on student engagement. Second, it explored the impact of the use of technology in learning environments in terms of enhanced student participation. Third, it concluded that digital inquiry practices were a positive influence on collaborative learning experiences. The results also reinforced the theoretical perspectives used by the Constructivist Learning Theory, Inquiry-Based Learning Theory and the Technology Acceptance Model, which all focus on active learning, collaboration and successful use of technology in the learning process.

Recommendations

Results are presented and a number of recommendations made. Incorporate online discussion, collaborative projects, simulations and problem-based learning tasks into the classroom to engage students and motivate them to participate. There should also be regularized in-service trainings to enhance teachers' digital pedagogical skills.

Higher education institutions need to create educational policies that will allow the effective integration of technology and promote digital inquiry-based teaching practices. Support and investments should be made to improve digital learning environment infrastructure.

Educational institutions should provide enabling learning environments using technology by providing reliable internet, Learning Management Systems (LMS), multimedia and interactive digital tools. The institutions should also promote collaborative and student learning systems.

Suggestions for Future Research

Future studies could be mixed method to have a better understanding of student experience and perception in relation to digital inquiry-based learning. Comparative analysis and research between public and private universities or between different levels of education can also offer a wider understanding of digital learning practices. Additionally, longitudinal study is suggested to explore the long-term impacts of digital inquiry-based teaching on students' engagement, learning performance, and learning outcomes over time.

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