Examining the Impact of Technology-Based Collaborative Learning on Student Engagement in Higher Education

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Abstract

Technology-based collaborative tools provide a promising strategy to boost student engagement. Yet understanding how these tools impact student engagement and their combined effect, especially in higher education, is underexplored. Thus, this research examines the impact of multiple, technology-based learning tools on student engagement in a course offered to undergraduate students at a selected university. Furthermore, how the students' attitudes towards technology moderate these relationships was also investigated. The research utilized a quantitative approach, using a standard questionnaire and collecting data from 123 students enrolled in a 'Business Innovation' course at the given university. The findings indicate significant positive relationships between the use of technology-based collaborative learning tools and student engagement. Furthermore, students' attitude towards technology was also found to moderate these relationships. The findings contribute to the field of education technology, offering a comprehensive understanding of how a combination of multiple technology-based tools can impact student engagement. It underlines the significance of considering student attitudes towards technology when designing and planning these learning tools. The findings encourage investment in resources as well as training to support the effective utilisation of technology-based teaching and learning tools in the classroom.

Keywords: Attitudes towards technology, Collaborative learning, Student engagement, Technology-based tools.

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Introduction

Student engagement has become one of the most desired outcomes of higher educational institutions in recent years because of its strong connection to academic performance and student well-being (Li & Xue, 2023). Studies have identified factors that determine the level of student engagement including students' characteristics such as age, gender, and socio-economic status (Kuh, 2008), their behaviors (Zepke, 2014), academic programs, institution, perceived workload, characteristics of peers and teachers (Xerri et al., 2018) and technological interventions (Teng & Wang, 2021: Muhridza et al., 2018). Meanwhile, the education field has experienced substantial changes, with new information and communication technologies (ICT) being developed and evolving rapidly, resulting in further use of new digital tools across all educational levels, specifically in the higher-education sector.

This technological revolution is enabling a better-personalized way to manage individual educational needs – by offering greater access to materials, curricular adjustments, active learning opportunities, and variations in learning speed (Teng & Wang, 2021; Muhridza et al., 2018; Sawang et al., 2017). Therefore, with the continuous evolution of technology, the importance of integrating ICT into the educational process is currently established, making it an essential partner for building equitable educational environments. In the prevailing Fourth Industrial Revolution (IR 4.0) era, advanced technologies dominate the education industry, and the technology-savvy Generation Z is enrolling in higher education (Abinowi, 2022). Technology-Based Active Learning (TBAL) is a pedagogical approach that uses various technologies to enhance student involvement and performance (Ghilay & Ghilay, 2015). TBAL creates spaces where students take part in learning by incorporating digital tools and resources. TBAL has its roots in active learning and emphasizes activities centred around students' problem-solving and decision-making skills and applying knowledge to real-world scenarios. TBAL consists of a wide range of technologies, including data analytics, collaborative tools, virtual and augmented reality, interactive simulation games, online learning platforms, etc.

Acknowledging the significance of aligning technology with teaching and learning, the researchers of this study intended to integrate some selected collaborative learning technologies out of TBAL tools into their teaching and examine their impact on student engagement. Although the impact of certain technological interventions on student engagement has been tested (E.g., Ahmed et al., 2020; Almusaed et al., 2023; Hanaysha et al., 2023), few studies have been conducted to examine the impact of Technology-Based Collaborative Learning on student engagement in large classrooms with more than 150 students and concerning courses where student engagement is essential for achieving learning outcomes. Many of the studies were conducted in general without focusing on a specific discipline. This study aimed to address the above-mentioned research gaps. A specific discipline, Business Innovation, in which student engagement is essential to achieve learning outcomes, was selected, and the course was delivered within a large classroom where the normal attendance was more than 150 students.

Moreover, recent studies illustrate the integration of different technology-based collaborative learning tools like Kahoot (E.g., Muhridza et al., 2018; Tao & Zou, 2021), Padlet (E.g., Mehta et al.,2021; Naamati-Schneider & Alt, 2023), Mentimeter (E.g., Pichardo et al., 2021; Wulan & Sulisworo, 2023), Slido (E.g., Ningsih, 2023; Zulfa & Laras, 2020), MindMeister (E.g.,

Zhou & Schofield, 2024) to increase student engagement separately. Accordingly, this study examines the combined effect of a set of collaborative teaching tools (Kahoot, Padlet, Mentimeter, Slido, and MindMeister) that were used throughout the teaching of an undergraduate course on student engagement filling another research gap.

In addition, student characteristics have been considered a critical success factor in technology-based learning in developing countries such as Sri Lanka. These characteristics include computer self-efficacy, Internet self-efficacy, computer experience, Internet experience, computer anxiety, and attitudes toward technology-based teaching tools (Chu & Chu, 2010; Chiu & Wang, 2008; Sun et al., 2008). The student's attitudes towards technology-based teaching tools are impacted by the quality and perceived ease of use, functionality of the software, level of student computer skills, perceived self-efficacy, enjoyment, and usefulness in using these technologies (Liaw & Huang, 2011). The selected course, Business Innovation, is followed by students with different backgrounds, who come from rural and urban areas and have various levels of access to resources and computer skills. Thus, their attitudes towards technology-based interactive learning tools may differ from each other and finally influence the level of student engagement. Therefore, this study further investigates how attitudes towards technology moderate the relationship between using technology-based collaborative learning tools and student engagement.

By examining the impact of the above-mentioned tools on student engagement and considering the moderating role of students' attitudes toward technology, this study provides valuable insights into effective pedagogical practices and the enhancement of student learning experiences in higher education. Additionally, by focusing specifically on the Business Innovation course, this study addresses a gap in the literature regarding the application of technology in teaching business-related subjects, further enriching the field of educational research.

Research Objectives

- To examine how technology-based collaborative learning impacts student engagement in the classroom.
- To investigate the moderate role of students' attitudes towards technology in the relationship between technology-based collaborative learning and student engagement

The article is organised as follows: initially, the theoretical framework is introduced; subsequently, the proposed model and associated hypotheses are presented; thereafter, the data analysis methodology employed to evaluate the model is discussed; ultimately, the findings are disclosed, accompanied by a discussion of their implications and the study's limitations.

Literature Review

Student Engagement in Higher Education

Student engagement is a critical factor in the success of students enrolled in higher educational institutions (Maxwell-Stuart & Huisman,2018). Student engagement refers to the efforts that students invest in their own learning, as measured by their time, effort, and resources

(Krause & Coates, 2008). It has also been established that student engagement is related to other areas such as student retention (Kuh et al., 2008), academic performance (Yang et al., 2023), and well-being (Donovan et al., 2020). Moreover, four distinct perspectives have been used to study student engagement: behavioural, psychological, socio-cultural, and holistic (Kahu, 2013; Xerri et al., 2018). According to the first perspective, engagement is an outcome of the interaction between students' behaviour and teaching practices (Chickering & Gamson, 1987). This approach defines student engagement as the "time and effort students devote to educationally purposeful activities." Studies adopting this perspective have focused on active learning, students' thinking processes, and their behaviour (Kahu, 2013). According to the second perspective, which emphasises psychological aspects, student engagement is an internal psychological process that evolves over time. The way it distinguishes between involvement and its antecedents sets it apart from the first perspective. This viewpoint suggests several connected characteristics, such as cognition, emotion, and conation, influence student engagement (Kahu, 2013). The third perspective considers the institutional culture and other sociopolitical factors that influence student engagement. For instance, Xerri et al. (2018) discovered that when students develop strong bonds with their peers and teachers, they are more engaged. According to the fourth viewpoint, which is the holistic one, the first three are all pertinent. It views engagement as both an outcome (the SE itself, which reflects the psychological state of the individual with engagement) and a process (the antecedents or factors that influence SE) (Tani et al., 2021). This study adopts the fourth perspective because it provides a clearer distinction between process and outcomes, considering process as factors that could include engagement, while outcomes are the engagement itself.

Student engagement encompasses behavioural, emotional, and cognitive dimensions (Fredricks, 2011). Behavioural engagement includes students' effort, persistence, attention, participation, asking questions, following rules, and the absence of disruptive behaviours. Emotional engagement involves affective reactions in the classroom, such as boredom, happiness, sadness, anxiety, identification with the institution (a sense of belonging), and attitudes toward the university. Cognitive engagement refers to students' investment in learning, self-regulation, preference for challenges and hard work, going beyond requirements, effort in mastering new knowledge and skills, and the use of learning strategies (Fredricks, 2011).

Technology-Based Active and Collaborative Learning Tools

Technology-based active learning integrates the learning process with various technologies to enhance students' performance and deeper understanding (Freeman et al.., 2014). Students who partake in these activities become more engaged in the learning process, gain critical and problem-solving skills, and achieve better results as learners when compared to the traditional forms of lectures.

TBAL comprises gamification, simulation, virtual reality, online collaboration, blended learning, and artificial intelligence-based tools for education. These approaches aim to promote active learning, critical thinking, and personalisation, improving engagement and outcomes. Amongst these tools, technology-based collaborative learning tools are critical in improving student performance. Collaborative learning can be defined as a shared construction of knowledge where participants cumulatively share their knowledge and jointly build on each

other's ideas and thoughts to construct new knowledge (Ness & Søreide, 2014). They are software applications and platforms that enable students to work on group projects successfully. They use digital technologies to accomplish information sharing, collaborative problem-solving, and teamwork on different projects.

Technology-based Active/Collaborative Learning and Student Engagement

Being actively engaged in the classroom may lead to better learning performance, and a technology-based learning environment enhances student engagement (Rienties et al., 2017; Hsieh et al., 2016). Collaborative learning is a process where individuals learn by engaging and interacting with peers to accomplish a common objective (Laurillard, 2013). To put it into the context of this research, the researchers used five technology-based collaborative learning tools: Padlet, Kahoot, Mentimeter, Slido and MindMeister. All these tools could be accessed with computers or mobile devices. Almost all the students have mobile phones and some laptops; they were used as technology platforms.

Padlet serves as another valuable tool for collaborative learning, particularly in the format of debates, fostering the generation of new ideas (Dewitt et al., 2015). This platform enables the posting of multimedia content such as documents, questions, comments, images, videos, and audio clips (Zainuddin et al., 2020). Research indicates that active learning through Padlet significantly enhances student engagement during classroom activities (Zainuddin et al., 2020).

Among the array of available digital games, Kahoot stands out as an excellent tool for university-level instruction due to its compatibility with mobile devices, widespread Wi-Fi availability, and students' fondness for computer games. Kahoot shares similarities with earlier clicker technology but distinguishes itself as free and user-friendly (Gokbulut, 2020; Nuci et al., 2021). Educators utilise Kahoot to develop engaging game-based quizzes, facilitate discussions, and conduct surveys with minimum effort (Raju et al., 2021; Tao & Zou, 2023). This eLearning tool injects positive energy into the classroom, encourages exploration of concepts, and infuses an element of fun, which has been linked to improved comprehension and motivation (Plump & LaRosa, 2017). Kahoot is recognised as a user-friendly technology-based instructional tool that requires minimal training for instructors and students yet yields substantial benefits in student engagement and metacognitive support (Heni et al., 2019). Consequently, Kahoot has been shown to effectively initiate and nurture student engagement in language learning activities while simultaneously enhancing language proficiency (Muhridza et al., 2018). It signifies that advancements in technology have expanded the possibilities for educators to incorporate game elements into their lesson plans, thereby enhancing learning outcomes.

Mentimeter is another well-known tool used to enrich collaborative learning within the classroom. It is a web-based platform utilised for creating interactive presentations with real-time feedback (Madiseh et al., 2022). This versatile application enables users to share knowledge and gather feedback via smartphones through presentations, surveys, class opinion sessions, quizzes, meetings, conferences, and various other group activities (Gokbulut, 2020). Mentimeter's inclusive features are highlighted by both students and educators, enabling participation from diverse audiences and ensuring equitable education (Pichardo et al., 2021). Integration of Mentimeter in educational settings not only enriches student-centred pedagogy but also

accommodates diverse cultural backgrounds and competencies, provides immediate anonymous feedback, enhances student motivation, and promotes active participation (Madiseh et al., 2022). According to Wulan and Sulisworo (2023), Mentimeter enhances student learning interaction, making it a recommended tool for educators seeking to improve learning quality and foster engaging and interactive environments.

Similarly, Slido has been identified as another significant tool which influences students' classroom engagement, motivation, and satisfaction. It is an interactive platform, functioning as a web-based Q&A and polling platform, designed to facilitate real-time participant interaction and engagement (Ningsih, 2023). Slido's interactive features, including quizzes, polls, and surveys, facilitate immediate feedback and contribute to increased student engagement (Ningsih, 2023). Moreover, the utilisation of Slido positively impacts learner interaction and engagement during classes, fostering an intriguing learning atmosphere (Dineshika, 2023). Additionally, Slido usage has been associated with benefits such as promoting active learning, providing immediate feedback, reinforcing learning points, and facilitating both independent and collaborative learning (Dineshika, 2023).

Furthermore, students can derive significant benefits from employing networking tools for collaborative academic projects, enabling them to identify and articulate the most relevant concepts of a topic through social tags (Santos-Caamaño et al., 2015). MindMeister is an online collaborative mind-mapping tool that offers various features such as different types of lines and colours for connectors, as well as the ability to add text to connectors (Aoki & Molnár, 2010). These features allow for the creation of intricate networks of concepts, enhancing the depth and complexity of the mind maps (Koznow & Pliskin, 2008; Zhou & Schofield, 2024). The use of digital mind maps in education stimulates the development of student's creative abilities and critical thinking, cultivates their cultural competencies in group settings, fosters argumentation skills and the ability to articulate viewpoints clearly both orally and in writing, enhances teamwork and cooperation skills, accelerates mastery of course material, and facilitates the development of various types of memory (Aimoldina & Zharkynbekova, 2023).

All the aforementioned tools are employed as technology-based learning tools in the execution of this study. Collaborative learning is a well-known approach that enhances the quality of learning (Ma et al., 2020; Qureshi et al., 2023; Warsah et al., 2021). Collaborative learning technologies encompass various communication tools that enable synchronous and asynchronous text, voice, or video interactions, along with online platforms that support brainstorming, document collaboration, and remote presentations (Winter, 2015). Thus, incorporating learning tools further enriches the quality of learning by fostering dynamic interaction and collaborative engagement among students.

Based on the above-mentioned discussion following hypothesis is developed.

H1*: Technology-based collaborative learning has a positive impact on student engagement*

The Moderating Role of Students' Attitudes Towards Technology

A crucial factor that determines the effectiveness of a technology-based learning environment is the moderating influence of students' attitudes toward technology. Technology-

based collaborative learning allows students to work together to create engaging and interactive learning experiences (Aliyu et al., 2022). However, students' attitudes towards technology may determine how much TBCL improves student engagement.

Teo et al., (2019) stated that students with positive attitudes toward technology embrace digital collaboration, actively participate in group discussions, and engage with learning materials effectively, thereby strengthening the positive impact of TBCL on their engagement. On the contrary, students with negative attitudes towards technology may reject using technology, leading to reduced participation and lower engagement levels. Moreover, research has shown that a positive attitude toward technology significantly contributes to self-efficacy. It suggests that students who perceive technology as a favourable element are more confident in their ability to use digital tools effectively, which enhances their engagement in TBCL environments. Theories of information technology (IT) usage indicate behavioural intention of users as the basic predictor of their IT usage behaviour (Bhattacherjee & Sanford, 2009). Mantello et al. (2023) revealed that students' attitudes towards technology predominantly affect acceptance and usage behaviours of technology-oriented tools and then their outcomes. Based on the findings of the above-mentioned empirical research, the following hypothesis is formulated.

H2: Students' attitudes toward technology moderate the relationship between Technology-based collaborative learning and student engagement.

Figure 1 depicts the conceptual framework, which contains all the variables that would be examined.

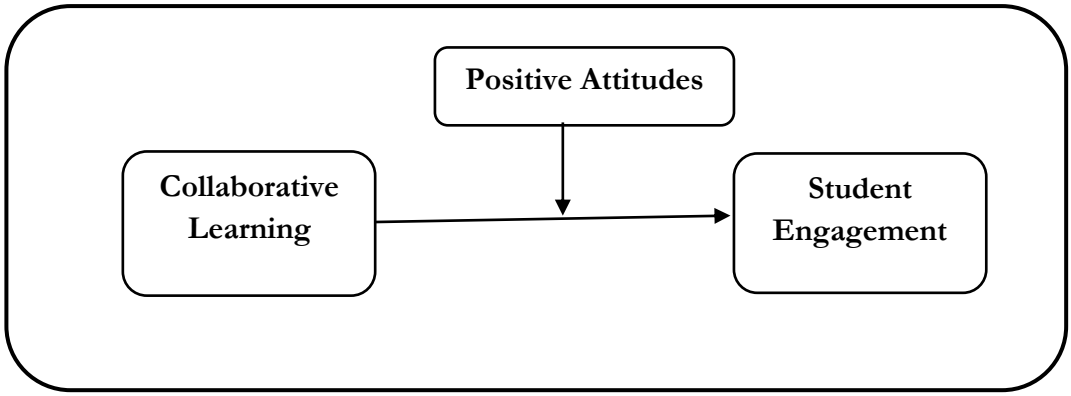

Figure 01. Conceptual framework

Source: Authors' presentation

Methodology

Context

The researchers of this study are the course instructors of the Business Innovation course, which is offered to 230 third-year undergraduates pursuing a Business Administration

degree program at a public university in Sri Lanka. The typical student attendance for lectures ranges from 150 to 170 participants. The Business Innovation course is a 3-credit course designed to introduce and explore innovation management concepts, manage product and service innovation, and build competitiveness through innovation. The students directly engage with the course instructor in a three-hour face-to-face physical classroom session for a week. Based on the experience of the researchers as the course instructors and the feedback received from past students, it was necessary to implement some significant strategies to improve student engagement and satisfaction throughout the course. As a result, it was collectively decided to integrate technology-based teaching and learning tools throughout the teaching and learning process of the course to enhance student engagement. Table 1 illustrates some examples of using collaborative learning technologies throughout the course.

Table 01. Technology-Based Collaborative Learning

Lesson	**Intended Learning Outcome**	**Activity**	**Mode of the activity**	**Used tool**
Fostering creativity in organisations	Identifying the concept of "creativity".	Which words come into your mind when you hear the term "creativity"?	Individual	Mentimeter
	Explaining how creativity can be fostered in business organisations.	Just go through the Web and find 5 real-world business examples of creative initiatives under each of the product, service, process, and business model aspects. Enter your answers by accessing the Padlet.	Paired	Padlet
Sources of innovation	Identifying different sources of innovation	Get into 10-12 member groups and try this quiz on refreshing your knowledge on the different sources of innovation you learned. Only one member of a group should access the interface and the group should answer the quiz collaboratively.	Group	Kahoot
Innovation networks	Explain the different forms of innovation networks.	As a group, you are organising a creative and innovative talent show within the university. Draw your innovation network collaboratively, adding the nodes and connectors.	Group	MindMeister
New product development (NPD)	Identify the reasons for developing new products. Identify	What are the reasons for developing new products? Students need to identify a real-world example of a new	Individual	Slido

	the reasons for the new product failure.	product failure. Explore the causes behind the failure of the new product that has been selected.	

Source: Authors' computation

All technology-based collaborative learning tools utilised in the classroom are readily available online. During the session, the instructor projected a QR code onto the teaching material, allowing students to access the interface. However, Kahoot was restricted to only 10 participants. To address this, students formed groups and collaboratively engaged in the quiz using one group member's mobile phone. Additionally, other tools enabled access for all class participants to complete their tasks. After the activity, students could view all responses on the projected screen, facilitating further discussion led by the instructor based on students' input. At the end of the semester, a standard questionnaire was used to measure the level of technology-based collaborative learning and student engagement. Under ethical considerations, prior to distributing the questionnaire, the researchers clearly communicated the purpose of the study and provided participants with the opportunity to ask questions and clarify any concerns. Furthermore, the researchers took reasonable measures to avoid offering any financial or other inducements to encourage participation. Participants were given the freedom to choose whether to participate in the study and were also allowed to withdraw at any time. The researchers ensured that the data collected would only be used for the purposes of this study, and the confidentiality and privacy of the participants' information would be strictly maintained.

Research Approach

This study is inspired by the positivist paradigm, which embraces the notion of a single reality. Employing a deductive approach, this quantitative research examines the impact of using technology-based learning tools on student engagement in the classroom.

Data Collection

Researchers collected data using a structured questionnaire administered through Google Forms. The questionnaire consisted of multiple-choice questions to collect demographic data. A five-point Likert scale was used in collecting data on item variables. The questionnaire for the present study was developed by the researchers based on pre-tested questionnaires used in previous studies. Student engagement was assessed using five items adopted from Gray and DiLoreto (2016), while student attitudes toward technology were measured using five items developed by Ardies et al. (2015). Collaborative learning was measured through eight items adapted from Ullah and Anwar (2020) and Dewitt et al. (2015). Several of these items were modified to better capture the use of technology-based learning tools. Furthermore, control variables were not included in this study because the sample was relatively homogeneous in demographic and academic characteristics. All participants were from the same program, followed the same course, and were exposed to identical teaching and evaluation environments. Therefore, the potential for confounding effects from demographic or contextual differences was minimal.

As the sampling method simple random sampling technique was utilised, and questionnaires were administered to 130 students who followed the Business Innovation course. One hundred twenty-three (123) students out of a total of 130 students have filled out the questionnaire. As can be seen in Table 2, 123 complete questionnaires were forwarded to the next stage, and the response rate was 94.6%.

Table 2: Summary of Administered and Received Questionnaires

Number of Questionnaires administered	Number of Questionnaires Received	Number of Questionnaires Rejected	Response Rate
130	123	0	94.6%

Source: Survey Data

Data collection took place from April 4th, 2024, to April 11th, 2024, sharing the questionnaire's link through WhatsApp. All questionnaire items were presented in English. The reliability of the questionnaire was confirmed, with Cronbach's Alpha value surpassing 0.7.

Data Analysis Methods

The data analysis was conducted using the Statistical Package for Social Sciences (SPSS) version 24. To ensure the completeness and consistency of the data, a preliminary univariate frequency analysis and boxplot analysis were conducted. In addition, the Paired Samples T-Test was utilised in the present study to detect nonresponse bias errors, and then the data was transformed and edited. After the data cleaning and editing phase, descriptive data analyses were conducted for all the demographic variables. As a prerequisite, normality, linearity, and multicollinearity assumptions were satisfied before proceeding with regression analysis. Then, a three-step hierarchical regression was performed to test the direct effect and the moderating effect. To further enhance comprehension, simple slope analyses were used to demonstrate moderating effects.

Results

This section presents a comprehensive analysis of data from nonresponse bias analysis to test the study's hypothesis. Descriptive analysis, reliability test, testing multivariate assumptions, and regression analysis were conducted to meet the objectives of the research.

Nonresponse bias analysis

To test the nonresponse biases, the Paired Samples T-Test was utilised in the present study. Thirty early responses and thirty late responses have been used for this analysis, and the null and alternative hypotheses of the Paired Samples T-Test are as follows,

H_0 - There is no significant difference between the mean values of the two samples (i.e., early responses and late responses)

H_1 - There is a significant difference between the mean values of the two samples (i.e., early responses and late responses)

As depicted in Table 3, the P-values are greater than the 0.05 significance level, and the researcher can confidently conclude that there is no significant difference between the mean values collaborative learning, attitudes, and student engagement of the early respondents and late respondents. Hence, nonresponse bias error was not detected in the present study.

Table 03. Nonresponse Bias Analysis: Paired Samples T-Test

Variable		Mean	N	Std. Deviation	t-Statistic	Sig. (2-tailed)
Collaborative Learning	Coll_E	4.1000	30	.88717	.042	.967
	Coll_L	4.0917	30	.53128		
Positive Attitudes	Att_E	4.0556	30	.66138	.061	.952
	Att_L	4.0444	30	.54480		
Student Engagement	SE_E	4.3000	30	.75986	.643	.525
	SE_L	4.1778	30	.55179		

Source: Survey Data

Data screening and cleaning

Univariate frequency analysis was conducted in the present study to identify the missing values. As depicted in Table 4 below, no missing values were identified through the initial data screening process. The researchers have taken measures to prevent encountering non-ignorable missing data during data collection. They accomplished this by using the "Required" option in Google Forms, which ensured that respondents could not submit the form without answering all questions.

Table 04. Univariate Frequencies Analysis

Variable	N	
	Valid	Missing
Gender	123	0
Collaboration_1	123	0
Collaboration_2	123	0
Collaboration_3	123	0
Collaboration_4	123	0
Collaboration_5	123	0
Collaboration_6	123	0
Collaboration_7	123	0
Collaboration_8	123	0
Attitudes_1	123	0
Attitudes_2	123	0
Attitudes_3	123	0
Attitudes_4	123	0

Student_Engagement_1	123	0
Student_Engagement_2	123	0
Student_Engagement_3	123	0
Student_Engagement_4	123	0

Source: Survey Data

Since the outliers significantly impact the results of the analyses, the box plot analysis was conducted to identify outliers. As per the results, no common outliers were found, and the researchers were able to proceed with 123 questionnaires to the next stage of the study.

Some variables in the study required scale transformation and re-specification. The variable "Attitudes_1" (I think technological tools are boring) underwent a scale transformation. This variable was originally assessed using a negatively worded 5-point Likert scale question in the questionnaires. To reverse it, the researcher used SPSS version 24 and reordered the scale in reverse sequence (1 to 5, 2 to 4, 3 to 3, 4 to 2, and 5 to 1). This reversed variable was then recorded as "Attitudes_1_R". Furthermore, the researcher utilised the compute variable option in SPSS to calculate the mean value of the independent, dependent, and moderating variables of the study.

{Mean_Student_Engagement = (Student_Engagement_1 + Student_Engagement_2 + Student_Engagement_3 + Student_Engagement_4)/4}.

In the present study, interaction variables were created to assess the impact of moderating variables. Hence, the researcher created mean-centred independent variables and moderator variables before forming the product terms. Then, interaction variables were derived by multiplying the centred variable.

{Interaction_CollaborativeXAttitudes = Centre_Collaborative_Learning *Centre_Attitudes}

Descriptive Data Analysis

As depicted in Table 5, the analysis shows that the majority of the study respondents were female, with a response frequency of 91. Among the respondents, 26.0% of the undergraduates who responded were male, while 74.0% were female.

Table 05: Demographic Characteristics: Gender

	Frequency	**Percent (%**	**Valid Percent (%)**	**Cumulative Percent (%)**
Female	91	74.0	74.0	74.0
Male	32	26.0	26.0	100
Total	123	100	100	

Source: Survey data

In addition, descriptive analysis uncovers students' responses in terms of usage, ease of use, entertainment and fun, idea shareability, and visual appeal of the interface of each tool used in the classroom.

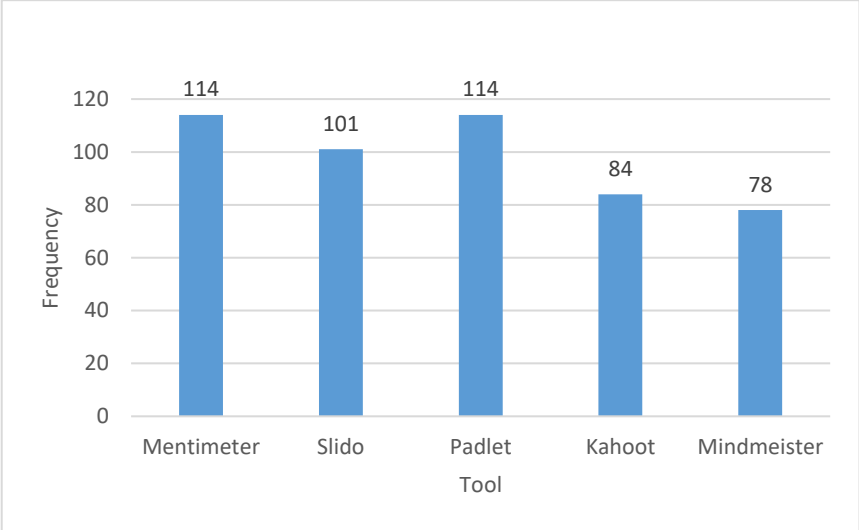

Figure 02: Tools used in Classroom Activities

Source: Survey Data

As depicted in Figure 2, the majority of respondents have used Mentimeter and Padlet Tools in their classroom activities for the Business Innovation course, with a response frequency of 114. According to respondents, the second and third most frequently experienced technology-based collaborative learning tools are Slido and Kahoot, with 101 and 84 uses, respectively. Hence, the graph highlights that Mentimeter and Padlet are the tools that the highest number of students have experienced for classroom activities. In addition, Slido also demonstrates significant usage. Kahoot and MindMeister are the tools that students have the least experience with compared to others.

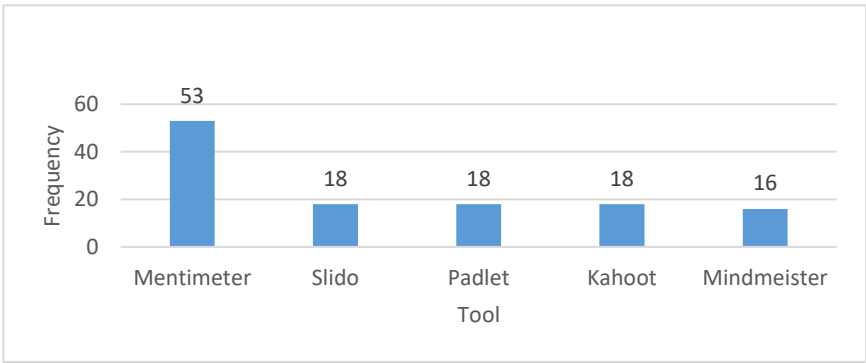

Figure 3: Ranking of technology-based learning tools based on ease of use

Source: Survey Data

As depicted in Figure 3, the respondents found the Mentimeter to be the easiest tool to use compared to the other four tools, with a response frequency of 53. The Slido, Padlet, and Kahoot tools all received an equal response with a frequency of 18, indicating that they are the second-most-easy-to-use tools. However, respondents revealed that MindMeister is more challenging to use compared to the other four tools, as indicated by a frequency of 16.

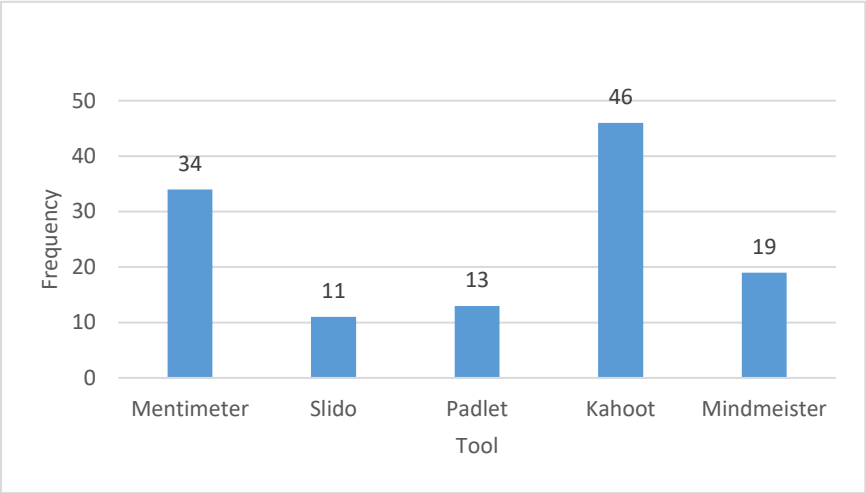

Figure 04: Ranking technology-based learning tools by their ability to provide entertainment and fun for learning activities

Source: Survey Data

As shown in Figure 4, most of the respondents have experienced Kahoot as a tool that provides entertainment and fun for their learning activities, depicting a frequency of 46. Based on responses, Mentimeter is considered the second most entertaining and fun tool, with 34 students' responses. The frequencies of the remaining three tools are notably lower: MindMeister with 19 students, Padlet with 13 students, and Slido with 11 students.

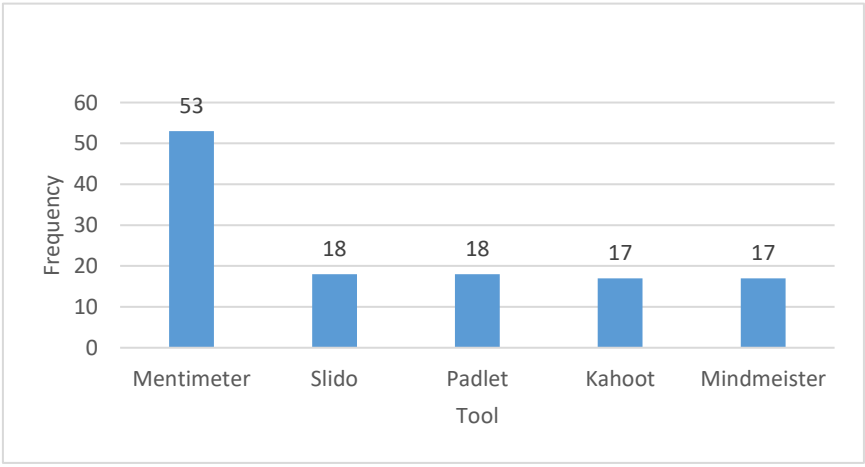

Figure 05: Ranking technology-based learning tools by their ability to facilitate sharing their ideas and thoughts in the classroom

Source: Survey Data

As depicted in Figure 5, Mentimeter has the highest ability to facilitate the sharing of ideas and thoughts in the classroom, with the highest frequency of 53. Slido and Padlet tools received an equal response with a frequency of 18, indicating that they have the second-highest ability to facilitate the sharing of ideas and thoughts. On the other hand, Kahoot and MindMeister both received 17 responses, indicating that they have the least ability to facilitate the sharing of ideas and thoughts compared to others.

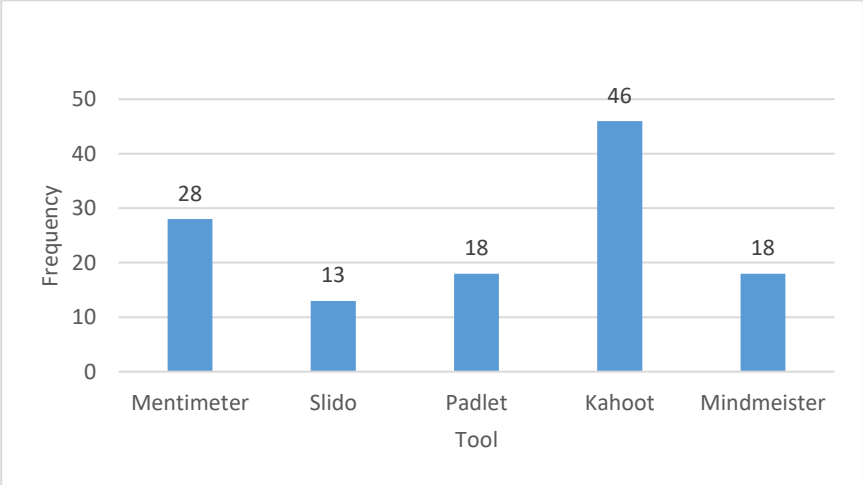

Figure 06: Ranking technology-based learning tools based on the attractiveness of the interface

Source: Survey Data

As illustrated in Figure 6, the majority of participants indicated a strong preference for Kahoot in terms of interface attractiveness, with a response frequency of 46. Based on the responses, it is evident that Mentimeter has the second most appealing interface, with a response frequency of 28. The remaining three tools have significantly lower frequencies, with MindMeister at 18 students, Padlet at 18 students, and Slido at 13 students.

Descriptive Statistics of Variables

The following section outlines the descriptive statistics, including the mean, standard deviation, and variance of the independent, dependent, and moderating variables.

Table 06: Descriptive Statistics of Variables

Variable	Mean	Std. Deviation	Variance
Collaborative learning	4.086	0.7548	0.570
Student engagement	4.037	0.7975	0.636
Student attitudes	3.978	0.7450	0.555

Source: Survey Data

As presented in Table 6, the mean value of the Collaborative Learning variable is 4.086, indicating that students generally agreed that the technological tools used in the classroom supported collaborative learning. The Student Engagement variable recorded a mean value of

4.037, suggesting that students also agreed these technological tools enhanced their classroom engagement. The mean value of the Student Attitudes variable is 3.978, showing that the majority of students held positive attitudes toward the use of technology in their learning process. Furthermore, the relatively low standard deviations for Collaborative Learning (0.7548), Student Engagement (0.7975), and Student Attitudes (0.7450) indicate that the data are closely clustered around their respective mean values. This indicates low variability and a high degree of consistency among all three variables.

Reliability of the Variables

The researchers utilised Cronbach's alpha analysis to assess the reliability of the five-point Likert scale questions used in the present study. According to George and Mallery (2003), a Cronbach's alpha (α) of 0.9 or higher indicates excellent internal consistency, while an alpha (α) value between 0.7 and 0.9 is considered good internal consistency among the items/questions.

Table 7: Reliability Analysis

Cronbach's alpha	Internal consistency
Collaborative Learning	0.884
Positive Attitudes	0.843
Student Engagement	0.799

Source: Survey Data

As indicated in Table 7, Cronbach's alpha scores for all variables exceeded 0.7. This demonstrates that the five-point Likert scale questions used to measure the variables independent, dependent, and moderating variable satisfactorily meet Cronbach's required reliability.

Preliminary statistical analysis

This section presents the results of key assumptions necessary for conducting multiple regression analysis, such as normality, linearity, and multicollinearity.

Testing for skewness and kurtosis values is a popular statistical technique used to assess whether data conforms to a normal distribution. If skewness and kurtosis values fall within the +2 to -2 range, the data is considered normally distributed (Garson, 2012).

Table 08: The Shape of the Data Distribution Based on Skewness and Kurtosis Values

Variables	Minimum	Maximum	Skewness	Kurtosis
Collaborative_Learning_1	1	5	-1.058	1.137
Collaborative_Learning _2	1	5	-.774	.380
Collaborative_Learning _3	1	5	-1.144	1.504
Collaborative_Learning _4	1	5	-1.175	1.232
Collaborative_Learning _5	1	5	-1.341	1.056
Collaborative_Learning _6	1	5	-1.099	1.590

Collaborative_Learning _7	1	5	-1.353	1.655
Collaborative_Learning _8	1	5	-1.129	.987
Positive_Attitudes_1	1	5	-1.033	1.086
Positive_Attitudes_2	1	5	-1.129	1.893
Positive_Attitudes_3	1	5	-.961	1.247
Positive_Attitudes_4	1	5	-1.103	1.870
Student_Engagement_1	1	5	-1.043	1.118
Student_Engagement_2	1	5	-.954	1.048
Student_Engagement_3	1	5	-.988	.862
Student_Engagement_4	1	5	-1.599	1.949

Source: Survey Data

Table 8 indicates that all the skewness values are less than two (-1.599 to -.774), confirming that all the items maintain an acceptable level of skewness. Additionally, the kurtosis values are less than two (.380 to +1.949), confirming that all the items maintain an acceptable level of kurtosis. Hence, the researchers can conclude that data distribution is normal.

In order to test the Linearity, the Mean Procedure Test (MPT) has been employed in the present study. The mean procedure test (ANOVA) for linearity splits down the paired groups into their linear and non-linear components. As a result of that researchers can more easily detect the existence of non-linearity among variable pairs.

Table 09: Mean Procedure Test for Linearity

Variable Pairs	**Condition**	**Sum of Squares**	**F**	**Sig.**
Student Engagement* Collaborative Learning	Combined	19.380	2.791	.002
	Linearity	8.184	15.323	.000
	Deviation from Linearity	11.195	1.747	.067
Student Engagement* Positive Attitudes	Combined	29.716	10.195	.000
	Linearity	26.230	62.993	.000
	Deviation from Linearity	3.486	1.395	.222

Source: Survey Data

As depicted in Table 9, the *f-ratio* value for the linear component is significant (p-value ≤ 0.05) for both two variable Pairs (Student Engagement* Collaboration and Student Engagement* Attitudes), whereas, the *f-ratio* value for the non-linear component is insignificant (p-value ≥ 0.05) for both two variable Pairs. Hence, the researchers can confidently conclude that the data meet the assumption of linearity.

Tolerance and Variance Inflation Factor (VIF) are commonly used statistical methods to evaluate multicollinearity. A VIF value of 1 suggests that there is no multicollinearity present, indicating that the variable is not highly correlated with any of the variables within the model. As

a rule of thumb, if the VIF value for a variable exceeds ten (10), it indicates the presence of a multicollinearity issue. On the other hand, if the tolerance value is closer to one (1), it indicates that there is little multicollinearity associated with that variable. Hence, the tolerance value should be 0.1 or greater, whereas a value less than 0.1 indicates a high level of multicollinearity (Hair et al., 2010).

Table 10: Tolerance and the Variance Inflation Factor

	Collinearity statistics	
	Tolerance	**VIF**
Mean_Collaborative_Learning	.606	1.649
Mean_Positive_Attitudes	.555	1.802

Source: Survey Data

As depicted in Table 10, the tolerance values of the variables are greater than 0.1 and the variance inflation factors (VIF) are also less than 10, indicating no significant issues with high correlations among these variables in the model.

Regression (Hierarchical) Analysis

A three-step hierarchical regression was performed to test the hypothesis of the present study. Collaborative learning was included as predictor in the initial regression model, with Student Engagement as the dependent variable. As shown in Table 11 below, the R-squared (R^2) value of the first model is 0.451. This indicates that collaborative learning explains 45.1% of the variance in student engagement. Also, the inclusion of the moderator variable —positive attitudes into Model 2 added an additional 10.2% variance in predicting student engagement ($\Delta R^2 = 0.102$). Model 3 showed that the addition of the interaction variable collaborative learning interacted with positive attitudes accounted for an additional 1.7% variance in predicting student engagement ($\Delta R^2 = 0.017$).

Table 11: Model Summary

Model	**R**	**R Square**	**Δ R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.672a	.451	.451	.446	.59336
2	.743b	.553	.102	.545	.53780
3	.755c	.570	.017	.559	.52974

Source: Survey Data

Table 12 shows that the significance values of the three models are 0.000 (< 5%), indicating the model fitness.

Table 12: ANOVA[a]

Model		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
1	Regression	34.999	1	34.999	99.407	.000b

	Residual	42.602	121	.352		
	Total	77.601	122			
2	Regression	42.894	2	21.447	74.152	.000c
	Residual	34.707	120	.289		
	Total	77.601	122			
3	Regression	44.206	3	14.735	52.509	.000d
	Residual	33.395	119	.281		
	Total	77.601	122			

Source: Survey Data

The regression coefficient results are presented in Table 13. The predictor variables of the first model demonstrate that they have a significant impact on student engagement, as their significant values are less than 5%. The significant values of predictor variables belonging to Models 2 and 3 both illustrate the same results as they are also less than 5%. Moreover, all three models have t-values for the predictors greater than 2, confirming their statistical significance.

Table 13: Regression Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.038	.054		75.474	.000
	Centre_Collaborative_Learning	.713	.072	.672	9.970	.000
2	(Constant)	4.038	.048		83.271	.000
	Centre_Collaborative_Learning	.488	.078	.459	6.267	.000
	Centre_Positive_Attitudes	.410	.078	.383	5.224	.000
3	(Constant)	4.075	.051		80.266	.000
	Centre_Collaborative_Learning	.453	.078	.427	5.785	.000
	Centre_Positive_Attitudes	.357	.081	.333	4.393	.000
	Interaction_Collaborative_LearningXPositive_Attitudes	.121	.066	.149	2.163	.033

Source: Survey Data

H1: Technology-based collaborative learning has a positive impact on student engagement

H1 evaluates whether collaborative learning has a significant and positive impact on student engagement. The results revealed that collaborative learning has a positive impact on student engagement (ß = 0.453, t = 5.785, p = 0.000). Therefore, the first hypothesis of the study is accepted. This research finding empirically confirms research findings revealed by Cheng et al. (2021), who found that collaborative learning offered by technology-based teaching and learning tools significantly contributes to students' satisfaction and engagement.

Moreover, studies revealed that Padlet and Mentimeter are popular tools used by educators to facilitate collaborative learning in the classroom, including debates, group activities,

and collective problem-solving to generate new ideas (Madiseh et al., 2022; Dewitt et al., 2015). Additionally, students who perceive themselves as adaptable demonstrate a greater willingness to utilise Padlet, appreciating its role as an enabler of collaborative learning platforms (Naamati Schneider & Alt, 2023). Furthermore, MindMeister is an online collaborative mind-mapping tool that enables the creation of intricate networks of concepts, thereby enhancing the depth and complexity of mind maps (Zhou & Schofield, 2024; Kosnow & Pliskin, 2008). The use of digital mind maps in education stimulates the development of students' creative abilities and critical thinking and enhances teamwork and learner involvement (Aimoldina & Zharkynbekova, 2023).

H2: Students' attitudes toward technology moderate the relationship between Technology-based collaborative learning and student engagement

H2 evaluates whether positive attitudes toward technology moderate the relationship between collaboration and student engagement. The results revealed that the main effect—collaboration positively impacts student engagement was statistically significant (ß = 0.453, t = 5.785, p = 0.000). On the other hand, positive attitudes toward technology served as a positive predictor (β = 0.357, t = 4.393, p = 0.000), as well as an interaction variable (Interaction_CollaborationXAttitudes), revealing a significant positive impact (β = 0.121, t = 2.163, p = 0.033). Since the direct effect, the moderation effect, and the interaction effect were positively significant, researchers can conclude that positive attitudes toward technology significantly and positively moderate the relationship between collaboration and student engagement. Therefore, the second hypothesis of the study is accepted.

This fact is also emphasized in the research study conducted by Baanqud et al. (2020), which found that positive attitudes toward technology enable better knowledge sharing and critical thinking, both of which are essential for effective collaborative learning and student engagement. Furthermore, studies indicate that students' positive attitudes toward technology significantly influence their use of technology-based educational tools. Therefore, positive attitudes toward technology lead to greater interaction with these tools, enhancing both learning experiences and outcomes (Schindler et al., 2017).

Moreover, previous literature has indicated that students' positive attitudes towards technology are essential and serve as a crucial prerequisite for adopting technology-based tools (Abdullah & Ward, 2016; Scherer et al., 2019). Furthermore, a positive attitude towards technology fosters related factors such as perceived enjoyment, which enhances the willingness to explore new technologies (Priyatno et al., 2024). Therefore, students with positive attitudes are more eager and interested in trying new technology-based collaborative learning tools. This fosters greater student engagement by making classroom learning more enjoyable and interactive (Bond & Bedenlier, 2019; Priyatno et al., 2024). Additionally, other studies confirm that students who view technology as a beneficial resource are more confident in their ability to use digital tools effectively, which further enhances their engagement in technology-based collaborative learning environments (Mantello et al., 2023).

On the contrary, students who have negative attitudes towards new technologies may choose to reject Technology-Based Collaborative Learning tools (Liaw & Huang, 2011). As a result, they are less likely to engage with tools such as Padlet, Kahoot, Slido, and Mentimeter,

regardless of the collaborative activity designed by teachers. Their attitude serves as a direct barrier to engagement (Dianati et al., 2020).

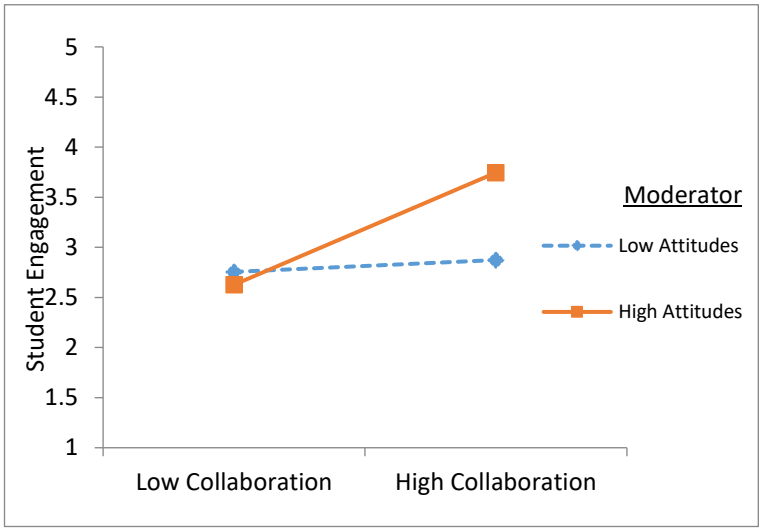

Figure 07. Moderating Effect of Positive Attitudes on Collaborative Learning and Student Engagement

Source: Survey Data

The results of the simple slope analysis are visually represented in Figure 7 below to enhance comprehension further. As can be seen in Figure 7, the line is much steeper for a higher level of positive attitudes, this shows that at a higher level of positive attitudes, the impact of collaborative learning on student engagement is much stronger in comparison to a lower level of positive attitudes. Hence, as shown in the figure below, as the level of positive attitudes increased, the strength of the relationship between collaborative learning and student engagement increased.

Figure *7: Positive attitudes toward technology strengthen the relationship between collaborative learning and student engagement.*

Conclusion and Recommendations

This research examined the impact of technology-based collaborative learning on student engagement. Furthermore, it investigated whether these relationships differ based on students' positive attitudes toward technology. The findings exerted strong support for all hypotheses. The results are aligned with previous research that highlights the benefits of these approaches to learning by fostering active participation and collaborative learning. Further, students' attitude towards technology-based learning was the main variable that moderated the relationship between technology-based collaborative learning with student engagement. The findings indicated that positive attitudes towards technology-based learning strengthen this relationship. It reflects that students with more positive attitudes toward technology were more likely to gain benefits from collaborative learning activities facilitated by educational technology tools. The results underline the significance of incorporating technology-based collaborative teaching and learning activities within classrooms. Based on the findings it can be concluded that by fostering a

positive attitude towards technology-based learning and including engaging tools, academics can create a more meaningful and enriching learning environment that encourages student participation and academic performance.

As a novel contribution, this study unveils how student attitudes toward technology interact with learning and teaching tools to influence engagement. The findings proved that their attitudes could influence how effectively they use these tools to learn actively and collaborate with others. Furthermore, it enriches the field of educational technology by investigating the combined impact of multiple technology-based collaborative learning tools such as Mind Meister, Mentimeter, Slido, Padlet, and Kahoot on student engagement. Even though previous research has focused on the effectiveness of these tools, this study provides a more comprehensive understanding of how a combination of these tools can change student engagement.

The findings inform academics in higher educational institutions about the effectiveness of various technology-based collaborative learning tools to enhance students' engagement within the classroom. Higher Educational institutions can invest in collaborative learning tools and training programs to ensure that academics have the necessary knowledge and skills to utilise technology-based collaborative learning tools effectively. The results reflect the significance of incorporating technology into teaching methodologies. As per the findings of the descriptive analysis, which highlighted that the ease of use of these collaborative tools varies among them. Therefore, when adopting technology-based collaborative learning tools, academics must consider their ease of use from the students' perspective to achieve greater effectiveness. Additionally, descriptive analysis revealed that the ability to provide entertainment and fun in learning activities significantly differs among collaborative learning tools. Thus, it is essential to seriously consider reducing monotony and dullness in the classroom learning process to enhance student engagement. Utilisation of educational technologies unlocks valuable opportunities to equip undergraduates with necessary technology-based competencies while activating socially constructed and active learning critical for their professional and academic goals.

Limitations and Areas for Future Research

However, this research is also not free from limitations. It was conducted with a relatively small sample from a selected university in a single course. Further, the study relied on self-reported data collected from undergraduates, which can be subject to bias. The present study did not incorporate control variables such as age or gender of the students, which limits the scope of the research. Finally, since the study examined the impact of these tools on student engagement in a single course, this impact may differ in other courses based on their nature.

There are several gaps in knowledge in research around educational technology and student engagement that follow from the findings of this study and would benefit from future research. First, an in-depth exploration of how technology-based collaborative learning tools influence outcomes such as academic performance, critical thinking, and deep understanding would be important. It would also be supportive to capture the long-term effect of utilising these collaborative learning tools on students' learning outcomes. Further researchers can examine whether the findings of this study are consistent when tested with a larger sample. Finally,

conducting more research is required to replicate this study in different courses, in different institutions, with a larger and more diverse sample of students.

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