Tablet and Apps Impacts on Students' Learning Performance: A Digital Literacy and Student Engagement Mediation Analysis

Azhan Rashid Senawi*, Shariff Harun

Circular Economy of Logistics & Operation (CELO) RIG Department of Economics and Financial Studies, Faculty of Business and Management, Universiti Teknologi MARA, Malaysia

DOI: https://dx.doi.org/10.47772/IJRISS.2025.91100054

Received: 10 November 2025; Accepted: 20 November 2025; Published: 28 November 2025

ABSTRACT

The advancement of tablets and applications in education is crucial, particularly regarding the impact of mobile smart devices on performance in tertiary-level economics. This tertiary-level course examines mobile smart devices and applications via the perspectives of digital literacy and student involvement. The study employed structural equation modeling as its digital methodology, analyzing the model's validators for scope and relevance based on established standards of beta coefficients, t-values, p-values, and R-squared (R^2) in relation to the responses of two hundred and fifty undergraduates. The investigation indicated that tablets and mobile applications significantly enhanced digital literacy, engagement, and student performance. Of the three, digital literacy emerged as the most significant mediator. The study demonstrated a robust R^2 of 0.789 related to student performance. Therefore, enhancing performance by fostering participation and digital literacy is a crucial finding that education authorities, including the ministry, universities, and schools, should address by incorporating technology into the curriculum to improve digital literacy. Specifically, rural participation in the improvement of digital engagement instruments. Future research should incorporate longitudinal and cross-cultural studies to enhance and expand these findings.

Keywords: Tablets and apps, student engagement, digital literacy, student performance, education

INTRODUCTION

For educators and students, using technology makes learning better. It makes learning better in school situations. The way students do in school makes us wonder if technology is really helpful or if students are just making things harder for future school systems.

Tablets and Apps in Education

Since the dawn of technology, Apple Inc. has been an industry leader, particularly when it comes to transforming technology pertaining to smartphones or tablets. Apple has merged the use of technology in schools for educational purpose in an innovative way for the benefit of both teachers and learners. Apple has introduced teaching aids that are innovative and connect learners to different parts of the world, and even provide 3D Augmented Reality (Algoufi, 2016; Xie et al., 2018) for lessons in history. In addition, Xie et al. (2018) stated that tablets have considerable espousal in the growth of learners in a so-called student center learning framework. Therefore, the use of technology has been integrated in the educational pedagogical framework to provide an even greater tools the proposed holistic education paradigm of student-centered teaching.

Effect on teaching and learning

Little research has tried to understand the impact of tablets and applications on teaching and learning economics. Scott (2011) recognized the potential of mobile devices to enrich their teaching. On the other hand, Wakefield et al. (2018) suggested that while tablets would greatly improve student interest and motivation, they could also distract students from face-to-face interactions and negatively impact their performance in the theory and critical thinking.

As stated in the meta-analysis, certain touchscreen devices have the potential to aid the learning processes of young children, although effectiveness hinges on the particular age of the child and their developmental capacity. This outcome differs, however, in the case of tertiary education, where it seems that mobile devices notably contributed to learning support in classroom activities (Xie et al., 2018).

Meriem (2024) refers to the integration of tablets and apps as complex and multifaceted. Despite the potential of tablets and apps to drive cost efficiency while increasing student interest and motivation, the affordances of the integrated technologies must be addressed first. Butcher (2016) reported that tablets and apps encourage educational institutions to greater independence while fostering more purposeful learning on the part of students. Still, as the report points out, there are learning enhancements that are obstructed, including institutional barriers and individual disengagement.

Some may consider this issue beneath academic scrutiny. Few rigorous studies have assessed the impact on student performance when mobile phones are used as learning aids. In the words of Haßler et al. (2015), the educational activities pertaining to these mobile learning aids are still rather elusive in gauging their success to learning.

More recently, however, some studies have investigated the role of digital literacy and the incorporation of technology into learning as influencing factors for student engagement and performance. For example, Smith (2017) attests that digital literacy is a motivating factor for active engagement and proficient performance in academic activities. Moreover, Johnson & Renner (2012) stated that learning activities that make use of interactive apps and tablet-based learning not only facilitate the students' comprehension of the topical content but also enhance their motivation. Still, the exact link to learning tablets as a specific resource to achieve better learning outcomes is unclear. It is possible that the students' performance may improve from the use technology along with efforts to develop digital literacy.

The application of tablets in economics education for practical purposes

With a focus on practical relevance, this study focused on the use of tablets and educational applications in the study of economics at the university level. Students employed tablets in a range of learning activities that helped them master additional economic concepts while enhancing their analytical skills.

In the microeconomics classes, the students used the Khan Academy and Coursera apps to obtain microeconomics lecture series, including video and interactive tutorials on supply and demand, elasticity, and market structures. Students are able to deepen their understanding of the concepts through the visual and real-time economic simulation. For instance, students are able to adjust the price level and instantly see the demand curve shift to visualize the concept.

In the study of macroeconomics, students used the Trading Economics and World Bank Data apps for tablets to obtain real-time economic data for analysis. These applications helped students to analyze the current economic indicators such as GDP and inflation, and unemployment figures, and to apply the theory in real economics. Students developed digital portfolios that documented their analysis of economic trends, and they shared them with other students using cloud collaboration tools.

Digital reading tasks, economic reading, making notes, active reading, and interaction with academic texts are all made. To help them learn better, they should keep track of and share information about study groups, shared tools, and active reading.

Market games and policy economics simulations were also used in studying economics. They took part in games in which they were free to make economic decisions and trade in a virtual environment, then, see their decisions and actions play out in a virtual market. Gamified, task-oriented, and interactive curriculum played a major role in motivation past theoretical reinforcement. Students say the simulations were interactive predecessors to lectures on complex theory.

Therefore, the present study investigates students' performance on the economics subject that relied on printed books and lectures. How do tablets and apps influence written and electronic materials, and subjected economics content?

LITERATURE REVIEW

Tablets and Apps in the Learning Process

The use tablets and applications in education has been revolutionary. It offers new ways to capture students' interests and enhance academic achievements. Haßler et al. (2019) wrote a critical review of the evidence of learning outcomes associated with the use tablets in education. They concluded that tablets can accomplish numerous learning tasks. However, the fractured nature of the available literature, and the absence of substantive studies, makes it impossible to arrive at any firm conclusions. The review called for better systematic and comprehensive studies to expand the existing body of work.

Mulet et al.(2019) analyzed students' views of tablet use in primary and secondary education and found that students generally have positive views with some caveats. The study underscored the importance of understanding students' views for promoting the adoption and effective use of tablets in teaching. The review affirmed the synergistic nature of quantitative and qualitative approaches in documenting the impact of tablets on learning.

Tablets and applications in education have reported constructive results pertaining to student performance. An example is Limniou's (2021) study which noted the positive effects of digital devices, tablets included, on academic performance, as devices helped students access multiple educational resources and learning opportunities. Nevertheless, Limniou (2021) also noted that students who use devices for excessive multitasking may become distracted, and that will negatively affect performance as well.

Student Engagement

Student engagement is one of the multifaceted phenomena that is important for educational outcomes. A Systematic review on higher education student engagement highlighted the use of Learning Analytics (LA) for the measurement of engagement. The review explained how LA is mostly powered by the behavioral traces of engagement in the form of clicks and time spent on tasks (Bergdahl et al., 2024). The research proposed the use of multiple streams of data alongside targeted strategies that could be implemented to bolster engagement.

Deshmukh et al. (2024) focused on the use of deep learning techniques to assess student engagement through the lens of observable behaviors and emotions within the classroom. The review provided a comprehensive synthesis of the deep learning techniques and highlighted the importance of having a well-rounded understanding of the different dimensions of engagement. The study also focused on the influence of technology on student engagement in classrooms.

As you stated student engagement greatly affects how well a student does academically. Higher levels of student engagement driven by digital technology leads to better results. The study recommends personalized learning analytics to measure and to help optimize student engagement (Bergdahl et al., 2024).

Digital Literacy

Digital Literacy is a stepping stone to thriving in our educational system and our study focused on digital literacy outlined four key areas: digital literacy, digital competencies, digital skills, and digital thinking. The study pointed out growing importance of digital literacy and the need to build new digital literacy frameworks. The review focused on the need to address digital inequalities and the impact digital literacy on opportunities in life (Tinmaz et al., 2022).

Ilomäki et al. (2023) reviewed the school education context and frameworks on critical digital literacies and the school education context to identify key issues and components. The review focused on the importance of digital

literacy as a tool for citizenship and participation, as well as online learning. The study underscored the need to continuously adjust digital literacy frameworks to meet the needs of digital and technological advancement.

Research suggests students' achievements are more likely to improve when digital tools are used purposefully and when students' digital literacy skills are high (Ilomäki et al., 2023). Thus, having a comprehensive digital literacy framework within schools helps to improve student outcomes.

Research has been able to document the impact of technology on student outcomes. Zhang & Tur (2024) conducted a systematic review to understand the impact of schools and teachers on student academic outcomes using multilevel models. They noted a school and teacher impact on student outcomes to varying degrees and recommended comprehensive data collection and advanced statistical methods. They also contextualized the educational policies and practices surrounding diverse factors outside of the school on student outcomes, emphasizing the need to consider and adapt educational policies and practices to fit the various factors surrounding student performance.

A student performance prediction model based on machine learning was reviewed by Albreiki et al (2021). Their study highlights how predictive analytics enhances student performance and identification of students that are at-risk.

The review emphasized the importance of utilizing varying datasets and advanced techniques to enhance the precision of predicting performance. The use of tablets and applications positively impacts the level of student engagement, digital literacy, and academic achievement. Educational technology results in better learning outcomes, with student engagement and digital literacy as key intermediary variables.

Digital Literacy as a Mediator

In relation to Wu & Yuan (2023), the impact of digital literacy on college students' academic performance in a blended learning environment focuses on the mediating role of learning adaptability. Results show that digital literacy positively affects learning achievement and that learning adaptability partially mediates this relationship. This means that increased digital literacy leads to improved student learning achievement as they adapt more easily to blended learning environments. Zhao (2024) stated that students' information literacy positively affects their engagement in online learning and that students' self-efficacy in the use digital tools mediates this relationship. The research also stated that psychological resilience impacts the mediating role as a moderator, meaning students with more psychological resilience obtain greater benefits from information literacy.

Furthermore, Ilomäki et al. (2023) describes the important features of digital literacy within educational contexts, describing its role in fostering engagement, digital citizenship, and online education. The research also showed that students with higher digital literacy are better more able to use digital tools leading to improved academic performance. The study also stressed the need for continuous revisions of digital literacy frameworks in the study to ensure they meet the pace of technological advancement.

Student Engagement as a Mediator

Within the framework of student engagement as a mediator, Bergdahl et al. (2024) carried out a systematic examination of student participation in higher education, mainly using Learning Analytics (LA) as a method to gauge engagement. Distance technology at times engagement facilitated varying levels of academic achievement. The analysis noted the potential of personalized learning analytics in measuring and subsequently adjusting student engagement levels, situating engagement as the mediator in the interplay of technology and academic success.

In contrast, Deshmukh et al. (2024) utilized deep learning strategies to assess student participation through observable behaviors and emotions in classroom settings. The research recognized deep learning's capacity to transform engagement assessment, and more importantly, to demonstrate that engagement, empowered by skillful use of digital tools, significantly affects a learner's academic success. The need to unlock the different

dimensions of engagement and the role of technology to enhance student participation was also emphasized in the study.

As demonstrated in other research by Fredricks et al. (2016), providing clarity in understanding how students'engagement works and how it consists of the behavioral, emotional, and cognitive aspects, was accomplished. The research found that engagement significantly mediates the relationship between teaching and students' outcomes. The study found that the technology-enhanced and interactive and active learning environments, in which students learned, resulted in improved academic outcomes, when it came to fostering engagement.

Combine the influence of the two, he digital literacy and students' engagement.

In the realm of hybrid teaching and learning, Limniou (2021) studied the combined effect of digital literacy and student engagement on students' academic achievement. The research stated that students with higher levels of digital literacy are more likely to engage with learning materials and tools, which in turn, leads to higher academic achievement. The study reaffirmed the positive impact on student's academic outcomes when digital literacy and engagement strategies are integrated.

In predictive student achievement models, highlighted digital engagement and literacy as critical predictors. Students who have highly developed digital engagement and literacy are more likely to achieved better academic outcomes driven by predictive models. The review called for the the use of predictive modele to spot students who are likely to struggle, monitor that students, and strbe interventions aimed at improving students academic outcomes.

RESEARCH METHOD

Data

In this study I used a deductive approach to form testable hypotheses based on a documented source. I examine students using tablet computers and tablet applications. The data collection took three months, from December to February 2024, and used an online questionnaire on the Google Form application. The questions were specifically designed with our targeted audience in mind. The limited information on students' performance using tablets and applications led to the use of non-probability sampling. The respondents were later acquired through convenience sampling.

Figure 1 depicts the research framework in its entirety.

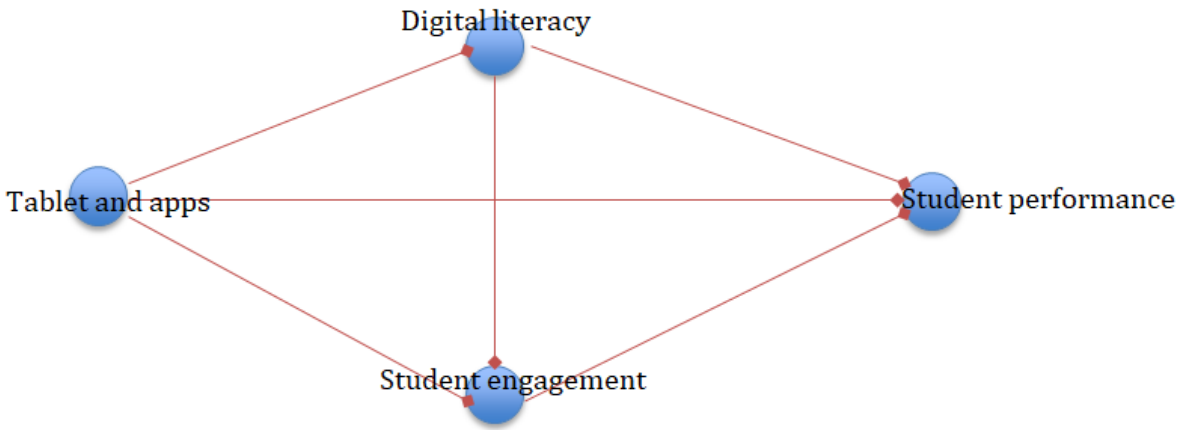

Figure 1: Conceptual Framework

Instrument Description and Development

The primary research instrument was a self-administered questionnaire consisting of four primary study variables, Tablets and Apps Usage (TA), Digital Literacy (DL), Student Engagement (SE), and Student

Performance (SP), with each of the variables consisting of several items derived from previous studies and the scaling used were modified from the original to the validated ones, which were used in previous studies. There were seven (7) items to the Likert scale; thus, the instrument was test on a seven-point scale from (1) (strongly disagree) to (7) (strongly agree).

For the TA variable, the items already were of Crompton and Burke (2018) and Hirshberg et al. (2022) with a focus on the frequency of use, perceived usefulness, and incorporation of use into learning activities. While the DL dimensions adapted from Hinze et al. (2023) and Gikas and Grant (2013) were focused on the ability of students to master the use of technology, the ability to evaluate the information obtained from the internet, the ability to use technology for learning, and the students' digital skills to use learning platforms. SE was focused on the behavioral, emotional and cognitive the variables of which were adapted from Kaware and Sain (2015), G. Zhang et al. (2025). Finally, self-reported academic achievement, quality of assignments, and learning outcomes were the variables of SP adapted from Al-Maroof et al. (2022) and Wilson et al. (2022).

Thirty economics students who were not part of the main research subject sample were involved in piloting the questionnaire. Feedback provided by these students indicated additional adjustments to wording. These adjustments improved clarity and the cultural nuances of the Malaysian tertiary education context for which the questionnaire was designed. The final exported instrument was comprised of 12 items across the 4 constructs, with 3 items per construct, thus allowing for parsimony and sufficient coverage of each construct.

Validity And Reliability Procedures

Different approaches were applied to help ensure that our measurement instrument was valid and reliable. As an initial step, content validity was automatic through an expert review, during which three faculty members specializing in educational technology and economics education were asked to evaluate whether each item's evaluation was relevant and representative. Their response affirmed that each item was representative of the constructs that were supposed to be measured.

In terms of the evaluation of construct validity, that was done through convergent validity and discriminant validity tests, which were measured using the measurement model of PLS-SEM. Convergent validity was achieved through factor loadings that were mostly greater than or equal to 0.981 and Average Variance Extracted (AVE) using Hairs (2017) threshold, which were within 0.966 to 0.972, which is way above 0.50. It can be concluded that there is convergence validity since the items within each construct were shown to expound upon a greater proportion of variance of what all of them were supposed to measure.

In assessing discriminant validity, we used two criteria, which were the Fornell-Larcker criterion and the Heterotrait-Monotrait (HTMT) ratio. The square root of each construct AVE was greater than its correlations with other constructs, which satisfied the Fornell-Larcker criterion. Furthermore, all HTMT ratios were less than 0.90 in that the constructs are all sufficiently different from each other and therefore measure different aspects of the phenomenon that is being studied.

To assess internal consistency reliability, we used a triad of measures, specifically Cronbach's Alpha, Composite Reliability (CR) and rho_A. More than 0.98 in all instances of Cronbach's Alpha, 0.99 and above in the case of Composite Reliability, and rho_A equaled the value of Cronbach's Alpha across the constructs. These values significantly surpass the required level of 0.70 and attest to the fact that the items comprising each of the constructs are measuring the same attributes and are thus highly intercorrelated (Dijkstra and Henseler, 2015).

To lessen potential common method bias, which can occur in circumstances where constructs data is collected in a single setting at a single point in time, we applied a number of procedural mitigations. First, we assured the participants of their anonymity and that there are no right or wrong answers. In the second instance, we randomized the items in the questionnaire to mitigate systematic response patterns. Finally, we conducted Harman's single factor test (Kock, 2021) which concluded there is no single factor that explains the majority of variance, hence, common method bias is of little concern in this research.

Ethical Considerations

In conducting this research, we have taken great care to ensure the rights of participants were respected and that the challenge of balancing the rights of participants against research integrity is addressed. Prior to starting the online questionnaire, participants were provided with an information sheet that detailed the purpose of the research, the process the participants would go through, and the participants' rights. All data were collected anonymously and treated with strict confidentiality. Information was stored securely and used only for research purposes.

Measurement item

Each item's data came from previous research. For the constructs of the three variables—knowledge, awareness, and financial literacy—an assessment consisting of three items each was adopted from the studies of Crompton & Burke (2018), Hirshberg et al. (2022), Hinze et al. (2023), Gikas & Grant (2013), Kaware & Sain (2015), G. Zhang et al. (2025), Al-Maroof et al. (2022), Wilson et al. (2022), Chen & Wong (2015), Gilboy et al. (2015), and Vaughan & Garrison (2005). The specific items used to assess each variable are provided in Table 1.

Table 1 Proposed measurement items

Construct	Item	Source
Tablet and apps	TA2: Using tablets and applications has improved my access to educational resources and materials. TA3: Tablets and applications have provided me with personalized and adaptive learning experiences. TA4: Integrating tablets and applications has transformed how I learn economics. TA5: Tablets and applications have made reviewing and revising course materials easier. TA6: I use tablets and applications to take notes during lectures. TA7: Tablets and applications have helped me stay organized with my coursework. TA8: I rely on tablets and applications for collaborative learning activities.	Crompton & Burke (2018) Hirshberg et al. (2022) Hinze et al. (2023) Gikas & Grant (2013) Kaware & Sain (2015)
Digital literacy	DL1: I am confident in using tablets and applications effectively for educational purposes. DL2: I have the necessary skills to navigate and utilize the features of tablets and educational applications. DL3: I can easily troubleshoot and resolve any technical issues that arise when using tablets and applications. DL4: I am able to critically evaluate the reliability and credibility of information accessed through tablets and applications. DL5: I am proficient in using various educational apps to enhance my learning.	G. Zhang et al. (2025) Al-Maroof et al. (2022) Wilson et al. (2022)

	DL6: I can effectively manage digital files and resources for my coursework. DL7: I am comfortable using online collaboration tools for group projects. DL8: I can adapt to new technologies and applications quickly.	
Student engagement	SE1: I am more attentive and focused during economics lectures and discussions when using tablets and applications. SE2: The use of tablets and applications has increased my participation and involvement in class activities. SE3: I am more motivated to learn and explore economic concepts through the use of tablets and applications. SE4: The interactive features of tablets and applications have enhanced my overall engagement with the course material. SE5: I actively participate in online discussions and forums related to my economics course. SE6: I use tablets and applications to ask questions and seek clarification during lectures. SE7: I feel more connected to my peers and instructors through the use of tablets and applications. SE8: Tablets and applications have made learning economics more enjoyable and rewarding.	Gikas & Grant (2013) Crompton & Burke (2018)
Student performance	SP1: My overall academic performance on the economics course has improved. SP2: I have achieved better grades and test scores since using tablets and applications. SP3: I have a better understanding of economic concepts and theories. SP4: I am able to apply economic principles more effectively in problem-solving scenarios. SP5: My learning outcomes in the economics course have been enhanced. SP6: I feel more confident in my ability to succeed academically in economics. SP7: My ability to complete assignments on time has improved. SP8: I am better at collaborating with peers on group projects in economics.	Chen & Wong (2015) Gilboy et al. (2015) Vaughan & Garrison (2005)

This study assesses the research model in two consecutive phases: (1) evaluating the measurement model and (2) assessing the structural model (Astrachan et al., 2014). For measurement and structural models, empirical work requires the upmost validation to align with the study's purpose of predicting key target constructs or identifying vital "driver" constructs. Hence, we employ the Partial Least Squares Structural Equation Modelling

(PLS-SEM) approach as recommended by Hair et al. (2011). This technique allows for the examination of the relationships created by the variables.

Data Analysis and Findings

Table 2: Demography Analysis

Demographic criteria	**Frequency (n) = 250**	**%**
Gender		
Male	135	54
Female	115	46
Year distribution		
Year 1	78	31
Year 2	54	22
Year 3	58	23
Year 4	60	24
Field Distribution		
Economics	88	35
Business	85	34
Finance	77	31

The demographic breakdown of our sample of 250 individuals shows consistency and equilibrium across several dimensions. 135 individuals were identified as male and 115 as female, correlating to 54% and 46% of our total sample. This balance suggests consistency for both genders and reinforces the idea that the data collected should be relevant to both populations equally, as it is unlikely to be biased toward one gender.

The breakdown of participants by academic year shows that the sample includes students from different years. First year students comprise 31% (n=78) of the sample, second year students comprise 22% (n=54), third year students account for 23% (n=58), and finally, 24% (n=60) are fourth year students. This balance suggests that the survey has captured the distance learning experience of students across various levels of their education.

According to analyses of the fields students study, sample participants were more or less evenly spread across the three major fields under study. Economics students made up 35 percent (n=88) of the sample, Business students were 34 percent (n=85), and Finance students were 31 percent (n=77). This even distribution across the fields ensures that the findings of the study are relevant to all areas of the business and economics territory.

Regarding the sample demographics, there was a complete and varied distribution, which enhances the reliability and generalisability of the study's findings. The balanced distribution of the sample across gender and academic years, and fields of study, was a strong grounds to study the impact of a wide range of variables on student performance and participation.

Table 1: Internal Consistency Reliability

	Item	**Loading**	**Cronbach'sAlpha**	**rho_A**	**CR**	**AVE**
Student_Performance	SP1	0.986	0.989	0.989	0.993	0.966

	SP2	0.981				
	SP3	0.983				
	SP4	0.983				
Tablets_Apps	TA1	0.983	0.989	0.989	0.993	0.966
	TA2	0.982				
	TA3	0.983				
	TA4	0.986				
Digital Literacy	DL1	0.987	0.987	0.987	0.998	0.972
	DL2	0.987				
	DL3	0.987				
	DL4	0.987				
Student Engagement	SE1	0.985	0.985	0.985	0.995	0.970
	SE2	0.985				
	SE3	0.985				
	SE4	0.985				

Table 3 shows evidence supporting the reliability study conducted on the Student Performance, Tablets and Apps, Digital Literacy, and Student Engagement constructs which reveals excellent internal consistency and construct validity. Each construct shows high factor loadings in the range of 0.981 to 0.987 which indicates a strong relationship of the items with their constructions. (Dijkstra & Henseler, 2015; Jung & Park, 2018; Malkewitz et al., 2023). Additionally, the scored Cronbach's Alphas, all exceeding 0.98, redound evidence of strong internal consistency of the units that make up of each construct. Moreover, the consistency of the rho_A values with that of the Coranbach's Alpha, provides further test of the constructs' reliability. The Composite Reliability (CR) values of greater than 0.99 show that the structures were evaluated with outstanding precision. Moreover, the results of the Average Variance Extracted (AVE) values of 0.966 to 0.972 indicates the constructs explanation a greater portion of variance in the items, which strongly convergent validity. The study results provide evidence that the measurement model is sound and reliable, and this will be a solid basis for further study and analysis.

Table 4: Discriminant Validity and Heterotrait-Monotrait Ratio (HTMT Ratio) (Fornell & Larcker, 2016)

Variables	Digital Literacy	Student Engagement	Student Performance	Tablets & Apps
Digital Literacy	0.986	0.876	0.865	0.873
Student Engagement	0.876	0.984	0.869	0.878
Student Performance	0.865	0.869	0.983	0.866
Tablets and Apps	0.873	0.878	0.866	0.984

Table 4 investigates the discriminant validity and HTMT ratio for Digital Literacy, Student Engagement, Student Performance, and Tablets and Apps, shows impressive outcomes. In the correlation matrix, the diagonal

elements, representing the average variance extracted (AVE) square root, exceed the off-diagonal ones. This shows discriminant validity. In addition, the Heterotrait-Monotrait (HTMT) ratios for the constructs are all below the 0.90 threshold, which means that there are no multicollinearity concerns. This means that the conceptions are separate and also close enough that strong inter-correlations. These would compromise the measurement model's validity. This attests the constructs reliability and validity which will be used in further research and analysis.

Table 5: Structural Path Analysis

Relationship	Std Beta	Std Error	T-Value	P-Value	Decision	R^2
TA -> SP	0.325	0.041	7.927	0.0	Supported	0.789
TA -> DL	0.873	0.018	47.944	0.0	Supported	0.762
TA -> SE	0.494	0.039	12.667	0.0	Supported	0.747
DL -> SP	0.284	0.043	6.605	0.0	Supported	
DL -> SE	0.427	0.039	10.949	0.0	Supported	
SE -> SP	0.356	0.042	8.476	0.0	Supported	

Evaluating the structural model, J. F. J. Hair et al. (2017) suggests looking at R2, beta, and t-values, where the t-values were calculated using the bootstrapping procedure of 1000 resamples.

Table 5 provides the results of the structural path analysis, which indicates the existence of several significant relationships among the constructs, which are Tablets and Apps (TA), Digital Literacy (DL), Student Engagement (SE), and Student Performance (SP). Everyone of these relationships is significant and p- valued at 0.000 and t- valued at over 1.96, which supports the proposed paths considerably. The connection from Tablets and Apps to Digital Literacy (TA → DL), has the greatest beta coefficient (0.873), demonstrating Tablets and Apps considerably impacts Digital Literacy The R^2 values also speak strong explanatory power for Student Performance (0.789) Digital Literacy (0.762), and Student Engagement (0.747). Tablets and Apps are pivotal in enhancing digital literacy which positively affects student engagement and performance. The analysis demonstrates the magnitude of these constructs, and how they work in synergy to enhance educational outcomes.

Table 6: Mediation Analysis

Relationship	Std Beta	T-Value	P-Value	Significance
TA -> DL -> SP	0.248	6.432	0.0	Significant
TA -> SE -> SP	0.176	7.183	0.0	Significant
TA -> DL -> SE -> SP	0.133	7.799	0.0	Significant

Table 6 of the mediation study displays all mediation paths, even Tablets and Apps (TA) -> Digital Literacy (DL) -> Student Performance (SP), as being statistically significant, with p value 0.000 and t value 1.96. This indicates the indirect effects hold real significance and are not merely a product of chance. The pathway with the highest significant mediation effect is TA -> DL -> SP, with a standardized beta value of 0.248. This research highlights Digital Literacy as a vital mediatory influence within the constellation of Tablets and Apps and Student Performance. Students' performance is highly affected when they use tablets and applications because they develop a higher level of digital literacy. This indicates that the use of digital tools in schools is of paramount importance to improve students' performance through increased digital literacy.

DISCUSSION

The analysis results underscore the positive effects that Tablets and Apps (TA) have on Digital Literacy (DL), Student Engagement (SE), and Student Performance (SP). Given the strong direct effect on Digital Literacy (β = 0.873), adopting Tablets and Apps in instructional practices will strengthen students' digital literacy capabilities. In turn, this serves as key mediator in the positive effect Digital Literacy has on Student Engagement and Performance. Digital Literacy also directly impacts Student Engagement and Performance, and more importantly, it serves as a critical mediator between Tablets and Apps and Student Performance (β = 0.248). With Student Engagement having a moderate direct effect on Student Performance (β = 0.356), it is clear that Student Engagement is a pre-condition and should be emphazised in any strategy to promote student success. The explained variance on Student Performance (0.789), Digital Literacy (0.762), and Student Engagement (0.747) relative to the R^2 values demonstrate the predictive power of the model. In the practical sense, this means that the value of educational apps, digital literacy programs, and interactivity to engagement in teaching and learning is not mere supportive, but essential. Furthermore, personalized feedback and learning paths based on data from these apps will boost student performance. To ensure these interventions are effective, regular assessments, integrating technology, building skills, and engaging all participants are recommended.

Digital Literacy as the Most Impactful Mediator

The mediation impact of DL indicated that it was the most impactful mediator of the usage of TA in relation to SP (β = 0.248, $p < 0.001$). This result provides an opportunity to dig deeper to understand the possible ways in which DL functions as a pathway for this impact.

DL being the most impactful mediator is the result of a number of factors which are interlinked. To start with, digital literacy is a primary skill that determines the extent to which students are able to use tablets and learning apps. Students with high digital literacy can more effectively use different digital tools, assess the credibility of information presented in the online platforms, and use information from different online resources for learning. All these students are likely to achieve better learning outcomes because they are able to remove irrelevant information, integrate knowledge from different sources, and use varied information digitally to arrive at a solution to an economics problem. Secondly, the ability to use technology helps learners to become more mindful when integrating technology for learning. Students with more advanced digital skills are more selective with the kind of technology they use. Rather than picking distracting or useless technologies, they use learning apps and other digital resources that serve the purpose of the intended learning goal. This kind of involvement increases the degree of efficacy that tablets can have on learning because students do not use technology at a shallow level.

Thirdly, digital skills also help learners to overcome challenges that could hinder their learning. When they face a new app or a different digital format, students with digital skills are able to use their adaptable problem solving to overcome the challenges. This means that the learning flow is not hindered at new technology introduction points, which is especially important in order to avoid the disengagement that may happen when students do not have the required skills.

The even stronger indirect impact of DL than of SE also indicates that for technology use in a learning context, the cognitive aspects may play a more important role than the non-cognitive. Engagement is more about motivation and willingness to participate while digital literacy is the ability to turn the access to technology into learning outcomes. This corresponds to theories on learning that focus on the importance of competency, not just participation.

Comparing with Previous Studies

It is interesting to see that our study found DL to be the strongest mediation effect ranging where DL also was found to be a predictor of academic performance in blended learning settings with learning adaptability as a partial mediator by Wu & Yuan (2023) . Our study builds on this by showing that DL mediates even when SE is controlled, thus affirming its strong influence on learning outcomes even on its own.

This also concurs with Ilomaki et al. (2023) who remarked that students with more digital literacy tend to be more capable of using various digital tools for learning. Our study, however, specifically quantifies the relationship to economics education using tablets and apps, thus providing a testimony to the claims suggested by Ilomaki et al (2023). The size of the effect can be estimated using the beta coefficient of 0.248 for the mediation pathway of digital literacy. This can be reference for future work.

In Zhao (2024) who used self-efficacy in digital tools as a mediating factor in the relationship between information literacy and engagement in online learning, While Zhao considers self-efficacy beliefs as proximal predictors, we suggest that DL (and not self-efficacy beliefs) is the more proximal, and, thus, the more influential factor. This self-efficacy differentiation elevates the complexity of the situation as self-efficacy can be enhanced through encouragement, while the development of digital literacy requires sustained efforts at skill acquisition through teaching and practice.

Partially contradictory to Bergdahl et al (2024), where the engagement in learning is described as the main pathway through the learning analytics and digital tools positively affect students' academically, we found a weaker (but positive) effect of engagement on outcomes ($\beta = 0.179$) when digital literacy was present which can explain the positive effect of engagement ($\beta = 0.248$). In lighter words, in discipline-specific (economics) learning, cognitive engagement is more crucial (and positively influencing) than affective engagement. This is particularly true when the learning is through a portable digital device (tablet) as opposed to learning in a higher education setting general online learning.

The high values of R^2 for SP (0.789) are far above what has been reported in the literature on educational technology, which has R^2 scores of 0.40–0.60 (Zhang & Tur, 2024). This means that the combination of tablets/apps, digital literacy, and engagement explains more of the variance in economics learning outcomes. Having this model with such high explanatory power, allows for this theoretical framework to be successfully applied in practice.

The ability to access technological tools & the ability to use technology remains an active area of discussion. This research, like Tinmaz et al. (2022) regarding digital inequalities, asserts that simply offering tablets and apps to students is not enough to achieve positive educational outcomes; students must have the ability to use the apps. There is a strong direct effect of TA on DL ($\beta = 0.873$), which means that the exposure to technology allows for the acquisition of new digital skills. This was the case in this educational scenario where the digital skills, once formed, improved educational performance.

Investing in educational TA has shown remarkable outcomes relating to DL, SE, and SP. For instance, Limniou (2021) shows the value of the digital gadgets in educational settings whereby they improved engagement and focus which in turn enhanced students' academic performance. Meanwhile, Wu and Yuan (2023) asserted that DL and academic performance are directly correlated and that DL mediates the relation between the use of digital technologies and student outcomes. The structural path analysis supports these findings as well, in which the TA has a significant direct impact on DL ($\beta = 0.873$) and thus impacting SP significantly. The provided R^2 values considerably supports the claims in which the accounted variance percentage in the values of SP (0.789), DL (0.762), and SE (0.747) shows educational value. Hence, the findings' validity is strongly reinforced. It is advised that educational institutions focus on the aforementioned construction and development of digital resources. Use TA and interactive techniques to maintain engagement and use application data to provide feedback and create personalized learning pathways. Doing so will assist in improving student performance. Regular evaluations and the use of an integrated approach involving technology, skill development, and engagement strategies will improve the efficiency of these treatments.

CONCLUSION

Tablets and Apps (TA) have a substantial influence on the development of Digital Literacy (DL), Student Engagement (SE), and Student Performance (SP). More recent literature also corroborates these results: studies demonstrate that the use of digital technology in the classroom increases students' academic achievement by enhancing engagement and minimizing distractions.

TA had the highest direct impact on DL (β = 0.873) and SE was a significant influence on SE (β = 0.356) in a mediating role. There were numerous significant mediating pathways to SP, which suggests the relationships are intricate. The mediation analysis indicated that the TA → DL → SP pathway constituted the strongest mediation effect at 0.248. All of the mediation paths were significant with $p < 0.001$, indicating strong evidence for mediation. This supports the findings of Wu and Yuan (2023), which highlights that digital literacy steers academic performance and also functions as a mediator in the suite of digital tools that students use and the academic performance outcomes.

The implications broaden the understanding of how technology impacts learning in education and confirms the applicability of technology acceptance models in educational settings. Higher learning institutions should invest in the establishment of holistic digital infrastructures, develop faculty competencies in technology-integration, and develop structured digital literacy curricula. For teachers, the use of tablets and various applications should prioritize engagement and the embedding of digital literacy within the curriculum, along with the regular assessment of student engagement and achievement. Students should acquire the necessary digital skills and the educational technology provided should be used to facilitate active learning. The proposed framework for implementation has immediate objectives of ensuring access to devices and training on basic digital literacy, followed by the development of more advanced digital skills and strategic comprehensive approaches for sustaining engagement as intermediate objectives, and finally, on the systemic technology integration which will be anchored on the ongoing enhancement of digital literacy as the ultimate objectives.

Coming studies can focus on technology's impact longitudinally, validating findings cross-culturally, and assessing the effectiveness of particular app features. Some limitations are the need for continuous updates on technology, different levels of digital access for students, implementation resource requirements, and ongoing training opportunities. High R^2 values (SP: 0.789, DL: 0.762, SE: 0.747) proves the model's strong explanatory power and showcases the study's evidence of effectiveness that tablets and digital apps positively enhance students' performance via digital engagement and literacy. For successful execution, planning, proper resource distribution, stakeholder engagement, regular appraisal, and ongoing support are required. This study provides a clearer understanding of the positive impact of technology on educational practices, and offers educational institutions and technology a new vision for improving educational practices.

REFERENCES

1. Al-Maroof, R. S., Alnazzawi, N., Akour, I., Ayoubi, K., Alhumaid, K., Nasser, N. M., Alaraimi, S., Al-Bulushi, A. A., Thabit, S., Alfaisal, R., Aburayya, A., & Salloum, S. (2022). Students' perception towards using electronic feedback after the pandemic: Post-acceptance study. International Journal of Data and Network Science, 6(4), 1233–1248. https://doi.org/10.5267/j.ijdns.2022.6.010
2. Chen, W. W., & Wong, Y. L. (2015). Chinese mindset: theories of intelligence, goal orientation and academic achievement in Hong Kong students. Educational Psychology, 35(6), 714–725. https://doi.org/10.1080/01443410.2014.893559
3. Crompton, H., & Burke, D. (2018). The use of mobile learning in higher education: A systematic review. Computers and Education, 123(April), 53–64. https://doi.org/10.1016/j.compedu.2018.04.007
4. Fornell, C., & Larcker, D. F. (2016). Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research This, 18(1), 39–50.
5. Gikas, J., & Grant, M. M. (2013). Mobile computing devices in higher education: Student perspectives on learning with cellphones, smartphones & social media. Internet and Higher Education, 19, 18–26. https://doi.org/10.1016/j.iheduc.2013.06.002
6. Gilboy, M. B., Heinerichs, S., & Pazzaglia, G. (2015). Enhancing student engagement using the flipped classroom. Journal of Nutrition Education and Behavior, 47(1), 109–114. https://doi.org/10.1016/j.jneb.2014.08.008
7. Hinze, A., Vanderschantz, N., Timpany, C., Cunningham, S. J., Saravani, S. J., & Wilkinson, C. (2023). A Study of Mobile App Use for Teaching and Research in Higher Education. Technology, Knowledge and Learning, 28(3), 1271–1299. https://doi.org/10.1007/s10758-022-09599-6
8. Hirshberg, M. J., Frye, C., Dahl, C. J., Riordan, K. M., Vack, N. J., Sachs, J., Davidson, R. J., & Goldberg, S. B. (2022). A Randomized Controlled Trial of a Smartphone-Based Well-Being Training in Public

School System Employees During the COVID-19 Pandemic. Journal of Educational Psychology, 1–56.
9. Kaware, S. S., & Sain, S. K. (2015). ICT Application in Education: An Overview. International Journal of Multidisciplinary Approach and Studies, 03(4), 25–32.
10. Kock, N. (2021). Harman ' s single factor test in PLS-SEM : Checking for common method bias. Data Analysis Perspectives Journal, 2(April), 1–6.
11. Vaughan, N., & Garrison, D. R. (2005). Creating cognitive presence in a blended faculty development community. Internet and Higher Education, 8(1), 1–12. https://doi.org/10.1016/j.iheduc.2004.11.001
12. Wilson, S. A., Byrne, P., Rodgers, S. E., & Maden, M. (2022). A Systematic Review of Smartphone and Tablet Use by Older Adults With and Without Cognitive Impairment. Innovation in Aging, 6(2), 1–19. https://doi.org/10.1093/geroni/igac002
13. Zhang, G., Chen, P., & Xu, S. (2025). Developing and validating a scale for measuring sustainable leadership development among teachers in Chinese higher education institutions. Journal of Cleaner Production, 486(January 2024). https://doi.org/10.1016/j.jclepro.2024.144403