



Perceived Ease of Use and Usefulness of Technology Integration for Learner Engagement at the Primary Level: A Mixed-Methods Study

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Abstract

As digital technologies continue to evolve rapidly within educational settings, there is an urgent need to investigate systematically how these developments affect student engagement, especially in primary classrooms. This investigation utilized a sequential explanatory mixed-methods framework to interrogate the interplay between perceived ease of use (PEOU), perceived usefulness (PU), and engagement within lessons supported by digital tools. The quantitative phase, informed by the Technology Acceptance Model (TAM), collected survey data from primary teachers who rated both the usability of the tools and their perceived contribution to maintaining student attention. Multivariate techniques indicated strong positive correlations between teachers' technology perceptions and both behavioral and emotional indicators of engagement. Concurrently, focus-group interviews provided qualitative dimensions, revealing concerns regarding curriculum integration, professional development, and necessary pedagogical shifts. Together, the data strands were synthesized into a reflective feedback model, yielding a richer, layered picture of how digital resources recalibrate teaching methods and student participation. The merged results suggest that technologies regarded as straightforward and pedagogically purposeful empower teachers to enact practices that foster deeper, longer-lasting engagement. The study concluded with tailored recommendations for teachers, system-level policymakers, and technology designers, underscoring the need for tighter coherence between intended pedagogical outcomes and the design of educational technologies. By carefully examining these interactions, the present study offers significant theoretical and practical contributions regarding the influence of the Technology Acceptance Model constructs on promoting sustained and meaningful engagement within primary instructional contexts.

Keywords: Perceived ease of use, Usefulness of technology, Learner engagement, Primary education, Technology integration, TAM model.



Introduction

During the past score of years, precipitous technological innovation has reconstituted the conventional primary classroom into an agile and interactive milieu. Devices ranging from interactive whiteboards and portable tablets to comprehensive learning management systems and gamified learning applications have attained normative status in numerous institutions. Yet, the consistent attainment of substantive educational returns is contingent upon factors that extend beyond material availability. The perceptions, competencies, and pedagogical intentions that teachers bring to technology-mediated instruction decisively mediate educational efficacy, an argument that carries special weight in primary contexts where the scaffolds for lifelong intellectual and social development are erected (Skantz-Åberg et al., 2022).

In contemporary educational discourse, stakeholders persistently champion technology integration as a means of amplifying pedagogical effectiveness and deepening learner engagement. Learner engagement, which encompasses the multifaceted attentional, emotional, and cognitive investments that students bring to the learning process, has repeatedly been empirically associated with elevated academic performance, enhanced behavioral norms, and strengthened retention of content (Xu et al., 2023). Such compelling correlations underscore the ideological and empirical underpinnings driving the technology integration agenda.

As Mugabekazi et al. (2025) stated, in primary education, where students are developing core skills and attitudes toward learning, maintaining engagement is especially critical. Technology offers various tools to stimulate engagement, from multimedia storytelling and interactive exercises to real-time feedback systems and collaborative platforms. However, the potential of these tools is only fully realized when teachers perceive them as both easy to use and beneficial to student learning.

The Technology Acceptance Model (TAM), originally developed by Davis (1989), has been further examined in recent research (Davis & Granić, 2024) provided a robust theoretical lens for understanding user acceptance of technology. TAM posits that two constructs, Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) are central determinants of whether individuals adopt and effectively use technological tools. PEOU refers to the extent to which a user believes that using a particular system will be free of effort, while PU refers to the degree to which an individual believes that the technology will enhance their performance. Applied in the educational context, these constructs offer valuable insights into teachers' willingness and ability to integrate technology into their instructional practices.

Despite the growing body of research on TAM in education, much of the literature has focused on higher education or professional training environments. Studies at the primary level remain relatively limited, even though the challenges and enablers of technology adoption in this context can differ significantly. Primary teachers often work with younger learners who require age-appropriate tools, more guided instruction, and higher levels of scaffolding (Ball & Fairlamb, 2025). Moreover, engagement at this stage is not solely cognitive, it is also emotional and behavioral, influenced by classroom climate, teacher enthusiasm, and the accessibility of learning materials. These differences highlight the need for research that examines PEOU, PU, and learner engagement specifically



within primary education.

Nevertheless, the processes that shape the adoption of instructional technology in primary settings cannot be reduced to the attitudes or competencies of individual teachers. Adoption is contingent upon a constellation of systemic variables, including the availability and reliability of infrastructure (e.g., stable internet access, sufficient devices), the extent of institutional support (e.g., professional development and technical assistance), and the degree to which curricular mandates promote and model the pedagogical use of technology. Critics who adopt a deficit view of teacher proficiency risk overlooking this multidimensional architecture (Zhang & Tian, 2025). Conversely, when educational professionals receive targeted, ongoing professional development, and when they are situated within an environment that supplies reliable infrastructure and curricular alignment, their affective and behavioral inclination to employ digital tools in instruction rises and their capacity to foster sustained student engagement is markedly enhanced.

A mixed-methods design affords an analytical stance well-positioned to explicate the interrelations among the factors such as perceived ease of use (PEOU), perceived usefulness (PU), and learner engagement. Quantitative procedures enumerate the degree to which the constructs covary, yet they do not account for the situated negotiations in which teachers engage. Qualitative inquiry in the present study, conversely, interrogates the day-to-day realities and tactical adaptations of primary classroom teachers, yielding an interpretive depth unavailable to survey instruments. By implementing a convergent design, the investigation leverages the confirmatory strength of the quantitative data and the contextual revelatory capacity of the qualitative data, thereby constructing a comprehensive account of technology enactment in primary education and its consequential effects on learner engagement.

The quantitative component operationalizes teacher perceptions of PEOU and PU, in addition to recording self-reported metrics of learner engagement, through a structured survey. Simultaneously, the qualitative phase employs multi-session focus groups to surface the differentiated experiences of teachers, explicating how technology reconstitutes pedagogical routines and recalibrates student participation. This triangulator strategy not only affirms the hypothesized paths among the technology acceptance model (TAM) constructs and engagement, but also enriches the statistical synthesis with context-sensitive disclosures regarding institutional, infrastructural, and interpersonal moderators.

The relevance of this investigation encompasses a diverse array of stakeholder groups. Educators may find value in the examination of how construct-shifted attitudes toward technology are constructively cultivated through intentionally targeted professional development and judiciously weighted distribution of material and human resources. Policymakers are urged to shape initiatives that exhibit congruence between intuitive functionality and pedagogical coherence. Concurrently, the scholarly community benefits from the study by extending Technology Acceptance Model (TAM) discourse to the primary education sector and by providing empirical assessments of the model's capacity to forecast learner engagement outcomes.

The analysis also reaffirms the instrumental influence of primary education in establishing durable learning pathways. Adequate engagement at this stage can reinforce positive student dispositions, cultivate proactive



classroom involvement, and nurture the self-efficacy foundational to surmounting progressively demanding curricular tasks in subsequent phases of academic development. In assessing the roles of perceived ease of use (PEOU) and perceived usefulness (PU) in technology-enhanced instructional environments, the research aspires to generate evidence-based recommendations for bolstering instructor preparedness and enriching learner experiences.

Given these premises, the introduction delineates three interlocked core propositions:

- a) Technology integration possesses the capacity to elevate engagement within primary education meaningfully, yet the degree of that elevation is contingent upon educators' assessment of the technology's ease of use, along with perceived value.
- b) The Technology Acceptance Model furnishes a theoretically robust lens for unpacking these assessments, albeit empirical scrutiny within the primary sector remains scarcely addressed.
- c) Employing a triangulated mixed-methods framework permits the scholarly evaluation of both quantitatively observable relationships and qualitatively rich dimensions requisite for the design of research-informed, evidence-based interventions aimed at accelerating the effective adoption and sustained engagement of instructional technologies within elementary-age classrooms.

By systematically addressing the rationales set forth, the research aspires to yield actionable insights that undergird the durable and pedagogically sound embedding of digital tools within the primary curriculum, thereby promoting sustained learner engagement and improving measurable educational results among young learners.

Conceptual Framework

The research draws upon the Technology Acceptance Model (TAM), first articulated by Davis in 1989, which posits that the adoption of a technological innovation is mediated by two anchor constructs:

- 1) Perceived Ease of Use (PEOU), which assessed the extent to which potential adopters anticipate that the technology can impose little or no effort in regular use, and
- 2) Perceived Usefulness (PU), which gauged the extent to which users expect that the technology can substantively enhance the effectiveness of the specific pedagogical or administrative task undertaken.

Within the primary educational context, these dimensions serve to interrogate how teachers' beliefs regarding the seamless embedding of digital tools interface with Learner Engagement (LE), operationally defined as the multidimensional participation of learners in cognitive, emotional, and behavioral registers during instructional and co-curricular activities.

The theoretical framework also acknowledged that beliefs concerning ease of use (PEOU) are closely linked with perceptions of usefulness (PU). Technologies that users find intuitive and manageable are often construed as more beneficial for teaching and learning, suggesting that ease of use can enhance the perceived value of technology even if not formally tested as a mediating pathway in this study.



Recent empirical work continues to validate the Technology Acceptance Model (TAM) within educational contexts. Marian et al. (2025) reiterated the model's sustained relevance, indicating that its core dimensions can be adapted to diverse instructional ecosystems. In parallel, Lee et al. (2025) enhanced the TAM by integrating it with the Technological Pedagogical Content Knowledge (TPACK) construct, assessing K–12 teachers' predispositions regarding emerging AI-integrated teaching platforms. Their results once more affirmed that perceived ease of use (PEOU) and perceived usefulness (PU) function as non-negotiable antecedents of acceptance for pedagogical technologies.

The present investigation situated PEOU and PU as functionally distinct predictors while designating learner engagement (LE) as the sole dependent construct. This model is anchored exclusively within TAM's original paradigm, concentrating on the direct, sequential effect of ease of use and usefulness on learner engagement, and deliberately excluding supplementary contextual moderators. The empirical relationships subject to analysis are specified through a set of null hypotheses, each formulated to deny the existence of a statistically significant linkage among the three primary constructs under investigation. This structure enables a disciplined investigation of both direct and indirect pathways suggested by the theoretical model, while maintaining a theoretically agnostic stance. Consequently, the outcomes of the analysis are permitted to adjudicate the coherence of the framework, independent of the researchers' pre-existing assumptions.

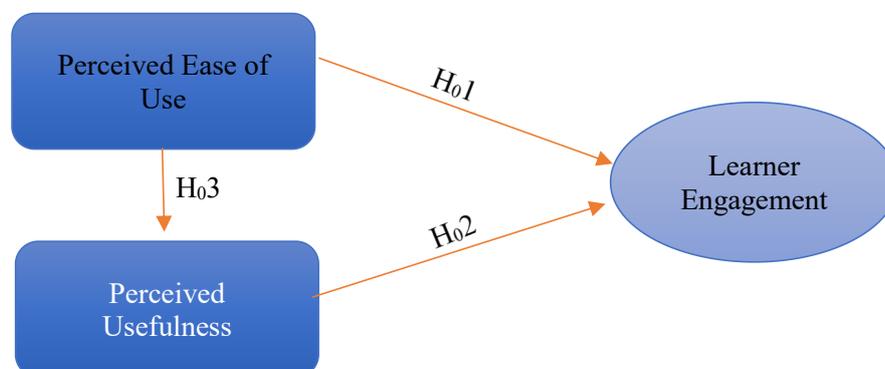


Figure 1 Conceptual Framework of Technology Integration and Learner Engagement

This framework illustrates the proposed relationships tested in the study, based on the Technology Acceptance Model (TAM). Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) are examined as direct predictors of Learner Engagement (LE).

Research Objectives

1. To examine the relationship between perceived ease of use of technology and learner engagement at the primary level.
2. To investigate the relationship between perceived usefulness of technology and learner engagement at the primary level.
3. To compare the relative influence of perceived ease of use and perceived usefulness on learner engagement in technology-integrated primary



classrooms.

Research Questions

1. What is the relationship between perceived ease of use of technology and learner engagement at the primary level?
2. What is the relationship between perceived usefulness of technology and learner engagement at the primary level?
3. Which factor perceived ease of use or perceived usefulness has a stronger influence on learner engagement at the primary level?

NULL Hypotheses

- H₀₁: There is no statistically significant relationship between perceived ease of use of technology and learner engagement at the primary level.
- H₀₂: There is no statistically significant relationship between perceived usefulness of technology and learner engagement at the primary level.
- H₀₃: There is no statistically significant difference in the influence of perceived ease of use and perceived usefulness on learner engagement at the primary level.

Literature Review

Technology Integration in Education

Technology integration designates the systematic embedding of digital tools and resources into pedagogical practice with the aim of enriching teaching and learning. Over the past twenty years, accelerating technological development has widened the horizons for instructional innovation. Resources such as learning management systems, multimedia repositories, digital interactive displays, and smartphone applications empower educators to broaden pedagogical repertoires, address diverse cognitive profiles, and engender sustained learner engagement (Hamzah et al., 2024). In the primary years, technology supports emergent literacy, numeracy, and critical thinking through game-based modules, adaptive algorithms, and cross-classroom collaborative tasks. Nevertheless, sustained success of such integration rests on the preparedness of educators, supportive governance structures, and coherence with instructional theory.

Technology in Primary Education

Technology in Primary Education The primary sector presents distinctive constraints on systematic technology adoption. Young learners require child-appropriate affordances, compellingly designed content, and carefully scaffolded guidance to traverse digital resources responsibly. Classroom practitioners are pivotal in orchestrating cared-for engagements and in matching the technology to developmental priorities. Recent investigations (Pappa et al., 2024) substantiate that, when adopted with intentional design, technology amplifies motivation, cultivates creativity, and fosters collaborative capacities among primary students. Counteracting these potential benefits are systemic barriers, notably pedagogical in-service that is insufficient, frequencies of design time that are scarce, and infrastructural reliability that is irregular.

Learner Engagement

Learner engagement is a multidimensional construct encompassing behavioral,



emotional, and cognitive dimensions. Behavioral engagement refers to participation in academic tasks and classroom activities, emotional engagement reflects students' attitudes and feelings towards learning, and cognitive engagement involves investment in learning and willingness to exert effort (Xu et al., 2023). Technology can support all three dimensions by offering interactive content, immediate feedback, and opportunities for personalized learning. Yet, engagement depends heavily on how technology is integrated into the curriculum and facilitated by the teacher.

Beyond the multidimensional model of engagement, integrating additional theoretical perspectives can deepen the understanding of how PEOU and PU shape learner outcomes. Self-Determination Theory (Ryan & Deci, 2024) emphasizes that autonomy, competence, and relatedness drive intrinsic motivation, which aligns with how perceived ease of use supports teacher competence and how perceived usefulness fosters autonomy in instructional decisions. Similarly, Flow Theory (Csikszentmihalyi et al., 2014; Habe & Biasutti, 2023) highlights the importance of optimal challenge and skill balance, suggesting that technology, when well-aligned with learning objectives, can maintain students in a state of deep engagement. Positioning TAM alongside these motivational frameworks creates a richer conceptual lens for examining technology's role in sustaining primary learners' attention, participation, and effort.

The Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), first articulated by Davis in 1989, remains a cornerstone in empirical investigations of technology uptake. Its core assertion is that users' perceptions of two principal constructs—Perceived Ease of Use and Perceived Usefulness, shape their attitudes toward a given technology and ultimately forecast its operational incorporation.

- **Perceived Ease of Use (PEOU):** It is defined as the degree to which a person judges that employing the technology will incur negligible physical or cognitive exertion. Within educational environments, this construct encompasses characteristics such as coherent design, accessible navigation, and a reduction of obstacles that require technical proficiency.
- **Perceived Usefulness (PU):** The belief that technology will enhance performance in this case, teaching effectiveness and student learning outcomes.

Empirical studies have consistently found both constructs to be significant predictors of adoption intentions among educators (Scherer et al., 2024).

TAM in Educational Research

Numerous studies have applied TAM to investigate technology adoption among teachers. Granić (2023) found that both PEOU and PU significantly influenced the intentions of pre-service teachers to use technology in future classrooms. Scherer et al. (2024) conducted a meta-analysis demonstrating the model's robustness across diverse educational contexts. However, the majority of TAM studies have been conducted in higher education or secondary school settings, with relatively few focusing on primary education.



Linking TAM to Learner Engagement

While TAM primarily addresses user acceptance, its constructs are indirectly linked to learner engagement. Teachers who find technology easy to use and perceive it as beneficial are more likely to integrate it effectively, thereby creating learning experiences that capture and sustain student attention. For example, when technology is perceived as useful for differentiating instruction or making content more accessible, it appears to enhance teachers' intrinsic motivation to leverage technology, a phenomenon that may translate into increased student engagement (Naidoo, 2023; Sabri et al, 2024). Conversely, when educators encounter persistent technical difficulties or perceive technology as peripheral to their pedagogical objectives, they are likely to abandon digital resources in favor of traditional, less interactive methodologies.

Mixed-Methods Approaches in Technology Integration Research

A mixed-methods design is gaining prominence as a rigorous framework for investigating technology integration (Asadi & Ebadi, 2024; Creswell & Inoue, 2025). Quantitative components enabled the systematic measurement of relationships among study's constructs, whereas qualitative components documented the subtleties of the implementation context. For instance, survey analyses demonstrated a statistically significant association between PU and engagement, while follow-up interviews revealed that the strength of this association is moderated by the presence of comprehensive technical support in the institution.

Gaps in the Literature

A number of significant gaps persist in the literature pertinent to the Technology Acceptance Model (TAM) as applied to primary education settings. First, investigations directly oriented to the primary education phase are noticeably rare (Georgiou et al, 2023; Scherer et al., 2024), even though the specific cognitive and socio-emotional characteristics of younger learners necessitate tailored theoretical considerations (Villena-Taranilla, 2023). Second, existing research has not systematically interrogated how the core constructs of TAM relate to the broad and nuanced domain of learner engagement (Naidoo, 2023; Sabri et al, 2024), thereby limiting the explanatory and predictive power of the framework in educational contexts. Lastly, while the simultaneous capture of quantitative and qualitative data promises a more rounded appraisal of technology adoption dynamics, mixed-methods investigations remain an underexploited methodological option (Dahri et al., 2024; Creswell & Inoue, 2025). Across the review, the literature calls for empirical work that marries TAM constructs, primary education, learner engagement, and a mixed-methods design, an agenda the current investigation fulfills in equal measure. The findings anticipated will, therefore, extend theoretical knowledge within TAM scholarship while furnishing practitioners with actionable pathways to enhance technology adoption in primary curricula.

Methodology

Research Design

For a comprehensive assessment, the study incorporated a convergent mixed-methods approach that concurrently collected quantitative and qualitative data.



Population and Sampling

The sample comprised primary-level teachers from both public and private institutions in Rawalpindi. To achieve a proportionate representation of school categories and geographic contexts, a stratified random sampling design was implemented. Stratification was conducted along the dimensions of school type (public or private) and locality (urban or rural). This framework ensured that perspectives from each defined category were systematically incorporated into the sample, thereby strengthening the generalizability of the results. No separate subgroup analyses were pursued; however, the stratified design effectively curtailed the likelihood of disproportionate representation of any single type of school or locality. Random selection of schools proceeded from a consolidated registry, with schools drawn independently within each stratum, followed by random sampling of teachers within the chosen institutions. In total, 210 teachers completed the survey instrument.

Inclusion Criteria

- Full-time teachers assigned to grades 1–5.
- Minimum 6 months teaching experience at the current school.
- Willing to provide informed consent.

Exclusion Criteria

- Teachers on extended leave during the data-collection window.
- Schools with no primary section or operating for < 1 year (to avoid atypical start-up conditions).

The combined school list formed the sampling frame, with a stratum label (public/private) for stratification and school as the clustering unit.

1. For the quantitative phase, the sampling frame was compiled from official registration lists of schools maintained by the District Education Authority (for public schools) and relevant private school associations (for private schools). Schools without active primary sections or those not meeting the inclusion criteria were excluded. From the eligible schools, a proportional number were randomly selected within each stratum. Within each selected school, a list of eligible teachers was obtained in anonymized form, and simple random sampling was applied to identify participants. A total of 210 teachers completed the survey.
2. For the qualitative phase, the same stratification logic guided participant selection, ensuring representation across the four strata. Four to six focus groups were conducted, each consisting of 6-8 teachers, providing a range of perspectives on technology integration and learner engagement.

The purposeful sampling procedures enacted in the study yielded a rich variety of teacher experiences and ensured deliberate representation of both the public and private school sectors. Participant anonymity and confidentiality were carefully preserved throughout, thereby safeguarding the ethical integrity of the investigation without compromising the validity of the resulting data set.

Instruments

Quantitative Survey: A structured questionnaire, adapted from validated TAM instruments, was used to measure the key constructs of perceived ease of use, perceived usefulness, and learner engagement:



- Perceived Ease of Use (5 items)
- Perceived Usefulness (5 items)
- Learner Engagement Indicators (6 items)

Responses were solicited on a 5-point Likert scale, the scale endpoints being anchored to facilitate nuanced interpretation of attitudes.

Qualitative Protocol: A semi-structured focus group guide explored:

- Experiences with technology integration
- Perceived challenges and facilitators
- Observed effects on student engagement

Data Collection and Analysis

- **Quantitative Analysis:** Descriptive statistics, Pearson product-moment correlation coefficients, and a hierarchy of multiple regression analyses were computed using SPSS version 27, thereby delineating the directional relationships among TAM constructs.
- **Qualitative Analysis:** Thematic analysis, supported by NVivo version 12, was systematically deployed to identify and interpret recurring themes and sub-themes within the transcribed semi-structured interviews, thereby augmenting the quantitative findings with contextual depth.
- **Integration of Results:** Quantitative and qualitative findings were compared and synthesized for the convergent interpretation of the Technology Acceptance Model research.

The quantitative questionnaire employed a refined version of the TAM scales originally validated by Davis (1989) and subsequently adapted for educational settings by Scherer et al. (2024)

Sample items comprised:

- **PEOU:** “Learning to operate technology tools in my teaching is easy for me.”
- **PU:** “Technology helps me engage students more effectively in lesson activities.”
- **LE:** “Students show more sustained attention when technology is used in lessons.”

Data were obtained via a five-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). Cronbach’s alpha coefficients demonstrated excellent internal consistency: perceived ease of use ($\alpha = 0.87$), perceived usefulness ($\alpha = 0.89$), and learner engagement ($\alpha = 0.85$). Exploratory factor analysis validated the constructs, with factor loadings exceeding 0.60 across all survey items.

The qualitative focus group protocol included open-ended questions such as:

- “Describe a lesson where technology helped increase student engagement.”
- “What challenges have you faced in integrating technology into lessons?”
- “How has training affected your confidence in using technology?”

Analysis and Findings

Quantitative Analysis

Descriptive Statistics

A total of $n = 210$ primary school teachers participated in the quantitative phase



of the study, representing both public (60%) and private (40%) schools. The mean scores (measured on a 5-point Likert scale) were as follows:

Table 1 Descriptive Statistics of Study Variables

Variable	Mean (M)	Standard Deviation (SD)
Perceived Ease of Use (PEOU)	3.62	0.74
Perceived Usefulness (PU)	3.78	0.71
Learner Engagement (LE)	3.69	0.68

The high mean scores suggest that, overall, teachers rated technology as both easy to use and useful, and perceived their students as being highly engaged when technology was integrated into lessons.

Correlation Analysis

Pearson correlation coefficients were calculated to examine the relationships between PEOU, PU, and LE.

Table 2 Relationship Matrix of PEOU, PU, and LE

Variables	PEOU	PU	LE
PEOU	1	.48**	.42**
PU	.48**	1	.51**
LE	.42**	.51**	1

p < 0.01 indicates significance at the 1% level.

The results show moderate positive correlations. PU was more strongly associated with LE (r = .51, p < .01) than PEOU (r = .42, p < .01). PEOU and PU were also moderately correlated (r = .48, p < .01), indicating some overlap but also distinct contributions.

These results suggest that while both ease of use and usefulness relate positively to learner engagement, the associations are not excessively strong, leaving room for other factors to shape engagement outcomes.

Multiple Regression Analysis

A multiple regression was conducted with learner engagement as the dependent variable and PEOU and PU as predictors.

Table 3 Model Summary

Predictor	β	95% CI for β	t(207)	p	VIF
Perceived Ease of Use (PEOU)	.22	[.09, .35]	3.48	< .01	< 2.0
Perceived Usefulness (PU)	.29	[.16, .42]	4.61	< .001	< 2.0

Model Summary: R² = .34, Adjusted R² = .33, F (2, 207) = 52.95, p < .001

Findings indicate that PU (β = .29) has a somewhat stronger influence on learner engagement than PEOU (β = .22). Specifically, PU predicted LE, β = .29, 95% CI [.16, .42], t(207) = 4.61, p < .001; PEOU predicted LE, β = .22, 95% CI [.09, .35], t(207) = 3.48, p < .01. Variance inflation factors (all VIFs < 2.0) confirmed no multicollinearity concerns. The overall model explained 34% of the variance in learner engagement, R² = .34, Adjusted R² = .33, F (2, 207) = 52.95, p < .001,



reflecting a moderate effect size ($f^2 \approx 0.52$). These results lead us to reject H_03 , confirming that both perceived usefulness and perceived ease of use contribute meaningfully to engagement, with usefulness exerting the relatively stronger influence.

For the quantitative analysis, regression assumptions were tested prior to model estimation. Normality was assessed through Q-Q plots and Shapiro–Wilk tests, while scatterplots were examined for linearity and homoscedasticity. Variance Inflation Factor (VIF) scores were all below 2.0, indicating no multicollinearity concerns.

For the qualitative phase, thematic coding was conducted independently by two researchers using NVivo. Inter-coder reliability reached Cohen’s kappa = 0.87, indicating substantial agreement. Themes were refined through iterative discussion to ensure credibility and confirmability.

Qualitative Analysis (Layered Narrative Approach)

The qualitative phase involved five focus groups with 30 primary-level teachers from public and private schools. Through thematic analysis, three major themes emerged. Each theme is presented as:

1. **Narrative Snapshot** – a short, anonymized composite narrative drawn from participant quotes.
2. **Analytic Commentary** – linking the lived experience to TAM constructs and quantitative results.
3. **Micro-Integration Box** – summarizing qualitative evidence alongside quantitative linkages.

Theme 1: Confidence and Comfort with Technology (Perceived Ease of Use – PEOU)

Narrative Snapshot:

“The first time I saw the new platform, I panicked,” admitted a public-school teacher with eight years’ experience. *“But the icons were big, the instructions were clear, and within a few lessons, I was using it like I’d been trained for months.”*

Another teacher from a private school echoed, *“When the software is intuitive, I can focus on my students instead of worrying about the buttons. That’s when I see the real smiles and curiosity in the classroom.”*

Analytic Commentary

These narratives highlight PEOU as a foundational factor for adoption. Teachers’ confidence grew when interfaces were simple, intuitive, and aligned with their expectations, reducing the cognitive effort required to manage the tools. This freed their attention for instructional interactions rather than troubleshooting. Quantitatively, this aligns with the moderate correlation between PEOU and learner engagement ($r = .42, p < .01$), and its significant regression weight ($\beta = .22, p < .01$). While PEOU does not dominate engagement outcomes, it clearly lowers barriers to integration and provides the necessary base for meaningful classroom use.



Table 4: Micro-Integration of PEOU and Engagement

PEOU Element	Observed Effect	Engagement	Quantitative Link
Intuitive layout & clear instructions	Teachers focus shifts from technology to students	from	Supports H ₀₁ (PEOU → LE)
Reduced cognitive load	More time for questioning & feedback	for active	$\beta = .22, p < .01$

Theme 2: Perceived Impact on Learning Outcomes (Perceived Usefulness – PU)

Narrative Snapshot

“My class loves the quiz games. Even the quiet ones are raising their hands,” shared a rural public-school teacher. “It’s not just fun – they remember more.” A private school participant explained, “The animation of the water cycle made it click for my students. They understood evaporation and condensation better than from the textbook.”

Analytic Commentary

Perceived usefulness emerged as a stronger predictor of *continued technology use* than ease of use. Teachers frequently recounted how digital tools enhanced learners’ comprehension, participation, and retention, reinforcing their intention to integrate such technologies consistently in classroom practice. However, some also noted that certain applications were more entertaining than educational, pointing to variability in perceived instructional value. Quantitatively, this corresponds with the moderate correlation between PU and learner engagement ($r = .51, p < .01$) and its significant regression weight ($\beta = .29, p < .001$). The value teachers assigned to technology was directly linked to observable learning benefits, reinforcing TAM’s proposition that PU provides the primary motivational driver for continued adoption, even though its effect was moderate rather than overwhelming.

Table 5 Micro-Integration of PU and Engagement

PU Element	Observed Engagement Effect	Quantitative Link
Gamified learning tools	Higher participation, even from low-confidence students	$r = .51, p < .01$
Visual/interactive explanations	Improved comprehension of abstract concepts	$\beta = .29, p < .001$

Theme 3: Barriers to Effective Integration

Narrative Snapshot:

“Half the computers in the lab don’t work, and the internet is like a snail,” sighed one public school teacher. “Even when I want to use technology, it’s a gamble.”

Another participant added, “Some apps don’t match our syllabus, so we have to improvise or skip them altogether.”

Analytic Commentary

Barriers such as unreliable internet infrastructure, limited device availability, and curriculum misalignment constrained both PEOU and PU. Teachers in



resource-limited schools expressed frustration when technical issues consumed instructional time, even when they valued the tools' potential. This reflects Ertmer's (1999) framework of first-order barriers, where external limitations hinder teachers' capacity to apply technology effectively. While these barriers were not directly tested in the hypotheses, the qualitative evidence suggests they may act as contextual moderators, dampening the strength of the PEOU → LE and PU → LE relationships. This perspective also helps explain why the regression model accounted for only 34% of the variance in engagement indicating that structural and contextual conditions, beyond TAM variables alone, play a meaningful role.

Table 6 Micro-Integration of Barriers and Engagement

Barrier Element	Observed Effect	Engagement	Implied Quantitative Link
Unreliable internet/infrastructure	Class time lost due to delays → student disengagement		Weakens PEOU effect (ease disrupted by technical issues)
Limited access to devices	Fewer opportunities for interactive tasks → uneven participation		Weakens PU effect (usefulness undercut by scarcity)
Curriculum misalignment	Tools seen as “extra” rather than essential → reduced adoption		Limits both PEOU and PU pathways to LE

Summary of Qualitative Insights

Across themes, PEOU facilitated initial adoption by lowering operational barriers, while PU ensured continued integration by delivering visible learning benefits. Barriers diminished both constructs' effects, highlighting the importance of infrastructural and curricular support for maximizing engagement outcomes.

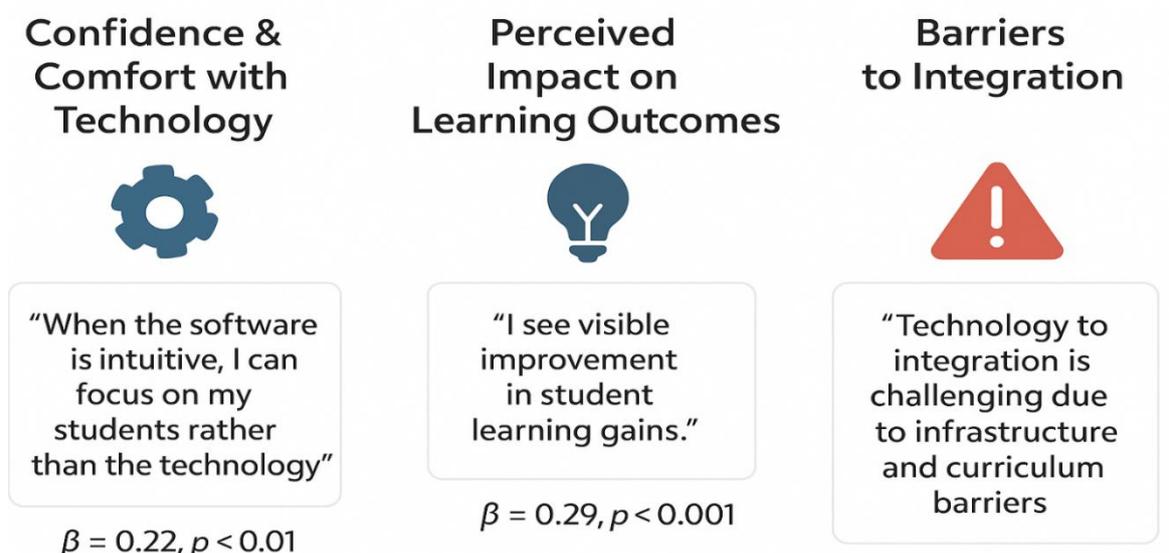


Figure 2 Mixed-Methods Insights on Technology Integration and Learner Engagement



Integration of Quantitative and Qualitative Findings

The quantitative results demonstrated moderate but significant relationships between both PEOU and PU with learner engagement, with PU emerging as the relatively stronger predictor. The qualitative findings added depth by clarifying why PU may exert greater influence: teachers valued tools that led to visible improvements in focus, participation, and comprehension. In contrast, ease of use was primarily important during initial adoption, lowering the entry barrier to technology use. However, sustained engagement depended more on teachers' perceptions of tangible learning benefits, underscoring PU's role as the key driver of ongoing integration.

In alignment with the convergent mixed-methods framework, data types cross-validated each other:

- PEOU → LE: Teachers' confidence with intuitive tools moderately predicted engagement. Qualitative accounts confirmed that ease of use supports initial adoption but is insufficient for sustained engagement.
- PU → LE: Perceived usefulness was the stronger predictor, aligning with narratives of improved comprehension and participation. However, qualitative skepticism suggested PU's influence is conditional, not absolute.
- Barriers: External issues (infrastructure, curriculum alignment) help explain why the model accounted for only one-third of engagement variance.

Table 7 Summary of Hypothesis Testing

Hypothesis	Result
H ₀₁ : PEOU is positively related to LE	Rejected (PEOU significantly predicted LE, $\beta = .22, p < .01$)
H ₀₂ : PU is positively related to LE	Rejected (PU significantly predicted LE, $\beta = .29, p < .001$)
H ₀₃ : PU has a stronger influence on LE than PEOU	Rejected (PU effect was stronger than PEOU: $\beta = .29$ vs. $\beta = .22$)

Table 8 Integration of Quantitative and Qualitative Findings

Research Question	Quantitative Result	Qualitative Theme	Integrated Insight
PEOU → LE	$r = .42, p < .01$	Confidence & comfort with intuitive tools	Ease of use lowers adoption barriers but does not guarantee sustained engagement
PU → LE	$r = .51, p < .01$	Tools improve focus & participation	Perceived benefits sustain engagement more consistently
PU > PEOU	$\beta = .29$ vs. $\beta = .22$	Value linked to learning outcomes	Sustained use is primarily driven by tangible academic benefits rather than usability alone

Qualitative evidence suggests that infrastructure reliability and curriculum alignment act as first-order moderators of the PEOU/PU → LE pathways. When



these conditions are weak, the quantitative advantages of PEOU and PU may not fully translate into sustained engagement, highlighting the importance of contextual enablers alongside the TAM constructs.

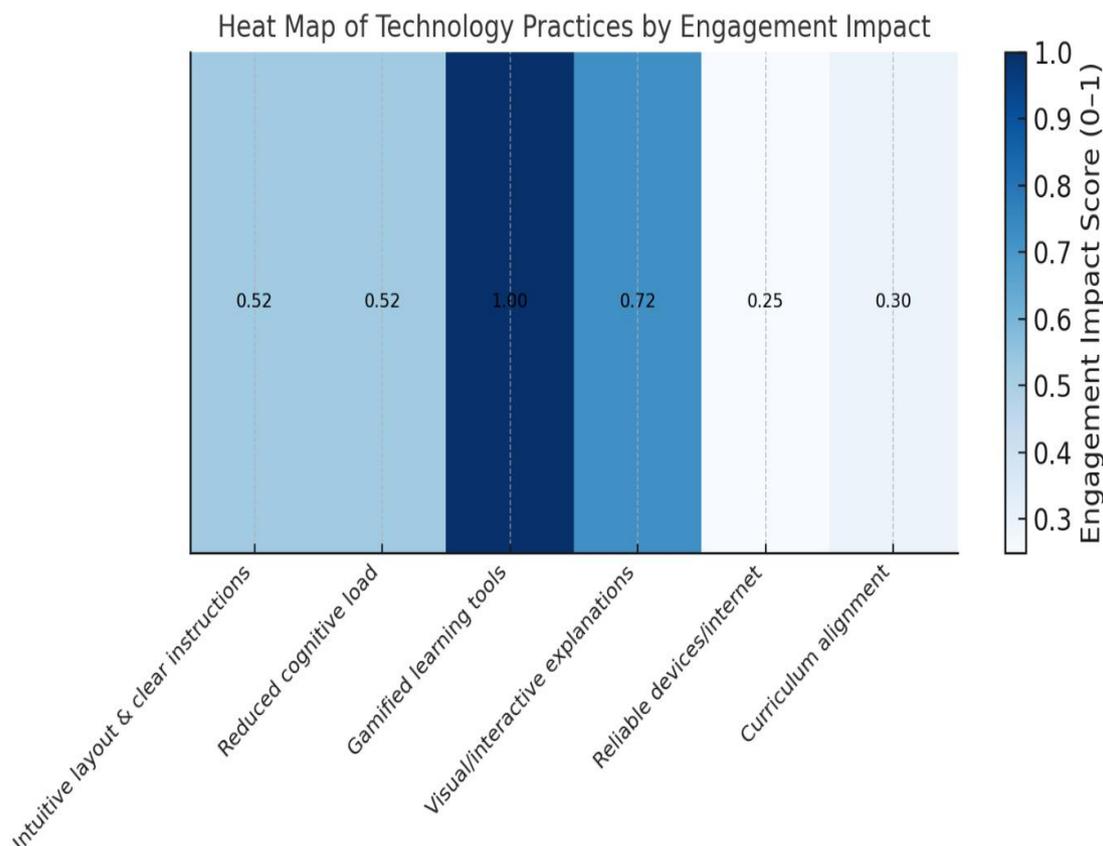


Figure 3 Heat Map of Quantitative Strength and Qualitative Frequency for Technology Integration Factors Influencing Learner Engagement

The heat map indicates that gamified learning tools and visual/interactive explanations had the most consistent impact on learner engagement, combining moderate statistical strength with frequent positive mentions from teachers. Ease-of-use features, such as intuitive layouts and reduced cognitive load, followed closely, facilitating smooth adoption, though with somewhat less sustained impact. Curriculum alignment and reliable devices/internet scored lower as direct engagement drivers, but the qualitative evidence emphasized their role as essential enablers, without which the benefits of ease of use and usefulness cannot be fully realized.

Discussion

This study examined the relationships between Perceived Ease of Use (PEOU), Perceived Usefulness (PU), and Learner Engagement (LE) in technology-integrated primary classrooms, guided by the Technology Acceptance Model (TAM). A convergent mixed-methods approach enabled both a quantitative assessment of these relationships and a qualitative exploration of teachers' lived experiences.

The quantitative findings revealed a moderate positive correlation between PEOU and LE ($r = .42, p < .01$), supporting H_01 . Regression analysis also showed



that PEOU significantly predicted learner engagement ($\beta = .22, p < .01$). Teachers who found technology intuitive and easy to operate reported smoother classroom experiences, as interfaces, simplified navigation, and prior training reduced cognitive effort and allowed them to focus on instructional delivery rather than troubleshooting. This aligns with earlier studies (Scherer et al., 2024; Wong, 2024), which argue that ease of use reduces educators' cognitive load, enabling more interactive and student-centered teaching. However, qualitative evidence revealed that ease of use alone was insufficient for sustained engagement: even simple tools failed to maintain interest if they lacked clear pedagogical value. This foreshadowed the relatively greater predictive influence of PU in the regression analysis.

PU demonstrated a moderate positive correlation with LE ($r = .51, p < .01$) and emerged as the stronger predictor in the regression model ($\beta = .29, p < .001$), supporting H₀₂ and H₀₃. Teachers consistently reported that their continued use of technology was driven by visible improvements in student comprehension, focus, and participation. Gamified tools, interactive simulations, and real-time feedback were particularly valued, as they linked directly to curriculum objectives and learning outcomes. This finding echoes the studies of Luo (2023), & Xu et al. (2025), who argued that in educational contexts, the perception of improved student learning is the most decisive factor in continued technology adoption.

The convergent mixed-methods approach enabled a richer interpretation of results:

- **Quantitative evidence** confirmed that both PEOU and PU significantly predicted learner engagement.
- **Qualitative narratives** clarified why PU was the stronger influence: teachers were more likely to sustain technology use when they saw tangible academic benefits.
- **Integrated insights** suggest that PEOU facilitates initial adoption, while PU ensures long-term integration and meaningful engagement.

These findings can also be interpreted through Self-Determination Theory (SDT) and Flow Theory, both introduced earlier in the literature review. From an SDT perspective, PEOU enhances teachers' sense of competence, as intuitive and low-effort tools reduce strain and build confidence in using technology. PU aligns with autonomy and internalized value, as teachers are more motivated to sustain technology use when they perceive it as advancing curricular goals and improving student learning outcomes. Together, these processes satisfy key psychological needs that energize engagement.

From a Flow perspective, PU supports the challenge, skill balance: tools that yield meaningful learning benefits enable teachers and students to remain in states of focused involvement. PEOU ensures that the "skill" side of this balance is attainable by lowering operational barriers, while PU provides the "challenge" that keeps engagement purposeful and rewarding.

Synthesizing both frameworks, the results suggest that PEOU primarily facilitates initial adoption by fostering competence, whereas PU drives sustained engagement by supplying autonomy and value. Together, they underpin the behavioral, emotional, and cognitive dimensions of learner engagement observed in this study, while contextual barriers such as infrastructure and curriculum alignment help explain why the model explained only 34% of engagement



variance.

Limitations

- i. The study relied on self-reported perceptions, which may be affected by social desirability bias and lack of direct observational data on student engagement.
- ii. The study was conducted only in Rawalpindi; the findings may have limited generalizability to regions with different technological infrastructures and school resources.
- iii. The cross-sectional design restricts causal inferences, and variations in technology type and quality across schools were not controlled for, which could have influenced PEOU and PU scores.

Conclusion

This study shows that both perceived ease of use (PEOU) and perceived usefulness (PU) significantly shape learner engagement in primary school classrooms, with PU proving to be the stronger driver. In practice, this means that while teachers need technology to be simple and intuitive to get started, its real classroom value comes from usefulness, whether it improves student focus, comprehension, and participation. The study extends TAM by shifting the emphasis from technology *adoption* to its impact on *learner engagement*, a key outcome for primary education. At the same time, the findings highlight that without reliable infrastructure and curriculum alignment, the benefits of PEOU and PU may not fully translate into sustained engagement. In short, ease of use opens the door, but usefulness and the right conditions keep teachers and students inside.

Recommendations

Based on this study's findings following recommendations are suggested:

- i. Teachers should engage in hands-on professional development that emphasizes both operating digital tools and applying them effectively in lessons.
- ii. Classroom technologies should be selected for clear alignment with curriculum outcomes and their ability to foster active student participation.
- iii. Schools should ensure reliable infrastructure, including adequate devices and stable internet, to reduce classroom disruptions.
- iv. On-site technical support should be provided so teachers can concentrate on pedagogy rather than troubleshooting.
- v. Policymakers should make digital pedagogy training a standard part of teacher education and continuous professional development.
- vi. Government-endorsed technologies should undergo usability and pedagogical effectiveness testing before being scaled across schools.

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