

Digital Technology Application and Students' Learning Experience in Higher Education

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ABSTRACT:

This study develops and evaluates a reproducible analytical framework for examining how digital technology application may shape students' learning experience in higher education. The Vietnamese higher-education context provides the policy motivation: national digital-transformation initiatives require institutions to move beyond platform deployment and evaluate the learning conditions created by digital services. The measurement model satisfies conventional quality criteria: outer loadings range from 0.778 to 0.885, Cronbach's alpha from 0.870 to 0.905, composite reliability from 0.907 to 0.930, average variance extracted from 0.662 to 0.760, and the highest HTMT value is 0.642. The model explains 52.0% of the variance in learning experience. Digital technology application has the strongest direct association with perceived ease of use ($\beta = 0.512$), while ease of use, usefulness, and engagement each transmit a statistically significant portion of the relationship with learning experience.

Keywords: Composite path modeling; digital technology application; higher education; learning experience; student engagement

1. Introduction

Digital transformation has become a strategic concern for higher education systems because universities are expected to provide learning opportunities that are accessible, flexible, resilient, and responsive to diverse student needs. In Viet Nam, this agenda is embedded in the National Digital Transformation Program approved under Decision No. 749/QĐ-TTg and the education-sector project on information-technology

application and digital transformation approved under Decision No. 131/QĐ-TTg. The OECD Digital Education Outlook 2023 likewise frames digital education as an ecosystem involving governance, infrastructure, human capacity, digital resources, and evaluation rather than as a narrow procurement exercise.

The availability of technology does not automatically generate educational value. A university may deploy learning-management

systems, video-conferencing platforms, digital repositories, online assessment tools, and administrative applications while students continue to face unstable access, fragmented interfaces, inconsistent course structures, delayed feedback, or limited opportunities for meaningful interaction. The relevant analytical question is not only whether a technology is available, but whether its application improves the conditions under which students learn.

Students' learning experience is broader than login frequency, platform acceptance, or the intention to use a specific application. It concerns how students navigate, interpret, and benefit from the digital learning environment. A positive experience is associated with manageable effort, visible academic value, sustained engagement, coherent learning activities, and reliable access to resources and support. This distinction matters because high usage statistics may coexist with weak pedagogical integration when technology is used largely for compliance or administrative convenience.

Technology-acceptance research provides a useful theoretical foundation for investigating these mechanisms. Davis (1989) identified perceived usefulness and perceived ease of use as central determinants of user responses to information systems. Later developments incorporated system quality, social influence, enjoyment, and intervention design (Venkatesh & Davis, 2000; Venkatesh & Bala, 2008; Abdullah & Ward, 2016). The information-systems success literature further emphasizes system quality and service quality (DeLone & McLean, 2003), while student-engagement research highlights participation, attention, interaction, and persistence as integral to educational experience (Kahu, 2013).

The present study integrates these perspectives into a student-facing structural framework. Digital technology application is modeled as the quality with which digital services are embedded in academic activities. Students' learning experience is specified as the principal educational outcome, while perceived

ease of use, perceived usefulness, and student engagement represent explanatory mechanisms.

The study addresses three research questions. First, can a student-facing model of digital technology application and learning experience be operationalized with internally consistent reflective measures? Second, how do ease of use, usefulness, and engagement transmit the simulated relationship between digital application quality and learning experience? Third, what institutional questions should be prioritized when the framework is transferred from a transparent to a real multi-institution study?

2. Theoretical Background and Hypothesis Development

2.1. Digital technology application as a student-facing construct

Digital technology application in higher education should be evaluated at the point where institutional systems meet students' everyday academic activities. A platform-centered approach counts licenses, accounts, or online courses. A student-facing approach asks whether systems operate reliably, whether resources can be accessed across commonly available devices, whether digital tasks are integrated clearly into course requirements, whether materials are organized consistently, and whether support is available when difficulties arise.

This definition is informed by the information-systems success literature. DeLone and McLean (2003) emphasized the role of system quality and service quality in shaping user responses. In a higher-education environment, technical performance and service coherence are not peripheral conditions. They influence whether students can participate efficiently and whether digital activities support rather than obstruct learning.

2.2. Perceived ease of use and perceived usefulness

Perceived ease of use refers to the degree to which a student believes that using required

digital systems is understandable and manageable. Complexity, inconsistent navigation, fragmented authentication, poorly organized materials, and unclear submission procedures create avoidable transaction costs. A coherent digital environment should reduce these costs. Accordingly, stronger digital technology application is expected to improve perceived ease of use.

Perceived usefulness concerns the degree to which digital technologies are believed to improve academic performance, productivity, access to learning resources, and the effectiveness of study. Reliable and well-integrated technologies should make academic value more visible. Ease of use may also strengthen usefulness because students are more likely to recognize the benefits of a system when unnecessary effort has been reduced.

2.3. Student engagement and learning experience

Student engagement captures participation, attention, interaction, and persistence in digitally supported activities. Engagement is not identical to attendance. Students may access a platform without contributing to discussion, retrieving feedback, collaborating with peers, or persisting with demanding tasks. Digital technologies can support engagement when they provide stable access, clear structure, timely interaction, and meaningful opportunities to participate.

Students' learning experience is the principal outcome in the proposed model. It reflects an overall evaluation of access, coherence, interaction, support, and academic value. The model does not treat learning experience as a synonym for satisfaction or platform use. It is a broader educational

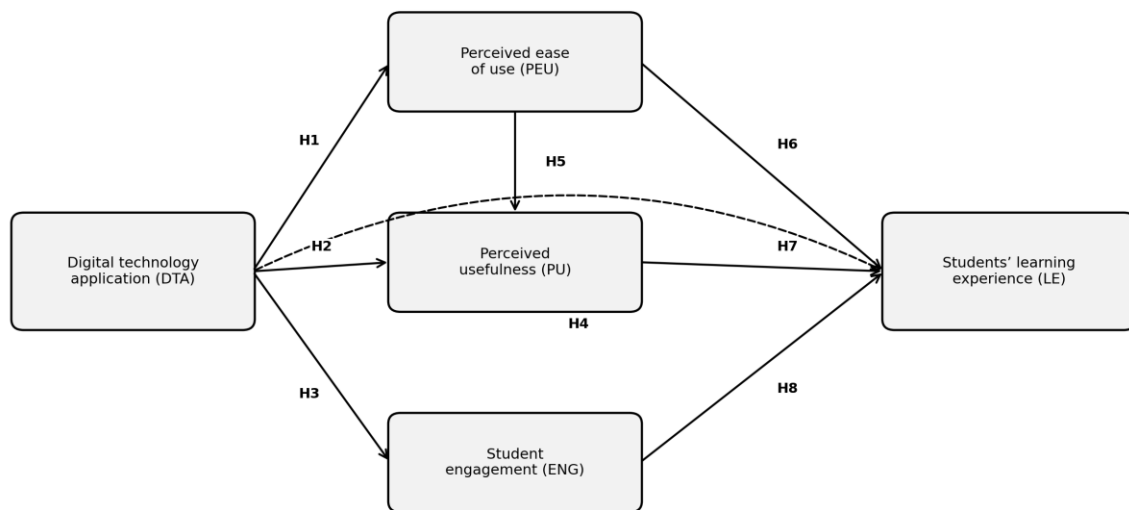
construct that should be interpreted alongside, rather than replaced by, usage statistics.

2.4. Hypotheses and conceptual model

Table 1. Hypotheses examined in the -based model

Hypothesis	Statement
H1	Digital technology application is positively associated with perceived ease of use.
H2	Digital technology application is positively associated with perceived usefulness.
H3	Digital technology application is positively associated with student engagement.
H4	Digital technology application is positively associated with students' learning experience.
H5	Perceived ease of use is positively associated with perceived usefulness.
H6	Perceived ease of use is positively associated with students' learning experience.
H7	Perceived usefulness is positively associated with students' learning experience.
H8	Student engagement is positively associated with students' learning experience.

The proposed relationships are summarized in Figure 1. The direct DTA → LE pathway is retained alongside the mediated routes because institutional digital quality may influence learning experience through mechanisms that are not fully captured by ease of use, usefulness, and engagement.

Conceptual model for the simulation-based methodological study

Note: the dashed arrow denotes the direct DTA → LE pathway retained alongside the three mediated mechanisms.

Figure 1. Conceptual model for the -based

3. Method

3.1. Constructs and measurement specification

Table 2. Constructs and operational definitions

Construct	Code	Items	Operational definition	Primary scale basis
Digital technology application	DTA	5	Reliability, accessibility, instructional integration, organization of resources, and support in the student-facing digital ecosystem.	DeLone & McLean (2003); Davis (1989); Venkatesh & Davis (2000)
Perceived ease of use	PEU	4	The degree to which students perceive required digital academic systems as understandable and manageable.	Davis (1989); Venkatesh & Bala (2008)
Perceived usefulness	PU	4	The perceived contribution of digital technologies to academic performance, productivity, and learning effectiveness.	Davis (1989); Venkatesh & Davis (2000)
Student engagement	ENG	4	Participation, attention, interaction, and persistence in digitally supported learning activities.	Kahu (2013); Davis (1989); Venkatesh & Davis (2000)
Students' learning experience	LE	5	An overall evaluation of access, coherence, interaction, support, and academic value in the digital learning environment.	Davis (1989); Venkatesh & Davis (2000)

All items use a five-point response scale ranging from 1 (strongly disagree) to 5 (strongly agree).

3.3. Synthetic dataset and scenario construction

The synthetic dataset contains 612 valid records. Each record includes seven profile variables and 22 reflective indicators. The profile variables describe gender, academic year, institution type, primary device, internet stability, field of study, and region.

The indicator values were generated as a bounded five-point Likert-style dataset with

internally coherent relationships among the five constructs. The scenario was calibrated so that digital technology application contributes to ease of use, usefulness, engagement, and learning experience; ease of use contributes to usefulness and learning experience; and usefulness and engagement contribute to learning experience. The synthetic dataset is supplied with the manuscript so that all numerical outputs can be checked independently.

Table 3. Synthetic scenario profile (N = 612)

Variable	Category	Number	Percentage (%)
Gender	Female	364	59.48
	Male	234	38.24
	Other / prefer not to state	14	2.29
Academic Year	Year 2	181	29.58
	Year 3	170	27.78
	Year 1	156	25.49
	Year 4 or above	105	17.16
Institution Type	Public	444	72.55
	Private / other	168	27.45
Device	Laptop / desktop	399	65.20
	Smartphone	180	29.41
	Tablet / other	33	5.39
Internet Stability	Stable	320	52.29
	Sometimes unstable	247	40.36
	Frequently unstable	45	7.35
Region	Northern Viet Nam	251	41.01
	Southern Viet Nam	228	37.25
	Central Viet Nam	133	21.73

3.4. Analytical strategy

The analysis follows the evaluation logic used in reflective composite path modeling and PLS-SEM reporting (Hair et al., 2022). To maximize reproducibility without proprietary software, each construct score is calculated as the standardized mean of its standardized

indicators. Structural relationships are then estimated as standardized ordinary least-squares regressions among the composite scores. This deterministic specification is intentionally simpler than a software-specific implementation of PLS-SEM and should be interpreted as a transparent composite path-

model .

Measurement quality is assessed using outer loadings, Cronbach's alpha, composite reliability, average variance extracted (AVE), and the heterotrait-monotrait ratio (HTMT). Structural interpretation uses standardized path coefficients, bootstrap confidence intervals, inner-model variance-inflation factors (VIF), f^2 effect sizes, explained variance (R^2), and ten-fold cross-validated construct-score Q^2 prediction statistics. The analysis script uses 1,500 bootstrap resamples and is supplied with the synthetic dataset. Positive Q^2 values indicate that the cross-validated model predictions outperform the training-mean benchmark at the construct-score level.

4. Results

4.1. Descriptive statistics

Table 4. Construct-level descriptive statistics in the synthetic dataset

Co de	Const ruct	M ea n	S D	Mini mum	Maxi mum
D T A	Digital technology application (DTA)	3.43	0.96	1.00	5.00
PE U	Perceived ease of use (PEU)	3.63	0.99	1.00	5.00
P U	Perceived usefulness (PU)	3.44	1.04	1.00	5.00
E N G	Student engagement (ENG)	3.28	1.03	1.00	5.00

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LE	Students' learning experience (LE)	3.42	1.03	1.00	5.00

The simulated construct means range from 3.28 for student engagement to 3.63 for perceived ease of use.

4.2. Measurement-model assessment

Table 5. Reflective measurement-model quality criteria

Con stru ct	Loa din g ran ge	Cron bach 's alph a	Com posit e reli ability	A V E	Asses smen t
DT A	0.778–0.845	0.872	0.907	0.662	Acce ptable
PEU	0.837–0.867	0.877	0.915	0.730	Acce ptable
PU	0.855–0.885	0.895	0.927	0.760	Acce ptable
EN G	0.821–0.861	0.870	0.911	0.719	Acce ptable
LE	0.825–0.884	0.905	0.930	0.726	Acce ptable

All outer loadings exceed 0.70. Cronbach's alpha and composite reliability exceed 0.80, while AVE values exceed 0.50. In the scenario, the indicators therefore display satisfactory internal consistency and convergent validity.

Table 6. HTMT discriminant-validity assessment

Construct	DTA	PEU	PU	ENG	LE
DTA	—	0.585	0.642	0.509	0.638
PEU		—	0.582	0.280	0.641
PU			—	0.270	0.638
ENG				—	0.5

					00
LE					—

The highest HTMT value is 0.642, observed between DTA and PU. All values remain below the conservative 0.85 threshold, supporting discriminant validity within the simulated measurement structure.

4.3. Structural-model results

Table 7. Standardized structural-path estimates in the synthetic scenario

Hyp.	Path	β	t-value	p-value	Bootstrap 95% CI	Decision
H1	DTA $\rightarrow$ PEU	0.512	16.615	< .001	[0.448, 0.568]	Supported
H2	DTA $\rightarrow$ PU	0.411	11.358	< .001	[0.340, 0.478]	Supported
H3	DTA $\rightarrow$ ENG	0.443	13.365	< .001	[0.376, 0.507]	Supported
H4	DTA $\rightarrow$ LE	0.155	3.755	< .001	[0.071, 0.234]	Supported
H5	PEU $\rightarrow$ PU	0.305	8.377	< .001	[0.234, 0.374]	Supported
H6	PEU $\rightarrow$ LE	0.289	8.287	< .001	[0.223, 0.354]	Supported
H7	PU $\rightarrow$ LE	0.281	7.606	< .001	[0.211, 0.355]	Supported
H8	ENG $\rightarrow$ LE	0.238	7.798	< .001	[0.180, 0.300]	Supported

All eight paths are statistically supported in the synthetic scenario. The largest direct association is DTA $\rightarrow$ PEU ($\beta = 0.512$), followed by DTA $\rightarrow$ ENG ($\beta = 0.443$) and DTA $\rightarrow$ PU ($\beta = 0.411$). Learning experience is associated with perceived ease of use ($\beta =$

0.289), perceived usefulness ($\beta = 0.281$), student engagement ($\beta = 0.238$), and a smaller remaining direct effect of digital technology application ($\beta = 0.155$).

4.4. Explanatory power, predictive assessment, and mediation

Table 8. Explained variance and construct-score predictive assessment

Endogenous construct	R ²	Q ² prediction statistic	Assessment
PEU	0.262	0.257	Positive cross-validated predictive relevance
PU	0.390	0.388	Positive cross-validated predictive relevance
ENG	0.196	0.195	Positive cross-validated predictive relevance
LE	0.520	0.514	Positive cross-validated predictive relevance

The model explains 52.0% of the variance in students' learning experience. Positive cross-validated Q^2 prediction statistics are obtained

Table 9. Indirect effects in the synthetic scenario

Indirect pathway	Effect	t-value	p-value	Bootstrap 95% CI	Assessment
DTA → PEU → LE	0.148	7.098	< .001	[0.109, 0.189]	Significant
DTA → PU → LE	0.115	5.908	< .001	[0.080, 0.158]	Significant
DTA → ENG → LE	0.105	6.707	< .001	[0.076, 0.138]	Significant
DTA → PEU → PU → LE	0.044	5.535	< .001	[0.030, 0.061]	Significant

The four indirect pathways are statistically significant. Digital technology application is connected to learning experience through ease of use, usefulness, engagement, and the sequential route from ease of use to usefulness. Because the direct DTA → LE pathway also remains significant, the pattern is consistent with complementary partial mediation within the constructed dataset.

5. Discussion

This study examines the mechanisms through which digital technology application quality contributes to students' learning experience in higher education. The structural model provides consistent support for the proposed relationships and explains 52.0% of the variance in students' learning experience. The results indicate that the educational value of digital technologies does not arise solely from their availability. It depends on whether students perceive digital systems as accessible, manageable, useful for academic activities, and capable of supporting meaningful engagement.

5.1. Digital Technology Application Quality and Perceived Ease of Use

The strongest relationship in the structural model is the effect of digital technology application quality on perceived ease of use ($\beta = 0.512$, $p < .001$). This finding highlights usability as a central condition for the successful integration of technology into learning activities. Students are more likely to perceive digital systems as easy to use when platforms are stable, logically organized,

for all endogenous constructs, indicating that the simulated model outperforms the training-mean benchmark at the construct-score level.

accessible across devices, and supported by clear procedures.

This result is consistent with the Technology Acceptance Model, which identifies perceived ease of use as a key determinant of users' responses to digital systems. In higher education, usability is not limited to interface design. It also includes the clarity of course organization, the consistency of navigation structures, the simplicity of assignment-submission procedures, the accessibility of learning resources, and the availability of timely technical support. Even relatively advanced platforms may create limited educational value when students encounter avoidable procedural barriers.

The practical implication is that institutions should evaluate digital applications from the perspective of the learner journey. A platform may meet technical specifications while still generating unnecessary friction in everyday academic activities. Regular usability reviews, student feedback mechanisms, and the standardization of core digital-learning procedures can help reduce these barriers.

5.2. Digital Technology Application Quality and Perceived Usefulness

Digital technology application quality also has a significant positive effect on perceived usefulness ($\beta = 0.411$, $p < .001$). Students are more likely to recognize the value of digital systems when these systems provide reliable access to learning materials, facilitate

communication, support academic tasks, and improve the efficiency of the learning process.

This finding reinforces the distinction between technological deployment and educational integration. Deployment concerns the provision of infrastructure, software, and digital platforms. Educational integration concerns whether these technologies contribute meaningfully to teaching and learning activities. A university may invest in multiple platforms without necessarily improving students' learning experience. The value of technology becomes visible only when it supports clear academic purposes.

Perceived ease of use also has a significant positive effect on perceived usefulness ($\beta = 0.305$, $p < .001$). This result suggests that usability and academic value are closely connected. When students can operate digital systems without excessive effort, they are more likely to recognize the contribution of those systems to learning performance. Conversely, complex procedures and fragmented platforms can reduce the perceived value of digital applications, even when their technical capabilities are substantial.

The relationship between ease of use and usefulness has important implications for institutional decision-making. Universities should avoid treating technical design and pedagogical effectiveness as separate issues. Digital applications should be evaluated according to both operational simplicity and their contribution to learning outcomes.

5.3. Digital Technology Application Quality and Student Engagement

The relationship between digital technology application quality and student engagement is also positive and statistically significant ($\beta = 0.443$, $p < .001$). This finding extends the analysis beyond technology acceptance. Digital systems influence not only whether students can access learning activities, but also whether they participate actively and remain involved throughout the learning process.

High-quality digital environments can support student engagement through timely communication, interactive learning activities, collaborative tools, structured feedback, and continuous access to academic resources. By contrast, unstable platforms, unclear instructions, and fragmented learning environments may reduce students' willingness to participate, even when formal attendance remains high.

This distinction is particularly important for higher education institutions that rely on administrative indicators such as login frequency, platform activation rates, or online attendance. These indicators capture access but do not necessarily reflect substantive engagement. A student may log into a system regularly without actively interacting with learning resources, contributing to collaborative tasks, or using feedback to improve academic performance.

Institutions should therefore combine technical indicators with measures of student participation and engagement. Such an approach can provide a more accurate assessment of the effectiveness of digital-learning strategies.

5.4. Direct and Indirect Effects on Students' Learning Experience

Digital technology application quality has a positive direct effect on students' learning experience ($\beta = 0.155$, $p < .001$). However, the magnitude of this direct relationship is smaller than the combined indirect effects transmitted through perceived ease of use, perceived usefulness, and student engagement.

This finding provides an important interpretation of digital transformation in higher education. Technology does not improve learning experience automatically. Its effect depends on the mechanisms through which students encounter, understand, and use digital systems. Digital applications are more likely to generate positive learning experiences when they reduce unnecessary effort, support

academic tasks, and encourage active participation.

Among the direct predictors of students' learning experience, perceived ease of use has the largest effect ($\beta = 0.289$, $p < .001$), followed by perceived usefulness ($\beta = 0.281$, $p < .001$) and student engagement ($\beta = 0.238$, $p < .001$). These results demonstrate that learning experience is multidimensional. Students need digital systems that are manageable, educationally valuable, and capable of sustaining participation.

The mediation results further clarify this pathway. The indirect effect of digital technology application quality on learning experience through perceived ease of use is statistically significant ($\beta = 0.148$, $p < .001$). The indirect effects through perceived usefulness ($\beta = 0.115$, $p < .001$) and student engagement ($\beta = 0.105$, $p < .001$) are also significant. In addition, the sequential pathway from digital technology application quality to perceived ease of use, perceived usefulness, and learning experience is supported ($\beta = 0.044$, $p < .001$).

Because the direct effect remains significant after the mediating variables are included, the results indicate complementary partial mediation. Digital technology application quality influences learning experience both directly and indirectly. The indirect pathways are especially important because they explain how technical quality is translated into educational value.

5.5. Explanatory and Predictive Capacity of the Model

The model explains 26.2% of the variance in perceived ease of use, 39.0% of the variance in perceived usefulness, 19.6% of the variance in student engagement, and 52.0% of the variance in students' learning experience. These values indicate that the framework captures a substantial proportion of the learning-experience pathway.

The predictive assessment also supports the relevance of the model. The Q^2_{predict} values

are positive for all endogenous constructs: 0.257 for perceived ease of use, 0.388 for perceived usefulness, 0.195 for student engagement, and 0.514 for students' learning experience. These results indicate that the proposed model has meaningful predictive relevance.

The variance inflation factor values remain within acceptable limits, suggesting that multicollinearity does not distort the estimated structural relationships. The measurement model also demonstrates satisfactory reliability and validity. The outer loadings, composite reliability values, average variance extracted values, and HTMT ratios meet commonly accepted thresholds. Taken together, these results support the internal consistency and discriminant validity of the proposed constructs.

5.6. Theoretical Implications

This study contributes to the literature in three ways.

First, it extends the analysis of digital transformation beyond the availability of infrastructure. The findings show that digital technology application quality should be evaluated through its influence on usability, perceived academic value, student engagement, and overall learning experience.

Second, the study integrates technology-acceptance variables with student engagement. Traditional acceptance models emphasize perceived ease of use and perceived usefulness. The present framework demonstrates that engagement is also an important mechanism through which digital technologies influence learning experience. This addition is particularly relevant in higher education, where the objective is not merely to encourage system adoption but to support active and meaningful learning.

Third, the mediation results provide a more detailed explanation of the relationship between technology quality and learning experience. The findings show that technical improvements create educational value

primarily when they are translated into manageable learning processes, visible academic benefits, and stronger student participation.

5.7. Managerial Implications

The findings suggest several priorities for higher education institutions.

First, universities should establish minimum student-facing quality standards for digital applications. These standards should cover system stability, access speed, device compatibility, navigation clarity, material organization, assignment procedures, feedback channels, and technical-support arrangements.

Second, institutions should reduce unnecessary platform fragmentation. The use of multiple systems for similar learning activities may increase cognitive load and create avoidable barriers. A coherent digital ecosystem with predictable procedures can improve perceived ease of use and strengthen students' recognition of academic value.

Third, staff-development programs should focus on pedagogical integration rather than technical operation alone. Lecturers need support in using digital applications to organize interactive activities, facilitate collaboration, provide timely feedback, and align online tasks with learning outcomes.

Fourth, universities should evaluate digital transformation through a balanced set of indicators. Technical metrics such as login frequency and platform availability remain important, but they should be complemented by evidence on usability, perceived usefulness, student engagement, and learning experience.

Finally, institutional strategies should recognize differences in students' digital conditions. Device availability, connectivity, prior experience, and access to support may influence how students interact with digital systems. Differentiated support measures can help ensure that digital transformation contributes to educational quality without widening existing inequalities.

5.8. Limitations and Directions for Further Research

The findings should be interpreted with appropriate caution. The proposed model focuses on a selected set of determinants and does not capture every factor that may influence students' learning experience. Lecturer capability, instructional design, assessment quality, peer interaction, students' self-regulation skills, digital literacy, connectivity conditions, and socioeconomic characteristics may also be relevant.

Future research should extend the framework by incorporating these variables and examining differences across institution types, academic disciplines, regions, and student groups. Multi-group analysis may help identify whether the structural relationships vary according to students' digital conditions or academic backgrounds.

Longitudinal designs would also provide valuable insights. Such designs could examine whether improvements in digital technology application quality generate sustained changes in student engagement and learning experience over time. Further research may also explore how emerging technologies, including artificial-intelligence-supported learning systems, influence the relationships identified in the present model.

6. Conclusion

This study develops and evaluates a student-centered model of digital technology application in higher education. The results show that digital technology application quality contributes to students' learning experience through multiple complementary pathways. High-quality digital systems improve perceived ease of use, strengthen perceived usefulness, and support student engagement. These factors, in turn, contribute to a more positive learning experience.

The model explains 52.0% of the variance in students' learning experience and demonstrates meaningful predictive relevance. Perceived ease of use is the strongest direct predictor of

learning experience, followed by perceived usefulness and student engagement. The mediation results show that digital technology application quality influences learning experience not only directly but also indirectly through usability, academic value, and participation.

The findings underline a central principle: digital transformation in higher education should not be assessed solely by the number of platforms deployed, the volume of digital resources created, or the level of investment in technological infrastructure. Its success depends on whether digital systems are reliable, manageable, academically useful, and capable of supporting meaningful student engagement.

For higher education institutions, the managerial implication is clear. Digital transformation should be governed as an academic-quality process rather than as an isolated information-technology project. Universities need coherent digital ecosystems, student-facing quality standards, effective pedagogical integration, continuous staff development, differentiated student support, and monitoring systems that capture both technical performance and learning experience.

The proposed framework provides a structured basis for evaluating digital-learning quality and identifying priority areas for institutional improvement. It also offers a foundation for further research on how digital technologies can be integrated more effectively into teaching and learning processes in higher education.

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- as field-collected survey evidence.1.**
- Introduction**
- Digital transformation has become a strategic concern for higher education systems because universities are expected to provide learning opportunities that are accessible, flexible, resilient, and responsive to diverse student needs. In Viet Nam, this agenda is embedded in the National Digital Transformation Program approved under Decision No. 749/QĐ-TTg and the education-sector project on information-technology application and digital transformation approved under Decision No. 131/QĐ-TTg. The OECD Digital Education Outlook 2023 likewise frames digital education as an ecosystem involving governance, infrastructure, human capacity, digital resources, and evaluation rather than as a narrow procurement exercise.
- The availability of technology does not automatically generate educational value. A university may deploy learning-management systems, video-conferencing platforms, digital repositories, online assessment tools, and administrative applications while students continue to face unstable access, fragmented interfaces, inconsistent course structures, delayed feedback, or limited opportunities for meaningful interaction. The relevant analytical question is not only whether a technology is available, but whether its application improves the conditions under which students learn.
- Students' learning experience is broader than login frequency, platform acceptance, or the intention to use a specific application. It concerns how students navigate, interpret, and benefit from the digital learning environment. A positive experience is associated with manageable effort, visible academic value, sustained engagement, coherent learning activities, and reliable access to resources and support. This distinction matters because high usage statistics may coexist with weak

pedagogical integration when technology is used largely for compliance or administrative convenience.

Technology-acceptance research provides a useful theoretical foundation for investigating these mechanisms. Davis (1989) identified perceived usefulness and perceived ease of use as central determinants of user responses to information systems. Later developments incorporated system quality, social influence, enjoyment, and intervention design (Venkatesh & Davis, 2000; Venkatesh & Bala, 2008; Abdullah & Ward, 2016). The information-systems success literature further emphasizes system quality and service quality (DeLone & McLean, 2003), while student-engagement research highlights participation, attention, interaction, and persistence as integral to educational experience (Kahu, 2013).

The present study integrates these perspectives into a student-facing structural framework. Digital technology application is modeled as the quality with which digital services are embedded in academic activities. Students' learning experience is specified as the principal educational outcome, while perceived ease of use, perceived usefulness, and student engagement represent explanatory mechanisms.

The study addresses three research questions. First, can a student-facing model of digital technology application and learning experience be operationalized with internally consistent reflective measures? Second, how do ease of use, usefulness, and engagement transmit the simulated relationship between digital application quality and learning experience? Third, what institutional questions should be prioritized when the framework is transferred from a transparent to a real multi-institution study?

2. Theoretical Background and Hypothesis Development

2.1. Digital technology application as a student-facing construct

Digital technology application in higher

education should be evaluated at the point where institutional systems meet students' everyday academic activities. A platform-centered approach counts licenses, accounts, or online courses. A student-facing approach asks whether systems operate reliably, whether resources can be accessed across commonly available devices, whether digital tasks are integrated clearly into course requirements, whether materials are organized consistently, and whether support is available when difficulties arise.

This definition is informed by the information-systems success literature. DeLone and McLean (2003) emphasized the role of system quality and service quality in shaping user responses. In a higher-education environment, technical performance and service coherence are not peripheral conditions. They influence whether students can participate efficiently and whether digital activities support rather than obstruct learning.

2.2. Perceived ease of use and perceived usefulness

Perceived ease of use refers to the degree to which a student believes that using required digital systems is understandable and manageable. Complexity, inconsistent navigation, fragmented authentication, poorly organized materials, and unclear submission procedures create avoidable transaction costs. A coherent digital environment should reduce these costs. Accordingly, stronger digital technology application is expected to improve perceived ease of use.

Perceived usefulness concerns the degree to which digital technologies are believed to improve academic performance, productivity, access to learning resources, and the effectiveness of study. Reliable and well-integrated technologies should make academic value more visible. Ease of use may also strengthen usefulness because students are more likely to recognize the benefits of a system when unnecessary effort has been reduced.

2.3. Student engagement and learning experience

Student engagement captures participation, attention, interaction, and persistence in digitally supported activities. Engagement is not identical to attendance. Students may access a platform without contributing to discussion, retrieving feedback, collaborating with peers, or persisting with demanding tasks. Digital technologies can support engagement when they provide stable access, clear structure, timely interaction, and meaningful opportunities to participate.

examined in the -based model

Students' learning experience is the principal outcome in the proposed model. It reflects an overall evaluation of access, coherence, interaction, support, and academic value. The model does not treat learning experience as a synonym for satisfaction or platform use. It is a broader educational construct that should be interpreted alongside, rather than replaced by, usage statistics.

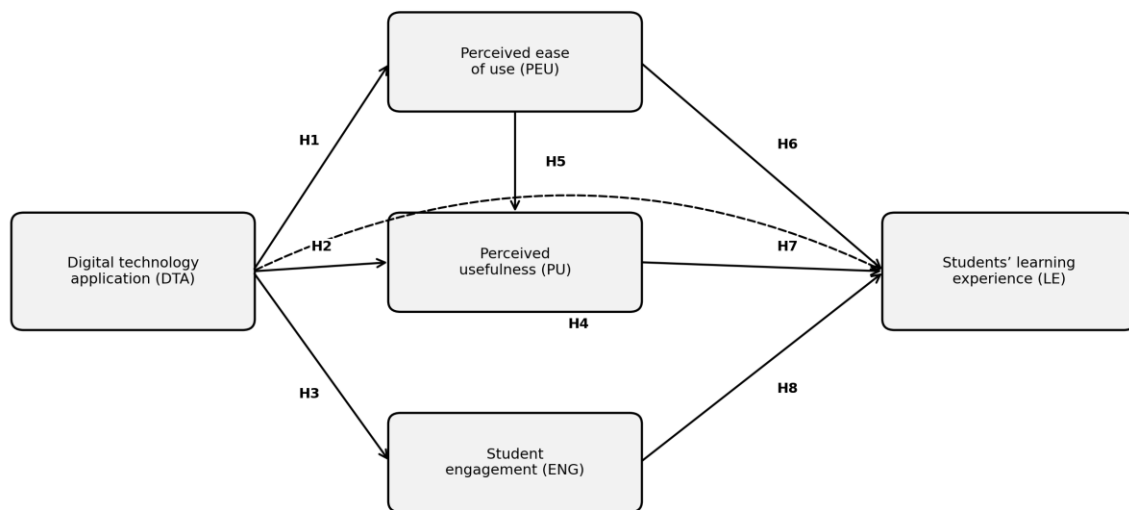
2.4. Hypotheses and conceptual model

Table 1. Hypotheses

Hypothesis	Statement
H1	Digital technology application is positively associated with perceived ease of use.
H2	Digital technology application is positively associated with perceived usefulness.
H3	Digital technology application is positively associated with student engagement.
H4	Digital technology application is positively associated with students' learning experience.
H5	Perceived ease of use is positively associated with perceived usefulness.
H6	Perceived ease of use is positively associated with students' learning experience.
H7	Perceived usefulness is positively associated with students' learning experience.
H8	Student engagement is positively associated with students' learning experience.

The proposed relationships are summarized in Figure 1. The direct DTA → LE pathway is retained alongside the mediated routes because institutional digital quality may

influence learning experience through mechanisms that are not fully captured by ease of use, usefulness, and engagement.

Conceptual model for the simulation-based methodological study

Note: the dashed arrow denotes the direct DTA → LE pathway retained alongside the three mediated mechanisms.

3. Method

3.1. Constructs and measurement specification

Figure 1. Conceptual model for the -based

Table 2. Constructs and operational definitions

Construct	Code	Items	Operational definition	Primary scale basis
Digital technology application	DTA	5	Reliability, accessibility, instructional integration, organization of resources, and support in the student-facing digital ecosystem.	DeLone & McLean (2003); Davis (1989); Venkatesh & Davis (2000)
Perceived ease of use	PEU	4	The degree to which students perceive required digital academic systems as understandable and manageable.	Davis (1989); Venkatesh & Bala (2008)
Perceived usefulness	PU	4	The perceived contribution of digital technologies to academic performance, productivity, and learning effectiveness.	Davis (1989); Venkatesh & Davis (2000)
Student engagement	ENG	4	Participation, attention, interaction, and persistence in digitally supported learning activities.	Kahu (2013); Davis (1989); Venkatesh & Davis (2000)
Students' learning experience	LE	5	An overall evaluation of access, coherence, interaction, support, and academic value in the digital learning environment.	Davis (1989); Venkatesh & Davis (2000)

All items use a five-point response scale ranging from 1 (strongly disagree) to 5 (strongly agree).

3.3. Synthetic dataset and scenario construction

The synthetic dataset contains 612 valid records. Each record includes seven profile variables and 22 reflective indicators. The profile variables describe gender, academic year, institution type, primary device, internet stability, field of study, and region.

The indicator values were generated as a bounded five-point Likert-style dataset with

Table 3. Synthetic scenario profile (N = 612)

Variable	Category	Number	Percentage (%)
Gender	Female	364	59.48
	Male	234	38.24
	Other / prefer not to state	14	2.29
Academic Year	Year 2	181	29.58
	Year 3	170	27.78
	Year 1	156	25.49
	Year 4 or above	105	17.16
Institution Type	Public	444	72.55
	Private / other	168	27.45
Device	Laptop / desktop	399	65.20
	Smartphone	180	29.41
	Tablet / other	33	5.39
Internet Stability	Stable	320	52.29
	Sometimes unstable	247	40.36
	Frequently unstable	45	7.35
Region	Northern Viet Nam	251	41.01
	Southern Viet Nam	228	37.25
	Central Viet Nam	133	21.73

3.4. Analytical strategy

The analysis follows the evaluation logic used in reflective composite path modeling and PLS-SEM reporting (Hair et al., 2022). To maximize reproducibility without proprietary software, each construct score is calculated as the standardized mean of its standardized

internally coherent relationships among the five constructs. The scenario was calibrated so that digital technology application contributes to ease of use, usefulness, engagement, and learning experience; ease of use contributes to usefulness and learning experience; and usefulness and engagement contribute to learning experience. The synthetic dataset is supplied with the manuscript so that all numerical outputs can be checked independently.

indicators. Structural relationships are then estimated as standardized ordinary least-squares regressions among the composite scores. This deterministic specification is intentionally simpler than a software-specific implementation of PLS-SEM and should be interpreted as a transparent composite path-

model .

Measurement quality is assessed using outer loadings, Cronbach's alpha, composite reliability, average variance extracted (AVE), and the heterotrait-monotrait ratio (HTMT). Structural interpretation uses standardized path coefficients, bootstrap confidence intervals, inner-model variance-inflation factors (VIF), f^2 effect sizes, explained variance (R^2), and ten-

fold cross-validated construct-score Q^2 prediction statistics. The analysis script uses 1,500 bootstrap resamples and is supplied with the synthetic dataset. Positive Q^2 values indicate that the cross-validated model predictions outperform the training-mean benchmark at the construct-score level.

4. Results

4.1. Descriptive statistics

Table 4. Construct-level descriptive statistics in the synthetic dataset

Code	Construct	Mean	SD	Minimum	Maximum
DTA	Digital technology application (DTA)	3.43	0.96	1.00	5.00
PEU	Perceived ease of use (PEU)	3.63	0.99	1.00	5.00
PU	Perceived usefulness (PU)	3.44	1.04	1.00	5.00
ENG	Student engagement (ENG)	3.28	1.03	1.00	5.00
LE	Students' learning experience (LE)	3.42	1.03	1.00	5.00

The simulated construct means range from 3.28 for student engagement to 3.63 for

perceived ease of use.

4.2. Measurement-model assessment

Table 5. Reflective measurement-model quality criteria

Construct	Loading range	Cronbach's alpha	Composite reliability	AVE	Assessment
DTA	0.778–0.845	0.872	0.907	0.662	Acceptable
PEU	0.837–0.867	0.877	0.915	0.730	Acceptable
PU	0.855–0.885	0.895	0.927	0.760	Acceptable
ENG	0.821–0.861	0.870	0.911	0.719	Acceptable
LE	0.825–0.884	0.905	0.930	0.726	Acceptable

All outer loadings exceed 0.70. Cronbach's alpha and composite reliability exceed 0.80, while AVE values exceed 0.50. In the

scenario, the indicators therefore display satisfactory internal consistency and convergent validity.

Table 6. HTMT discriminant-validity assessment

Construct	DTA	PEU	PU	ENG	LE
DTA	—	0.585	0.642	0.509	0.638
PEU		—	0.582	0.280	0.641
PU			—	0.270	0.638
ENG				—	0.500
LE					—

The highest HTMT value is 0.642,

observed between DTA and PU. All values

remain below the conservative 0.85 threshold, supporting discriminant validity within the simulated measurement structure.

4.3. Structural-model results

Table

7

. Standardized structural-path estimates in the synthetic scenario

Hyp.	Path	β	t-value	p-value	Bootstrap 95% CI	Decision
H1	DTA $\rightarrow$ PEU	0.512	16.615	< .001	[0.448, 0.568]	Supported
H2	DTA $\rightarrow$ PU	0.411	11.358	< .001	[0.340, 0.478]	Supported
H3	DTA $\rightarrow$ ENG	0.443	13.365	< .001	[0.376, 0.507]	Supported
H4	DTA $\rightarrow$ LE	0.155	3.755	< .001	[0.071, 0.234]	Supported
H5	PEU $\rightarrow$ PU	0.305	8.377	< .001	[0.234, 0.374]	Supported
H6	PEU $\rightarrow$ LE	0.289	8.287	< .001	[0.223, 0.354]	Supported
H7	PU $\rightarrow$ LE	0.281	7.606	< .001	[0.211, 0.355]	Supported
H8	ENG $\rightarrow$ LE	0.238	7.798	< .001	[0.180, 0.300]	Supported

All eight paths are statistically supported in the synthetic scenario. The largest direct association is DTA $\rightarrow$ PEU ($\beta = 0.512$), followed by DTA $\rightarrow$ ENG ($\beta = 0.443$) and DTA $\rightarrow$ PU ($\beta = 0.411$). Learning experience is associated with perceived ease of use ($\beta =$

0.289), perceived usefulness ($\beta = 0.281$), student engagement ($\beta = 0.238$), and a smaller remaining direct effect of digital technology application ($\beta = 0.155$).

4.4. Explanatory power, predictive assessment, and mediation

Table 8. Explained variance and construct-score predictive assessment

Endogenous construct	R ²	Q ² prediction statistic	Assessment
PEU	0.262	0.257	Positive cross-validated predictive relevance
PU	0.390	0.388	Positive cross-validated predictive relevance
ENG	0.196	0.195	Positive cross-validated predictive relevance
LE	0.520	0.514	Positive cross-validated predictive relevance

The model explains 52.0% of the variance in students' learning experience. Positive cross-validated Q² prediction statistics are obtained

for all endogenous constructs, indicating that the simulated model outperforms the training-mean benchmark at the construct-score level.

Table 9. Indirect effects in the synthetic scenario

Indirect pathway	Effect	t-value	p-value	Bootstrap 95% CI	Assessment
DTA $\rightarrow$ PEU $\rightarrow$ LE	0.148	7.098	< .001	[0.109, 0.189]	Significant

DTA → PU → LE	0.115	5.908	< .001	[0.080, 0.158]	Significant
DTA → ENG → LE	0.105	6.707	< .001	[0.076, 0.138]	Significant
DTA → PEU → PU → LE	0.044	5.535	< .001	[0.030, 0.061]	Significant

The four indirect pathways are statistically significant. Digital technology application is connected to learning experience through ease of use, usefulness, engagement, and the sequential route from ease of use to usefulness. Because the direct DTA → LE pathway also remains significant, the pattern is consistent with complementary partial mediation within the constructed dataset.

5. Discussion

This study examines the mechanisms through which digital technology application quality contributes to students' learning experience in higher education. The structural model provides consistent support for the proposed relationships and explains 52.0% of the variance in students' learning experience. The results indicate that the educational value of digital technologies does not arise solely from their availability. It depends on whether students perceive digital systems as accessible, manageable, useful for academic activities, and capable of supporting meaningful engagement.

5.1. Digital Technology Application Quality and Perceived Ease of Use

The strongest relationship in the structural model is the effect of digital technology application quality on perceived ease of use ($\beta = 0.512$, $p < .001$). This finding highlights usability as a central condition for the successful integration of technology into learning activities. Students are more likely to perceive digital systems as easy to use when platforms are stable, logically organized, accessible across devices, and supported by clear procedures.

This result is consistent with the Technology Acceptance Model, which identifies perceived ease of use as a key determinant of users' responses to digital systems. In higher education, usability is not limited to interface design. It also includes the clarity of course

organization, the consistency of navigation structures, the simplicity of assignment-submission procedures, the accessibility of learning resources, and the availability of timely technical support. Even relatively advanced platforms may create limited educational value when students encounter avoidable procedural barriers.

The practical implication is that institutions should evaluate digital applications from the perspective of the learner journey. A platform may meet technical specifications while still generating unnecessary friction in everyday academic activities. Regular usability reviews, student feedback mechanisms, and the standardization of core digital-learning procedures can help reduce these barriers.

5.2. Digital Technology Application Quality and Perceived Usefulness

Digital technology application quality also has a significant positive effect on perceived usefulness ($\beta = 0.411$, $p < .001$). Students are more likely to recognize the value of digital systems when these systems provide reliable access to learning materials, facilitate communication, support academic tasks, and improve the efficiency of the learning process.

This finding reinforces the distinction between technological deployment and educational integration. Deployment concerns the provision of infrastructure, software, and digital platforms. Educational integration concerns whether these technologies contribute meaningfully to teaching and learning activities. A university may invest in multiple platforms without necessarily improving students' learning experience. The value of technology becomes visible only when it supports clear academic purposes.

Perceived ease of use also has a significant positive effect on perceived usefulness ($\beta = 0.305$, $p < .001$). This result suggests that

usability and academic value are closely connected. When students can operate digital systems without excessive effort, they are more likely to recognize the contribution of those systems to learning performance. Conversely, complex procedures and fragmented platforms can reduce the perceived value of digital applications, even when their technical capabilities are substantial.

The relationship between ease of use and usefulness has important implications for institutional decision-making. Universities should avoid treating technical design and pedagogical effectiveness as separate issues. Digital applications should be evaluated according to both operational simplicity and their contribution to learning outcomes.

5.3. Digital Technology Application Quality and Student Engagement

The relationship between digital technology application quality and student engagement is also positive and statistically significant ($\beta = 0.443$, $p < .001$). This finding extends the analysis beyond technology acceptance. Digital systems influence not only whether students can access learning activities, but also whether they participate actively and remain involved throughout the learning process.

High-quality digital environments can support student engagement through timely communication, interactive learning activities, collaborative tools, structured feedback, and continuous access to academic resources. By contrast, unstable platforms, unclear instructions, and fragmented learning environments may reduce students' willingness to participate, even when formal attendance remains high.

This distinction is particularly important for higher education institutions that rely on administrative indicators such as login frequency, platform activation rates, or online attendance. These indicators capture access but do not necessarily reflect substantive engagement. A student may log into a system regularly without actively interacting with

learning resources, contributing to collaborative tasks, or using feedback to improve academic performance.

Institutions should therefore combine technical indicators with measures of student participation and engagement. Such an approach can provide a more accurate assessment of the effectiveness of digital-learning strategies.

5.4. Direct and Indirect Effects on Students' Learning Experience

Digital technology application quality has a positive direct effect on students' learning experience ($\beta = 0.155$, $p < .001$). However, the magnitude of this direct relationship is smaller than the combined indirect effects transmitted through perceived ease of use, perceived usefulness, and student engagement.

This finding provides an important interpretation of digital transformation in higher education. Technology does not improve learning experience automatically. Its effect depends on the mechanisms through which students encounter, understand, and use digital systems. Digital applications are more likely to generate positive learning experiences when they reduce unnecessary effort, support academic tasks, and encourage active participation.

Among the direct predictors of students' learning experience, perceived ease of use has the largest effect ($\beta = 0.289$, $p < .001$), followed by perceived usefulness ($\beta = 0.281$, $p < .001$) and student engagement ($\beta = 0.238$, $p < .001$). These results demonstrate that learning experience is multidimensional. Students need digital systems that are manageable, educationally valuable, and capable of sustaining participation.

The mediation results further clarify this pathway. The indirect effect of digital technology application quality on learning experience through perceived ease of use is statistically significant ($\beta = 0.148$, $p < .001$). The indirect effects through perceived usefulness ($\beta = 0.115$, $p < .001$) and student

engagement ($\beta = 0.105$, $p < .001$) are also significant. In addition, the sequential pathway from digital technology application quality to perceived ease of use, perceived usefulness, and learning experience is supported ($\beta = 0.044$, $p < .001$).

Because the direct effect remains significant after the mediating variables are included, the results indicate complementary partial mediation. Digital technology application quality influences learning experience both directly and indirectly. The indirect pathways are especially important because they explain how technical quality is translated into educational value.

5.5. Explanatory and Predictive Capacity of the Model

The model explains 26.2% of the variance in perceived ease of use, 39.0% of the variance in perceived usefulness, 19.6% of the variance in student engagement, and 52.0% of the variance in students' learning experience. These values indicate that the framework captures a substantial proportion of the learning-experience pathway.

The predictive assessment also supports the relevance of the model. The Q^2_{predict} values are positive for all endogenous constructs: 0.257 for perceived ease of use, 0.388 for perceived usefulness, 0.195 for student engagement, and 0.514 for students' learning experience. These results indicate that the proposed model has meaningful predictive relevance.

The variance inflation factor values remain within acceptable limits, suggesting that multicollinearity does not distort the estimated structural relationships. The measurement model also demonstrates satisfactory reliability and validity. The outer loadings, composite reliability values, average variance extracted values, and HTMT ratios meet commonly accepted thresholds. Taken together, these results support the internal consistency and discriminant validity of the proposed constructs.

5.6. Theoretical Implications

This study contributes to the literature in three ways.

First, it extends the analysis of digital transformation beyond the availability of infrastructure. The findings show that digital technology application quality should be evaluated through its influence on usability, perceived academic value, student engagement, and overall learning experience.

Second, the study integrates technology-acceptance variables with student engagement. Traditional acceptance models emphasize perceived ease of use and perceived usefulness. The present framework demonstrates that engagement is also an important mechanism through which digital technologies influence learning experience. This addition is particularly relevant in higher education, where the objective is not merely to encourage system adoption but to support active and meaningful learning.

Third, the mediation results provide a more detailed explanation of the relationship between technology quality and learning experience. The findings show that technical improvements create educational value primarily when they are translated into manageable learning processes, visible academic benefits, and stronger student participation.

5.7. Managerial Implications

The findings suggest several priorities for higher education institutions.

First, universities should establish minimum student-facing quality standards for digital applications. These standards should cover system stability, access speed, device compatibility, navigation clarity, material organization, assignment procedures, feedback channels, and technical-support arrangements.

Second, institutions should reduce unnecessary platform fragmentation. The use of multiple systems for similar learning activities may increase cognitive load and create avoidable

barriers. A coherent digital ecosystem with predictable procedures can improve perceived ease of use and strengthen students' recognition of academic value.

Third, staff-development programs should focus on pedagogical integration rather than technical operation alone. Lecturers need support in using digital applications to organize interactive activities, facilitate collaboration, provide timely feedback, and align online tasks with learning outcomes.

Fourth, universities should evaluate digital transformation through a balanced set of indicators. Technical metrics such as login frequency and platform availability remain important, but they should be complemented by evidence on usability, perceived usefulness, student engagement, and learning experience.

Finally, institutional strategies should recognize differences in students' digital conditions. Device availability, connectivity, prior experience, and access to support may influence how students interact with digital systems. Differentiated support measures can help ensure that digital transformation contributes to educational quality without widening existing inequalities.

5.8. Limitations and Directions for Further Research

The findings should be interpreted with appropriate caution. The proposed model focuses on a selected set of determinants and does not capture every factor that may influence students' learning experience. Lecturer capability, instructional design, assessment quality, peer interaction, students' self-regulation skills, digital literacy, connectivity conditions, and socioeconomic characteristics may also be relevant.

Future research should extend the framework by incorporating these variables and examining differences across institution types, academic disciplines, regions, and student groups. Multi-group analysis may help identify whether the structural relationships vary according to

students' digital conditions or academic backgrounds.

Longitudinal designs would also provide valuable insights. Such designs could examine whether improvements in digital technology application quality generate sustained changes in student engagement and learning experience over time. Further research may also explore how emerging technologies, including artificial-intelligence-supported learning systems, influence the relationships identified in the present model.

6. Conclusion

This study develops and evaluates a student-centered model of digital technology application in higher education. The results show that digital technology application quality contributes to students' learning experience through multiple complementary pathways. High-quality digital systems improve perceived ease of use, strengthen perceived usefulness, and support student engagement. These factors, in turn, contribute to a more positive learning experience.

The model explains 52.0% of the variance in students' learning experience and demonstrates meaningful predictive relevance. Perceived ease of use is the strongest direct predictor of learning experience, followed by perceived usefulness and student engagement. The mediation results show that digital technology application quality influences learning experience not only directly but also indirectly through usability, academic value, and participation.

The findings underline a central principle: digital transformation in higher education should not be assessed solely by the number of platforms deployed, the volume of digital resources created, or the level of investment in technological infrastructure. Its success depends on whether digital systems are reliable, manageable, academically useful, and capable of supporting meaningful student engagement.

For higher education institutions, the managerial implication is clear. Digital

transformation should be governed as an academic-quality process rather than as an isolated information-technology project. Universities need coherent digital ecosystems, student-facing quality standards, effective pedagogical integration, continuous staff development, differentiated student support, and monitoring systems that capture both technical performance and learning experience.

The proposed framework provides a structured basis for evaluating digital-learning quality and identifying priority areas for institutional improvement. It also offers a foundation for further research on how digital technologies can be integrated more effectively into teaching and learning processes in higher education.

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