



ORIGINAL ARTICLE

A Data-Driven Smart University Framework for Sustainable Internationalisation at Home: A PLS-SEM Study in Vietnamese Higher Education

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ABSTRACT

Internationalisation at Home is increasingly recognised as an alternative to conventional physical mobility, offering opportunities to broaden equitable access to knowledge and promote sustainable practices in higher education. This study develops and empirically tests a data-driven smart university framework as an integrative model for examining the structural relationships between technological foundations and the sustainable implementation of Internationalisation at Home. A quantitative, cross-sectional research design was employed, using primary data collected through a structured questionnaire administered to 312 managers and faculty members involved in transnational education programmes in Vietnam. The data were analysed using partial least squares structural equation modelling. The findings support the proposed structural relationships within the model. Specifically, integrated data infrastructure has a positive relationship with faculty digital competence. An ethical data governance framework and the adoption of learning analytics and artificial intelligence are also positively associated with the quality of Internationalisation at Home. In turn, the quality of Internationalisation at Home has a statistically significant positive relationship with perceived institutional sustainability. The study provides empirical evidence of the structural links between digital technological innovation and the sustainability of higher education internationalisation. The findings offer a basis for reconsidering institutional resource allocation strategies in developing countries, with greater priority given to integrated data architectures, digital capability development, and responsible data governance.

1. INTRODUCTION

The internationalisation of higher education is widely recognised as a strategic approach to enhancing educational quality and cultivating students' global competence. Concurrently, the rapid advancement of information and communication technologies has prompted higher education institutions worldwide to systematically pursue digital transformation. Recent literature at the intersection of these domains indicates a growing transition from traditional physical mobility to digitally mediated cross-border learning. While the concept of the Smart University has gained considerable traction globally, its application has predominantly focused on campus management and administrative efficiency. Consequently, its potential as a foundational ecosystem to support the sustainable implementation of Internationalisation at Home (IaH) remains largely underexplored.

Globally, successful digital transformation models in higher education highlight the necessity of interoperability and unified data architectures. In developing contexts such as Vietnam, however, practical implementation often

remains fragmented, despite digital transformation being formally promoted through national policy initiatives (e.g., Decision No. 131/QĐ-TTg). Many institutions confine this process to the basic digitisation of documents or the deployment of standalone platforms, including learning management systems (LMSs) and student information systems (SISs). This fragmentation creates data silos, diminishes system interoperability, and constrains the secure sharing of academic resources with international partners. Therefore, establishing a comprehensive data governance framework (DG) has become essential to safeguard data sovereignty and cultivate the strategic trust required for transnational educational collaborations.

Against this background, digital technology should be viewed not merely as an immediate remedy for operational constraints, but as part of a structured evolutionary pathway. The data-driven smart university (DDSU) model is conceptualised here as an enterprise architecture comprising interrelated functional layers: it begins with the development of an integrated data infrastructure (DI), progresses to the establishment of ethical data governance, and subsequently enables the deployment of advanced analytical tools. Building on this premise, the present study develops and empirically tests the DDSU ecosystem as a foundational structure for supporting sustainable IaH.

The research pursues two primary objectives: (1) to identify and structure the components of a digital university that supports IaH - specifically, integrated DI, an ethical data DG, faculty digital competence (FDC), and the adoption of learning analytics and artificial intelligence (LAAI); and (2) to examine the structural relationships between these components, the quality of transnational learning environments, and perceived institutional sustainability within the context of Vietnamese higher education.

To the best of our knowledge, there remains a scarcity of quantitative models that comprehensively assess these structural links. Theoretically, this study offers an integrative empirical framework connecting digital technological foundations with the sustainability of higher education internationalisation in the Global South. Practically, the findings provide a basis for institutions to reconsider their resource allocation strategies, suggesting a shift in priority from conventional physical infrastructure towards integrated data architectures, digital capability development, and responsible data governance.

The remainder of the article is structured as follows. Section 2 presents the theoretical foundations and develops the research hypotheses. Section 3 describes the materials and methods, including the data collection process and partial least squares structural equation modelling (PLS-SEM) procedures. Section 4 reports the empirical results and discusses their theoretical and practical implications. Section 5 concludes the article and outlines directions for future research.

2. LITERATURE REVIEW

The internationalisation of higher education has traditionally been associated with the cross-border physical mobility of students and faculty members (Knight, 2003). However, when evaluated against the United Nations Sustainable Development Goals, this approach exhibits structural limitations. Reliance on international mobility can exacerbate inequalities in access to educational opportunities, as its benefits are largely confined to demographic groups with sufficient financial resources. Furthermore, it contributes substantially to greenhouse gas emissions through international air travel (de Wit & Altbach, 2021). Consequently, the academic community is increasingly transitioning towards IaH. IaH intentionally integrates international and intercultural dimensions into formal curricula and extracurricular activities within the domestic learning environment. This approach preserves the global dimension of education while circumventing constraints related to cost, geography, and environmental impact, thereby aligning with sustainable development commitments (Mohammadalizadehkorde & Weaver, 2018).

Implementing IaH effectively in a digital environment requires an architecture capable of overcoming internal system fragmentation. Rather than treating technology merely as an immediate remedy for operational constraints, the DDSU emerges as a systematically structured enterprise architecture comprising interrelated functional layers (Benavides et al., 2020; Mohamed Hashim et al., 2022). It begins with an interoperable DI - integrating cloud computing, LMSs, and application programming interfaces (APIs) - to eliminate information silos and enable the seamless sharing of educational resources (Almoqry & AlSohybe, 2026). This integrated foundation supports the subsequent deployment of advanced analytical tools, such as AI and learning analytics, which extend beyond conventional academic risk prediction to provide mechanisms for measuring intercultural engagement within multinational student cohorts (Raghuvanshi, 2025). To safeguard these digital interactions, a comprehensive

governance layer is essential. Establishing ethical principles and transparent data policies protects data sovereignty and cultivates the strategic trust required to sustain cross-border partnerships (Benavides et al., 2020).

Although previous studies have established a theoretical basis for digital transformation in higher education, the structural relationships between these technological ecosystems and sustainable IaH remain underexplored, particularly within developing contexts in the Global South. Prior literature has frequently positioned digital technology either as an administrative optimisation tool or a temporary response to educational disruption (Abad-Segura et al., 2020). Furthermore, contemporary conceptual models of digital universities have often paid insufficient attention to data governance and the ethics of technology use. To the best of our knowledge, there remains a scarcity of quantitative models that comprehensively assess the structural links between the DDSU ecosystem and the sustainable implementation of IaH. Addressing this gap, the present study employs PLS-SEM to examine the statistical effects of interoperable infrastructure, data governance, and readiness to adopt AI and learning analytics on internationalisation outcomes (Raghuvanshi, 2025).

Building upon the theoretical foundations of the DDSU architecture and the identified research gaps, the following hypotheses are proposed to test the structural relationships within the model.

Effect of DI on FDC

Information system fragmentation in traditional institutional models frequently creates data silos, acting as a barrier to pedagogical innovation and cross-border collaboration. Establishing an integrated DI via APIs and centralised data repositories removes these technical constraints, providing an essential enabling environment (Almoqry & AlSohybe, 2026). From a theoretical design perspective, during the early stages of digital transformation, this integrated infrastructure functions primarily to trigger an internal capacity-building effect. Specifically, it allows faculty members to develop and apply their FDC more effectively when designing multicultural learning environments, independent of immediate learner-facing outcomes.

H1. Integrated DI has a positive structural relationship with FDC.

Effect of data governance on the quality of IaH (QIaH)

Cross-border educational collaboration necessitates the secure integration and sharing of student data under stringent ethical standards. A transparent, ethical data DG that complies with international privacy norms serves as a foundational mechanism for institutional trust (Zhang et al., 2022, Tan et al., 2022). By mitigating legal risks and addressing partner institutions' data sovereignty concerns, this framework directly enables and is positively associated with the QIaH. Within this specified architecture, data governance operates as a direct structural enabler rather than an indirect mediator.

H2. An ethical data DG has a positive structural relationship with the QIaH.

Effect of learning analytics and AI on the quality of Internationalisation at Home

Beyond foundational infrastructure and governance policies, the adoption of advanced technological tools extends beyond mere administrative support. The adoption of LAAI facilitates the personalisation of learning pathways and enables the measurement of students' intercultural engagement within digitally mediated, multinational cohorts (Raghuvanshi, 2025). Purposeful pedagogical interventions supported by these analytical tools are expected to deepen academic engagement and elevate the quality of domestic internationalised experiences.

H3. LAAI adoption has a positive structural relationship with the QIaH.

Effect of IaH on institutional sustainability

The transition of internationalisation activities into digitally mediated environments introduces structural changes to higher education operations. This digital approach supports broader equitable access to global education and optimises resource efficiency, while presenting alternatives to carbon-intensive physical mobility practices (de Wit & Altbach, 2021). Consequently, the quality of digitally mediated IaH is expected to contribute directly to the institution's broader perceived sustainability agenda.

H4. The QIaH has a positive structural relationship with institutional sustainability (IS).

3. MATERIALS AND METHODS

3.1. Research design

To address the research questions and test the proposed hypotheses, this study employed a quantitative, cross-sectional survey design. This methodology was appropriate for examining the research model, in which constructs such as the DDSU ecosystem and the sustainability of IaH were conceptualised as multidimensional latent variables. The quantitative design enabled abstract concepts to be operationalised through a set of observed variables, thereby providing a basis for consistent and replicable measurement. Furthermore, this approach supported the analysis of structural relationships - rather than definitive causal effects - among the variables and generated empirical evidence for hypothesis testing.

3.2. Sample and data collection techniques

The study population comprised individuals employed at higher education institutions in Vietnam who were directly involved in teaching, administering, or strategically planning transnational education and IaH programmes. Given the absence of a comprehensive national sampling frame covering this population, a non-probability sampling strategy combining convenience and snowball sampling was adopted. Initial participants were accessed through a professional network of transnational education experts, who subsequently distributed the survey within their respective institutions.

A rigorous ethical protocol was observed throughout the data collection process. All participants were provided with comprehensive information regarding the study's purpose and gave informed consent prior to commencing the survey. Participation was entirely voluntary, and all collected data were anonymised and treated with strict confidentiality, serving solely for academic research purposes.

An initial total of 385 responses was recorded. To ensure the integrity of the quantitative dataset, a stringent data-cleaning procedure was undertaken, resulting in the exclusion of 73 responses based on three criteria. First, responses with completion times of less than two minutes were removed. Given that reading and responding to a questionnaire comprising 21 Likert-scale items and demographic questions requires an average of five to seven minutes, a completion time under two minutes (equating to less than five seconds per item) constitutes evidence of unengaged respondent behaviour. Second, responses exhibiting straight-lining across the measurement scale were discarded. Third, questionnaires containing more than 10% missing data were excluded.

Following data screening, the final dataset comprised 312 valid observations from various higher education institutions. The sample demographics indicated distribution across the Vietnamese higher education system, with 62.8% of respondents affiliated with public universities and 37.2% with non-public institutions.

To determine the adequacy of this sample size for PLS-SEM analysis, a statistical power analysis was conducted using G*Power. For a structural model featuring a maximum of three independent variables predicting a single dependent construct (i.e., the structural paths predicting QIaH), with a significance level of $\alpha = 0.05$ and a statistical power of $1 - \beta = 0.80$, the minimum required sample size was calculated to be 74. Consequently, the final sample of 312 respondents significantly exceeded both this threshold and the 10-times rule, providing robust statistical power for estimating the structural relationships.

3.3. Data analysis techniques

To examine the structural relationships between digital technological factors and the sustainability of IaH, PLS-SEM was selected instead of covariance-based structural equation modelling. This choice was justified by three methodological considerations. First, PLS-SEM is highly suitable for structurally complex models involving multiple latent constructs and observed variables. Second, as a variance-based approach, it does not require survey data to satisfy the strict assumption of multivariate normality. Third, PLS-SEM is particularly well suited for theory development and integration in emerging research contexts, such as evaluating DDSU frameworks in developing countries.

The analysis was conducted in sequential stages using SmartPLS 4.0. Given the reliance on self-reported cross-sectional data, the potential risk of common method bias was initially evaluated using Harman's single-factor test and the assessment of inner variance inflation factor values. Subsequently, the measurement model was evaluated. Exploratory factor analysis was employed to assess the underlying structure of the observed variables. Confirmatory factor analysis was then conducted to verify internal consistency reliability, convergent validity (via outer loadings and average variance extracted), and discriminant validity (using the heterotrait-monotrait ratio, heterotrait-monotrait) of the latent constructs.

In the final stage, the structural model was estimated to test research hypotheses H1-H4. The explanatory power and out-of-sample predictive relevance of the model were assessed using the coefficient of determination (R^2), effect sizes (f^2), and the blindfolding and PLSpredict algorithms (Q^2). To determine the statistical significance of the path coefficients (β), a non-parametric bootstrapping procedure with 5,000 resamples was applied to compute t-values, p-values, and 95% confidence intervals, thereby ensuring the robustness of the structural estimates.

3.4. Measurement scales and survey instrument

The survey instrument was developed by adapting validated measurement scales from established international literature. To ensure content validity and semantic equivalence within the context of Vietnamese higher education, a rigorous back-translation procedure was applied. An educational management specialist translated the original English questionnaire into Vietnamese, after which an independent language expert translated it back into English. The two versions were critically compared, and any semantic discrepancies were resolved through discussion.

Given that certain latent constructs - particularly the ethical data DG - were initially conceptualised in theoretical or qualitative studies, an empirical validation step was deemed necessary. A pilot test involving 30 participants, comprising educational managers and information technology specialists, was conducted prior to the main survey. Feedback from this phase was utilised to eliminate ambiguous terminology and enhance the face validity of the instrument. Crucially, the pilot data were subjected to preliminary reliability and validity assessments; the items exhibited outer loadings exceeding 0.70 and average variance extracted values above 0.50, while also satisfying the heterotrait-monotrait criteria for discriminant validity. This provided quantitative evidence that the theoretical scales had been successfully operationalised for the current research context.

The DDSU ecosystem and the sustainability of IaH were measured using a total of 21 observed variables. All items were evaluated on a five-point Likert scale, ranging from 1 ("Strongly disagree") to 5 ("Strongly agree"). To ensure analytical transparency and facilitate cross-checking within the structural model, the measurement structure - including the latent constructs, systematic variable codes, number of items, and theoretical sources - is summarised in Table 1. Furthermore, to support replicability in future research, the complete wording of all 21 observed variables is provided in Appendix A.

Table 1. Summary of measurement scales and observed-variable coding

Latent construct	Code	Number of observed variables	Sources
Integrated DI	DI1-DI4	4	Almoqry and AlSohybe (2026)
Ethical data DG	DG1-DG3	3	Zhang et al. (2022); Raghuvanshi (2025)
FDC	FDC1-FDC4	4	Echtenbruck et al. (2025)
LAAI adoption	LAAI1-LAAI3	3	Ifenthaler and Yau (2020); Raghuvanshi (2025)
QIaH	QIaH1-QIaH3	3	de Wit and Altbach (2021)
IS	IS1-IS4	4	de Wit and Altbach (2021)

The constructs were operationalised based on their respective theoretical foundations. Integrated DI focused on the degree of information system integration, the availability of a centralised data lake, and API-enabled connectivity. FDC assessed faculty members' proficiency in using digital tools to design and implement transnational learning activities. The ethical data DG reflected the maturity of institutional policies concerning privacy protection, data transparency, and ethical AI applications. LAAI adoption evaluated the extent to which predictive tools were used to personalise learning pathways. Finally, the QIaH and IS were assessed through criteria compatible with self-reported data, specifically focusing on equitable access to international education, the optimisation of operating costs, and the perceived effectiveness of digital technology in reducing physical mobility.

4. RESULTS AND DISCUSSION

Data analysis was conducted using SmartPLS 4.0, employing the PLS-SEM algorithm. This variance-based approach was selected for its capacity to handle complex models involving multiple latent constructs and its suitability for predicting dependent constructs within the research model. The analysis proceeded in two main stages: evaluating the measurement model to verify scale reliability and validity, followed by assessing the structural model to test the hypothesised relationships and their statistical effects.

4.1. Characteristics of the research sample

Following a rigorous data-cleaning process, the final research sample comprised 312 valid observations ($n=312$). The sample reflected diversity and distribution across the Vietnamese higher education system, with 62.8% of respondents affiliated with public universities and 37.2% working in non-public institutions.

By occupational position, 46.5% of the respondents were faculty members, 32.1% were professional staff (including academic affairs, education management, and information technology personnel), and 21.4% held leadership positions at the faculty or institutional level. Furthermore, 75.0% of the respondents were directly involved in teaching or administering transnational education and IaH programmes, with 67.9% possessing more than five years of professional experience. These demographic characteristics, summarised in Table 2, confirm that the primary data were drawn from practitioners with substantial subject-matter expertise, providing a credible foundation for the subsequent quantitative analyses.

Table 2. Descriptive statistics for the demographic characteristics of the research sample ($n = 312$)

Characteristic	Category	Frequency (n)	Percentage (%)
Occupational position	Faculty member	145	46.5
	Professional staff (academic affairs, education management, and IT)	100	32.1
	Leadership (faculty, institute, and university levels)	67	21.4
Institutional type	Public	196	62.8
	Non-public	116	37.2
Professional experience	Less than 5 years	100	32.1
	5 years or more	212	67.9
Experience with transnational education/IaH	Directly involved in teaching or programme administration	234	75.0
	Indirectly involved or preparing for implementation	78	25.0

4.2. Assessment of the measurement model

The quality of the reflective measurement model was evaluated based on indicator reliability, internal consistency reliability, and both convergent and discriminant validity.

The outer loadings of all 21 observed variables ranged from 0.742 to 0.891, exceeding the recommended threshold of 0.708. This result confirms that each observed variable explained more than 50% of the variance in its corresponding latent construct. Internal consistency reliability was established using Cronbach's alpha and composite reliability. Cronbach's alpha values ranged from 0.853 to 0.890, while composite reliability values ranged from 0.881 to 0.924. All values fell within the acceptable range of 0.70 to 0.95, indicating high scale reliability without evidence of indicator redundancy (Hair et al., 2019).

Convergent validity was confirmed through the average variance extracted. All latent constructs yielded average variance extracted values above the 0.50 threshold, ranging from 0.612 for FDC to 0.735 for learning analytics and AI adoption, thereby demonstrating satisfactory convergence.

Discriminant validity was assessed using the heterotrait-monotrait ratio. All heterotrait-monotrait values between construct pairs were below the conservative threshold of 0.85 (Henseler et al., 2015), with the highest recorded value being 0.792. These results confirm that the latent constructs were empirically distinct from one another.

Table 3. Results of reliability and convergent validity assessment

Latent construct	Number of items	Outer loadings	Cronbach's alpha (α)	Composite reliability	Average variance extracted
Integrated DI	4	0.785-0.845	0.865	0.892	0.654
Ethical data DG	3	0.815-0.865	0.853	0.881	0.692
FDC	4	0.750-0.835	0.860	0.890	0.612
LAAI adoption	3	0.840-0.880	0.882	0.915	0.735
QIaH	3	0.810-0.891	0.890	0.924	0.715
IS	4	0.742-0.840	0.862	0.895	0.658

Given the reliance on self-reported cross-sectional survey data, the potential risk of common method bias was assessed prior to structural evaluation. Harman's single-factor test was executed using an unrotated principal component factor analysis, which revealed that the single largest factor accounted for less than 50% of the total variance. Furthermore, all inner variance inflation factor values among the predictor constructs ranged from 1.342 to 2.115, below the critical threshold of 3.0. These combined results provide empirical evidence that multicollinearity and CMB did not threaten the validity of the dataset.

4.3. Assessment of the structural model and discussion of findings

The explanatory power of the structural model was evaluated using the coefficient of determination (R^2). The constructs within the digital technology ecosystem explained 58.4% of the variance in the QIaH ($R^2 = 0.584$). Furthermore, as the sole predictor of institutional sustainability in this specified path, the QIaH accounted for 37.2% of its variance ($R^2 = 0.372$). This ensures mathematical consistency within the structural model, as the coefficient of determination equates approximately to the square of the path coefficient ($0.610^2 \approx 0.372$).

To assess the out-of-sample predictive relevance of the model, the blindfolding and PLSpredict algorithms were applied. The analysis yielded Q^2 values well above zero for all endogenous constructs, confirming the predictive validity and robustness of the model.

The research hypotheses (H1-H4) were tested using a non-parametric bootstrapping procedure with 5,000 resamples. The statistical significance of the structural relationships was determined based on path coefficients (β), t-values, p-values, 95% confidence intervals (CI), and effect sizes (f^2). The results, presented in Table 4, demonstrate that all proposed structural relationships were positive and statistically significant at $p < .001$.

Table 4. Results of structural relationship testing (H1-H4)

Hypothesis	Structural relationship	Path coefficient (β)	t-value	p-value	95% confidence interval	Effect size (f^2)	Conclusion
H1	DI $\rightarrow$ FDC	0.452	6.84	< .001	[0.323, 0.581]	0.285	Supported
H2	DG $\rightarrow$ QIaH	0.518	7.12	< .001	[0.375, 0.661]	0.342	Supported
H3	LAAI $\rightarrow$ QIaH	0.415	5.92	< .001	[0.278, 0.552]	0.210	Supported
H4	QIaH $\rightarrow$ IS	0.610	9.45	< .001	[0.483, 0.737]	0.488	Supported

The structural model results demonstrate that the DDSU ecosystem is associated with the implementation of IaH. For Hypothesis H1, the positive statistical relationship between integrated DI and FDC ($\beta = 0.452$, $f^2 = 0.285$)

confirms that isolated software deployments generate limited pedagogical value without underlying interoperability. By integrating systems through APIs and centralised repositories, institutions reduce administrative burdens associated with data silos, thereby enabling faculty members to focus their capabilities on designing multicultural learning activities.

Addressing Hypothesis H2, the empirical results support the association between an ethical data governance framework and the QIaH ($\beta = 0.518$, $f^2 = 0.342$). Unlike foundational literature that primarily evaluates IaH through a pedagogical lens - such as the conceptual frameworks proposed by de Wit and Altbach (2021) - this study contributes an empirical perspective. It demonstrates that in developing-country contexts, ethical data governance operates as a core structural mechanism that breaks down barriers to cross-border resource sharing and establishes the strategic trust required by international partners.

Consistent with Hypothesis H3, the adoption of learning analytics and AI exhibits a positive structural relationship with the QIaH ($\beta = 0.415$, $f^2 = 0.210$). This finding substantiates the premise that advanced analytical tools transcend operational support, providing the essential capability to personalise academic interventions and measure intercultural engagement within digitally mediated environments.

Finally, the acceptance of Hypothesis H4 ($\beta = 0.610$, $f^2 = 0.488$) empirically links the quality of digitally enabled IaH with perceived institutional sustainability. While traditional internationalisation models rely heavily on physical mobility (Knight, 2003), shifting cross-border learning activities to digital platforms facilitates structural changes that broaden equitable access and support the broader institutional sustainability agenda (de Wit & Altbach, 2021).

4.4. Practical and strategic management implications

Building on the policy direction established by Decision No. 131/QĐ-TTg on strengthening the application of information technology and digital transformation in education (Prime Minister of Viet Nam, 2022), the empirical findings provide a basis for revising institutional strategies in higher education. To ensure practical relevance and avoid over-extrapolation from self-reported cross-sectional data, the following management recommendations are anchored directly to the statistical effect sizes (f^2) observed in the structural model, focusing on perceived sustainability benefits rather than absolute reductions in emissions or costs.

First, given the substantial effect size of an ethical data governance framework on the QIaH ($f^2 = 0.342$), institutions must shift their strategic focus from merely acquiring physical hardware to developing transparent data policies. Higher education leaders should prioritise the establishment of a comprehensive data governance framework that regulates the collection, storage, and cross-border sharing of learner data. Adopting rigorous security standards aligned with international practices, including principles equivalent to those of the General Data Protection Regulation, is strongly recommended (European Union, 2016). This ethical governance structure operates as a strong driver for mitigating legal risks, safeguarding data sovereignty, and constructing the foundational trust necessary for initiating and sustaining transnational partnerships.

Second, based on the enabling effect of integrated DI on FDC ($f^2 = 0.285$), institutions should mandate the use of APIs as a technical prerequisite for future technological procurement. API-led connectivity enables structured, real-time data exchange without requiring the transfer of raw databases, thereby facilitating the secure integration of micro-credential systems and collaborative learning platforms. This structural upgrade effectively removes technical friction and data silos, freeing faculty members from manual administrative tasks. By enabling academic staff to focus their capabilities on designing advanced multicultural learning activities, these targeted technological investments optimise operational efficiency and translate into higher perceived sustainability benefits for the institution.

5. CONCLUSION

This study developed and empirically tested the DDSU framework as a foundational structure for implementing IaH to support sustainable development in Vietnamese higher education. The PLS-SEM results confirm that integrated DI, the adoption of LAAI, and an ethical data governance framework exhibit positive structural relationships with FDC and the quality of transnational learning environments. Theoretically, the research quantifies the role of digital technology not merely as a temporary operational remedy, but as a structural catalyst associated with the sustainability of higher education ecosystems in the Global South, supporting alternatives to carbon-intensive physical mobility.

Practically, the findings translate into two concise strategic imperatives for higher education leadership and policymakers. First, institutions must shift their investment focus from conventional physical infrastructure towards establishing API-led, interoperable data architectures. Second, leadership must prioritise the implementation of an ethical data governance framework aligned with international standards, such as the General Data Protection Regulation, which serves as a foundational mechanism for mitigating legal risks and cultivating strategic trust in cross-border collaborations.

Nevertheless, several methodological limitations must be acknowledged. The cross-sectional research design precludes a definitive assessment of cumulative and time-lagged effects of digital transformation. Additionally, the reliance on non-probability sampling may constrain the broader generalisability of the findings. Crucially, because the primary objective of this study was to establish and validate the baseline structural ecosystem of the DDSU framework, it did not examine potential heterogeneity among respondent profiles. Consequently, an avenue for future research is the application of Multi-Group Analysis to explore structural differences across distinct institutional stakeholder groups, particularly among faculty members, professional staff, and senior leadership. Finally, future scholarship would benefit from longitudinal designs and qualitative case studies to capture the micro-level organisational dynamics of digitally mediated international education.

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Appendix. Survey Instrument and Observed Variables

All items were evaluated on a 5-point Likert scale, ranging from 1 (“Strongly disagree”) to 5 (“Strongly agree”).

1. Integrated DI - 4 items Adapted from Almoqry and AlSohybe (2025)

DI1: Our institution has achieved a high degree of integration across various educational information systems (e.g., LMS, SIS).

DI2: Our institution has established a centralised data repository (data lake) that efficiently consolidates data from multiple sources.

DI3: APIs are systematically deployed to enable seamless data connectivity across our platforms.

DI4: Our current DI effectively supports the secure, cross-border sharing of resources for multinational learning environments.

2. Ethical data DG - 3 items Adapted from Zhang et al. (2022); Raghuvanshi (2025)

DG1: Our institution implements highly mature and strict policies regarding privacy protection in digital learning environments.

DG2: We have established transparent data policies regulating the secure collection, storage, and cross-border sharing of learner data.

DG3: Ethical governance principles are strictly enforced when deploying AI and analytical tools on educational data.

3. FDC - 4 items Adapted from Echtenbruck et al. (2025)

FDC1: Faculty members demonstrate high proficiency in utilising advanced digital tools for pedagogical purposes.

FDC2: Faculty members are highly capable of designing digitally mediated transnational learning activities.

FDC3: Faculty members can effectively implement and manage multicultural co-teaching models within virtual environments.

FDC4: Faculty members are confident in applying digital technologies to facilitate intercultural engagement among students.

4. LAAI adoption - 3 items Adapted from Ifenthaler and Yau (2020); Raghuvanshi (2025)

LAAI1: Our institution actively utilises learning analytics and predictive tools to personalise students' learning pathways.

LAAI2: Artificial intelligence (AI) is effectively adopted to identify academic risks and provide timely pedagogical interventions.

LAAI3: Advanced analytical tools are systematically used to accurately measure students' intercultural engagement within multinational cohorts.

5. QIaH - 3 items Adapted from de Wit and Altbach (2021); Leal Filho et al. (2020)

QIaH1: Our digitally mediated learning environments successfully provide students with high-quality intercultural and international experiences.

QIaH2: The intentional integration of international dimensions into our domestic digital curricula is highly effective.

QIaH3: Digital technology successfully enables deep international academic interactions without relying on the physical mobility of students or staff.

6. IS - 4 items Adapted from de Wit and Altbach (2021); Leal Filho et al. (2020)

IS1: Transitioning to digitally enabled IaH broadens equitable access to global education for diverse and disadvantaged student populations.

IS2: The digital implementation of cross-border activities significantly optimises the institution's operating costs and resource efficiency.

IS3: By reducing the reliance on international air travel, our digitally mediated IaH initiatives substantially contribute to decreasing carbon emissions.

IS4: The digital transformation of internationalisation activities structurally supports and aligns with the broader sustainability agenda of the institution.