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Foreign Policy Lock-In and Digital Transformation in Public Universities: Longitudinal Structural Modeling

Keterikatan Kebijakan Luar Negeri dan Transformasi Digital Universitas Negeri: Pemodelan Struktural Longitudinal

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Abstract

Geopolitical crises prompt states to redirect public budgets toward security mandates, threatening digital sustainability curricula while institutional analytics overlook external political constraints. This study examines how crisis-driven foreign policy lock-in and institutional path dependency constrain digital curriculum transformation and student platform engagement in public universities. Using a longitudinal design, institutional databases and platform archives from 20 public universities across 2023–2025 were analyzed via mean comparisons, regression, structural equation modeling, and path mediation. During crisis peaks, curriculum updates dropped from 74.20% to 31.50%, resource allocation declined from 88.50 to 42.10, module utilization fell from 18.40 to 9.20, and student engagement contracted from 82.10 to 39.60 hours, with all p-values below 0.001. Structural modeling confirmed a strong negative direct path, with institutional path dependency explaining 42% of transformation delay variance. Bridging International Relations theory with quantitative learning analytics, these results show that autonomous governance and ring-fenced digital funding effectively safeguard climate education.

Abstrak

Krisis geopolitik mendorong negara mengalihkan anggaran publik menuju mandat keamanan, mengancam kurikulum keberlanjutan digital sementara analitik institusional mengabaikan kendala politik eksternal. Penelitian ini mengkaji bagaimana keterikatan kebijakan luar negeri akibat krisis dan ketergantungan jalur institusional membatasi transformasi kurikulum digital serta keterlibatan platform mahasiswa di universitas negeri. Menggunakan desain longitudinal, basis data institusional dan arsip platform 20 universitas negeri periode 2023–2025 dianalisis melalui perbandingan rerata, regresi, pemodelan persamaan struktural, dan mediasi jalur. Selama puncak krisis, pembaruan kurikulum turun dari 74,20% menjadi 31,50%, alokasi sumber daya menurun dari 88,50 menjadi 42,10, pemanfaatan modul turun dari 18,40 menjadi 9,20, dan keterlibatan mahasiswa menyusut dari 82,10 menjadi 39,60 jam, dengan seluruh nilai-p di bawah 0,001. Pemodelan struktural mengonfirmasi jalur langsung negatif kuat, dengan ketergantungan jalur institusional menjelaskan 42% varians keterlambatan transformasi. Menjembatani teori Hubungan Internasional dan analitik pembelajaran kuantitatif, hasil ini menunjukkan bahwa tata kelola otonom serta pendanaan digital terlindungi efektif menjaga pendidikan iklim.

A. INTRODUCTION

1. Background

Public higher education institutions operate at the intersection of domestic academic governance, transnational sustainability commitments, and volatile geopolitical structures. As universities worldwide accelerate the integration of Learning Management Systems (LMS) and data-driven instructional ecosystems to deliver climate and sustainability curricula, macro-level external shocks—including interstate conflicts, geoeconomic disruptions, and diplomatic realignments—increasingly destabilize institutional autonomy. During periods of acute geopolitical crisis, national governments routinely reallocate public capital toward defense mandates, tighten regulatory oversight, and subordinate state-funded institutions to emergency foreign policy priorities. At the operational level of the university classroom and digital platform, these macro-level shifts manifest as frozen educational technology budgets, delayed software licensing, stalled digital course updates, and declining student interaction within online sustainability modules. Yet institutional analytics dashboards and educational policy evaluations rarely capture how external state-level constraints propagate downward into measurable learning platform contractions, leaving university leaders unable to anticipate or mitigate crisis-induced digital inertia.

Recent international scholarship from the past five years reveals a sharp disciplinary fragmentation across three relevant research streams. First, studies on digital transformation and sustainability in higher education—such as strategic frameworks by Mohamed Hashim, Tlemsani, and Matthews,[1] systematic barrier classifications by Gkrimpizi, Peristeras, and Magnisalis,[2] and empirical assessments by Alenezi,[3] Alenezi, Wardat, and Akour,[4] Haleem et al.,[5] and Leal Filho, Salvia, and Eustachio[6]—consistently

[1] Mohamed Ashmel Mohamed Hashim, Issam Tlemsani, and Robin Matthews, "Higher Education Strategy in Digital Transformation," *Education and Information Technologies* 27, no. 3 (2022): 3171–95, https://doi.org/10.1007/s10639-021-10739-1.
[2] Eleni Gkrimpizi, Vassilios Peristeras, and Ioannis Magnisalis, "Classification of Barriers to Digital Transformation in Higher Education Institutions: Systematic Literature Review," *Education Sciences* 13, no. 7 (2023): 746, https://doi.org/10.3390/educsci13070746.
[3] Mamdouh Alenezi, "Digital Learning and Digital Institution in Higher Education," *Education Sciences* 13, no. 1 (2023): 88, https://doi.org/10.3390/educsci13010088.
[4] Mamdouh Alenezi, Saja Wardat, and Mohammed Akour, "The Need of Integrating Digital Education in Higher Education: Challenges and Opportunities," *Sustainability* 15, no. 6 (2023): 4782, https://doi.org/10.3390/su15064782.
[5] Abid Haleem et al., "Understanding the Role of Digital Technologies in Education: A Review," *Sustainable Operations and Computers* 3 (2022): 275–85, https://doi.org/10.1016/j.susoc.2022.05.004.
[6] Walter Leal Filho, Amanda Lange Salvia, and João Henrique Paulino Pires Eustachio, "An Overview of the Engagement of Higher Education Institutions in the Implementation of the UN Sustainable Development

attribute stalled digital modernization and uneven Sustainable Development Goal (SDG) implementation to internal organizational deficits, including limited digital literacy, fragmented leadership, and localized resource constraints. Second, contemporary learning analytics literature led by Susnjak, Ramaswami, and Mathrani[7] and Prinsloo, Slade, and Khalil[8] demonstrates how LMS engagement metrics can generate actionable pedagogical insights while underscoring the governance and privacy tensions embedded in institutional data infrastructures; however, these computational models treat universities as largely self-contained systems insulated from macroeconomic and geopolitical realignments. Third, emerging scholarship on the geopolitics of higher education—exemplified by Marginson[9] and Brøgger et al.[10]—extends classical International Relations (IR) frameworks of structural neorealism and institutional path dependency to explain how national security imperatives reshape global academic cooperation, yet remains predominantly conceptual and macro-qualitative.[11] Consequently, a substantial methodological and analytical blind spot persists: existing higher education and learning analytics studies overlook macro-level foreign policy pressures, whereas IR scholarship rarely quantifies how crisis-driven state realignments translate into longitudinal declines in LMS utilization and digital curriculum adaptation.

In contrast to prior studies that either diagnose university digitalization barriers solely through internal organizational variables or examine geopolitical shifts through qualitative diplomatic narratives, this study introduces an interdisciplinary analytical model that bridges International Relations theory with quantitative educational policy and learning analytics. Specifically, it operationalizes Foreign Policy Lock-In (FPLI) alongside institutional path dependency within a Structural Equation Modeling (SEM) and

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Goals," *Journal of Cleaner Production* 386 (February 2023): 135694, https://doi.org/10.1016/j.jclepro.2022.135694.

[7] Teo Susnjak, Gomathy Suganya Ramaswami, and Anuradha Mathrani, "Learning Analytics Dashboard: A Tool for Providing Actionable Insights to Learners," *International Journal of Educational Technology in Higher Education* 19, no. 1 (2022): 12, https://doi.org/10.1186/s41239-021-00313-7.

[8] Paul Prinsloo, Sharon Slade, and Mohammad Khalil, "The Answer Is (Not Only) Technological: Considering Student Data Privacy in Learning Analytics," *British Journal of Educational Technology* 53, no. 4 (2022): 876–93, https://doi.org/10.1111/bjet.13216.

[9] Simon Marginson, "What Drives Global Science? The Four Competing Narratives," *Studies in Higher Education* 47, no. 8 (2022): 1566–84, https://doi.org/10.1080/03075079.2021.1942822.

[10] Katja Brøgger et al., "Introduction: The Shifting Geopolitics of Higher Education: Knowledge, Power, Protest," in *World Yearbook of Education 2026: The Shifting Geopolitics of Higher Education: Knowledge, Power, Protest*, ed. Katja Brøgger et al. (London: Routledge, 2026), 1–9, https://doi.org/10.4324/9781003442264-1

[11] Kenneth N. Waltz, *Theory of International Politics* (Reading, MA: Addison-Wesley, 1979), 102–28; Paul Pierson, "Increasing Returns, Path Dependence, and the Study of Politics," *American Political Science Review* 94, no. 2 (2000): 251–67, https://doi.org/10.2307/2586011.

longitudinal institutional dataset to quantify how state-level crisis realignments constrain Digital Curriculum Transformation (DCT) and student platform engagement in university sustainability programs.

This study advances the central thesis that crisis-driven foreign policy lock-in systematically erodes institutional digital modernization and student engagement within public higher education sustainability curricula through security-oriented resource reallocations and structural path dependency. For the international educational research and learning analytics community, quantifying this macro-to-micro transmission mechanism is critical for designing resilient digital governance frameworks capable of safeguarding quality education (SDG 4) and climate action literacy (SDG 13) during geopolitical turbulence. Empirical analysis across twenty public universities between 2023 and 2025 confirms statistically significant crisis-peak contractions ($p < 0.001$) across digital curriculum updates (74.20% to 31.50%), institutional resource allocation (88.50 to 42.10), platform module utilization (18.40 to 9.20), and student digital engagement (82.10 to 39.60 hours), while path mediation modeling indicates that institutional path dependency accounts for 42% of the variance in digital transformation delays.

2. Research Questions

To dissect the quantitative relationships between macro-level geopolitical constraints, institutional digital readiness, and student platform behavior, this study addressed two primary research questions:

a. How do geopolitical crisis realignments and state-level foreign policy lock-in, framed through International Relations theory, quantitatively constrain the rate of digital curriculum transformation and resource allocation within higher education sustainability programs?

b. To what extent does crisis-driven institutional policy lock-in—mediated by institutional path dependency—account for variance in platform module utilization and student digital engagement across public university systems?

Corresponding to these research questions and the structural model, three empirical hypotheses were formulated and tested at a two-tailed significance level of $\alpha = 0.05$:

a. H_1**:** Geopolitical crisis peaks are associated with statistically significant declines in digital curriculum updates, resource allocation, platform module

utilization, and student digital engagement relative to pre-crisis baseline levels.

b. H_2**:** Foreign Policy Lock-In (FPLI) exerts a statistically significant negative direct effect on Digital Curriculum Transformation (DCT) within public higher education sustainability curricula.

c. H_3**:** Institutional path dependency significantly mediates the relationship between Foreign Policy Lock-In (FPLI) and delays in Digital Curriculum Transformation (DCT) during external crisis cycles

3. Research Methods

Research Design and Approach. This study employed a quantitative descriptive and inferential longitudinal design integrating multi-institutional panel records with Structural Equation Modeling (SEM) and multivariate regression. A longitudinal multivariate framework was selected over a cross-sectional descriptive design because evaluating how geopolitical disruptions propagate into university learning ecosystems requires tracking temporal shifts between pre-crisis baselines and crisis-peak intervals while simultaneously estimating direct and mediated latent structural relationships. Grounded in structural neorealist and historical-institutionalist International Relations frameworks,[12] this design enabled rigorous empirical testing of the structural pathways linking macro-level foreign policy constraints to meso-level institutional governance and micro-level digital learning platform outcomes.

Data Sources and Participants. The empirical data corpus comprised longitudinal academic program records, digital course platform (LMS) archives, and institutional administrative databases collected across 20 public universities over the 2023–2025 academic reporting periods. Public universities were targeted as the institutional sampling frame because state-funded higher education systems exhibit direct fiscal and regulatory exposure to national defense realignments and emergency policy mandates. Rather than relying on self-reported individual perceptions alone, the dataset captured verified institutional-level and course-cohort behavioral indicators across sustainability-oriented curricula. Three core constructs were operationalized from the panel archives:

[12] Waltz, *Theory of International Politics*, 102–28; Pierson, "Increasing Returns, Path Dependence, and the Study of Politics," 251–67.

a. Foreign Policy Lock-In (FPLI): Operationalized as the exogenous macro-policy construct quantified through state emergency regulatory mandates, security-driven public budget reallocations, and national policy alignment indices.
b. Digital Curriculum Transformation (DCT): Operationalized as the endogenous educational construct measured via four longitudinal performance indicators: verified digital curriculum update rates (%), an institutional resource allocation index, LMS platform module utilization, and student digital engagement measured in cumulative platform interaction hours.
c. Institutional Path Dependency: Operationalized as the structural mediating construct capturing procedural rigidity, funding earmark inertia, and administrative delays in curriculum modernization during external crisis cycles.

To protect institutional confidentiality and mitigate political sensitivity surrounding national security budget disclosures, both the participating universities and their specific national jurisdictions were strictly masked throughout the reporting process.

Data Collection, Preprocessing, and Ethical Compliance. Longitudinal performance records and platform interaction logs were extracted systematically from institutional administrative databases, academic curriculum repositories, and digital course management archives spanning the 2023–2025 reporting cycles. Prior to modeling, the raw multi-institutional corpus underwent a structured preprocessing pipeline. First, reporting intervals were harmonized across universities to align pre-crisis baselines and crisis-peak observation windows cleanly. Second, heterogeneous administrative metrics were standardized onto comparable analytical scales for multivariate estimation. Third, data integrity was verified through completeness auditing, missing-value screening using listwise complete-case validation to maintain balanced longitudinal comparability across periods, and diagnostic screening for extreme statistical anomalies. To uphold institutional data protection standards and learning analytics ethics,[13] all university identifiers and student-level LMS interaction logs were strictly de-identified and aggregated at the institutional and course-cohort levels prior to statistical processing, ensuring complete participant anonymization and eliminating the collection of personally identifiable student data.

[13] Prinsloo, Slade, and Khalil, "The Answer Is (Not Only) Technological," 876–93.

Data Analysis Techniques. Quantitative estimation proceeded through a four-stage analytical pipeline evaluated at a two-tailed statistical significance threshold of $\alpha = 0.05$. First, descriptive statistics and longitudinal mean-comparison tests were computed to quantify contraction magnitudes and statistical significance between pre-crisis and crisis-peak periods across all four DCT indicators. Second, measurement model diagnostics were applied to assess construct reliability, convergent validity, and discriminant validity prior to structural path estimation.[14] Third, Structural Equation Modeling (SEM) and multivariate regression were conducted to estimate the direct structural path from Foreign Policy Lock-In (FPLI) to Digital Curriculum Transformation (DCT) while evaluating overall model adequacy and explanatory power.[15] Fourth, quantitative path mediation analysis was performed to isolate the indirect structural pathway and determine the proportion of variance in digital transformation delays explained by institutional path dependency across external crisis cycles.[16]

B. RESULTS

1. Longitudinal Contractions in Digital Curriculum Transformation and Resource Allocation

Longitudinal analysis of institutional databases and digital course platform records across the 20 public universities from 2023 through 2025 revealed statistically significant, system-wide contractions across all four empirical indicators of Digital Curriculum Transformation (DCT) during peak geopolitical crisis periods relative to pre-crisis baselines ($p < 0.001$ across all variables). As summarized in Table 1, every tracked dimension of instructional modernization, fiscal support, and learner platform activity contracted by at least half during peak external disruptions.

[14] Claes Fornell and David F. Larcker, "Evaluating Structural Equation Models with Unobservable Variables and Measurement Error," *Journal of Marketing Research* 18, no. 1 (1981): 39–50, https://doi.org/10.1177/002224378101800104.
[15] Li-tze Hu and Peter M. Bentler, "Cutoff Criteria for Fit Indexes in Covariance Structure Analysis: Conventional Criteria Versus New Alternatives," *Structural Equation Modeling: A Multidisciplinary Journal* 6, no. 1 (1999): 1–55, https://doi.org/10.1080/10705519909540118.
[16] Kristopher J. Preacher and Andrew F. Hayes, "Asymptotic and Resampling Strategies for Assessing and Comparing Indirect Effects in Multiple Mediator Models," *Behavior Research Methods* 40, no. 3 (2008): 879–91, https://doi.org/10.3758/BRM.40.3.879.

Table 1. Longitudinal Comparison of Digital Curriculum Transformation Indicators Across Pre-Crisis and Crisis-Peak Periods (2023–2025)

Variable Indicator	Pre-Crisis Mean	Crisis-Peak Mean	Absolute Change (Δ\DeltaΔ)	Relative Change (%)	p-Value
Digital Curriculum Updates (%)	74.20	31.50	−42.70	−57.55%	< 0.001
Resource Allocation Index	88.50	42.10	−46.40	−52.43%	< 0.001
Platform Module Utilization	18.40	9.20	−9.20	−50.00%	< 0.001

Source: Processed Institutional Primary Data (2026).
Note: Absolute and relative changes were derived directly from the longitudinal pre-crisis and crisis-peak institutional means across the 20 public universities (2023–2025).

Examining the contraction magnitudes in Table 1 addresses the first research question by exposing a clear empirical sequence from administrative capacity to student platform activity. The sharpest relative decline occurred in digital curriculum updates, which dropped by 42.70 percentage points—from a pre-crisis mean of 74.20% to 31.50% at the crisis peak (a 57.55% relative reduction; $p < 0.001$). This deceleration in instructional modernization closely mirrored a severe fiscal contraction in the institutional resource allocation index, which fell by 46.40 points from 88.50 to 42.10 (a 52.43% relative decline; $p < 0.001$).

Corresponding downstream contractions emerged concurrently within the digital learning environment. Platform module utilization declined by exactly 50.00%, dropping from a pre-crisis mean of 18.40 to 9.20 during peak geopolitical disruptions ($p < 0.001$). Similarly, cumulative student digital engagement contracted by 42.50 hours—falling from 82.10 hours prior to the crisis to 39.60 hours at the crisis peak (a 51.77% relative reduction; $p < 0.001$). Collectively, the uniformity and statistical significance of these four downward shifts provide full empirical support for H_1, confirming that geopolitical crisis peaks coincide with substantial contractions in both institutional digital readiness and student engagement within sustainability curricula.

2. Structural Pathways, Institutional Mediation, and Cross-System Variance

Structural Equation Modeling (SEM) and multivariate regression analyses directly evaluated how Foreign Policy Lock-In (FPLI) and institutional path dependency account for the longitudinal contractions observed in Table 1. Empirical estimation confirmed a statistically significant negative correlation between crisis-driven foreign policy realignments and university investments in digital transformation, alongside a strong negative direct regression path from FPLI to DCT. As regulatory lock-in and security-

driven resource reallocations intensified during external crisis cycles, institutional capacity to execute digital course updates and sustain platform engagement declined systematically, providing empirical confirmation for H_2.

To address the second research question regarding variance attribution, quantitative path mediation analysis isolated the indirect structural mechanism operating within university governance. The mediation results demonstrated that institutional path dependency accounted for 42% of the total variance in digital transformation delays across the public university panel during external crisis cycles. This empirical variance share confirms H_3, showing that nearly half of the observed stagnation in digital sustainability modernization operated through internal procedural rigidity and pre-existing state-aligned funding dependencies rather than immediate short-term budget shocks alone.

Cross-institutional comparison of the panel records further revealed notable heterogeneity across political-administrative governance contexts. Public universities operating within centralized or corporatist political settings exhibited the highest variance in both digital course material updates and student digital engagement, reflecting tighter structural coupling between institutional curricula, state funding pipelines, and national foreign policy agendas. Within the institutional operational logs, these structural contractions corresponded to four recurring disruptions: frozen instructional technology budgets, delayed software licensing renewals, restricted integration of global environmental datasets, and curtailed student access to live higher education databases. Table 2 consolidates the empirical results across the longitudinal comparison, structural model, and mediation tests relative to the three formulated hypotheses.

Table 2. Summary of Empirical Findings and Hypothesis Verification Across Longitudinal and Structural Analyses

Hypothesis	Analytical Procedure	Evaluated Relationship / Construct	Empirical Finding	Outcome
H_1	Longitudinal mean comparison	Pre-crisis vs. crisis-peak DCT indicators	Significant contractions across all four indicators (-50.00% to -57.55%; all $p < 0.001$)	Supported
H_2	SEM & multivariate regression	Direct structural path: FPLI → DCT	Statistically significant negative correlation and strong negative direct regression path	Supported
H_3	Quantitative path mediation	Mediated path: FPLI → Institutional Path	Institutional path dependency accounts for 42% of total	Supported

		Dependency → DCT Delays	variance in digital transformation delays	

Source: Synthesized from Processed Institutional Primary Data and Structural Model Outputs (2026).
Note: FPLI = Foreign Policy Lock-In; DCT = Digital Curriculum Transformation; SEM = Structural Equation Modeling.

C. Discussion

1. Theoretical Mechanisms Linking Foreign Policy Lock-In to Digital Learning Contractions

The empirical contractions documented in the Results expose a structural transmission chain connecting macro-level geopolitical disruptions to micro-level instructional and behavioral degradation inside higher education sustainability programs. Addressing the first research question, the steep simultaneous declines in the institutional resource allocation index (-52.43%) and digital curriculum update rates (-57.55%) during crisis peaks reflect the core behavioral logic of structural neorealism.[17] Under conditions of external threat or systemic vulnerability, state authorities prioritize survival imperatives and centralize fiscal and regulatory control over state-funded entities, including public universities. Rather than acting as autonomous arenas of long-term academic modernization, university administrations experience acute policy lock-in, redirecting managerial attention toward regulatory compliance and financial conservation. Because sustainability and climate curricula rely heavily on continuous pedagogical iteration to remain aligned with evolving net-zero missions and international environmental agreements, security-driven fiscal freezes destabilize these programs disproportionately.

From the complementary vantage point of neoliberal institutionalism, transnational academic modernization and climate education depend on stable institutional channels, predictable grant regimes, and continuous cross-border data flows.[18] Crisis-driven security imperatives fracture these cooperative mechanisms, triggering administrative paralysis across public university systems. Crucially, addressing the second research question, the finding that institutional path dependency accounts for 42% of the total variance in digital transformation delays demonstrates that crisis-induced stagnation is not merely a transient budgetary shock. Grounded in historical institutionalism, self-reinforcing administrative routines, state-earmarked funding structures, and

[17] Waltz, *Theory of International Politics*, 102–28.
[18] Robert O. Keohane, *After Hegemony: Cooperation and Discord in the World Political Economy* (Princeton, NJ: Princeton University Press, 1984), 85–109.

bureaucratic procurement pipelines lock universities into rigid operational trajectories even when faculty recognize the urgency of digital curriculum renewal.[19]

Crucially, these macro-political and meso-institutional constraints propagate directly into student learning behavior within digital platforms, explaining why platform module utilization contracted by exactly half (−50.00%) and student digital engagement dropped from 82.10 to 39.60 hours (−51.77%). At the operational layer, frozen educational technology budgets, delayed software licensing renewals, restricted integration of global environmental datasets, and curtailed access to live higher education databases degrade the functional quality of Learning Management Systems (LMS). Interpreted through Cognitive Load Theory, outdated course modules, broken external data links, and unstable software tools impose substantial extraneous cognitive load on learners, forcing students to expend mental effort navigating technological friction rather than processing complex climate and sustainability concepts.[20] Concurrently, through the lens of Self-Regulated Learning (SRL), sustained digital engagement requires iterative feedback loops, timely content relevance, and reliable access to analytical resources that support learner goal-setting and self-monitoring.[21] When policy lock-in strips LMS environments of live environmental datasets and updated modules, learners experience diminished perceived utility and disrupted self-regulatory cycles, manifesting empirically as steep drops in platform interaction hours.

2. Scholarly Dialogue with Existing Literature

Confronting these empirical patterns with recent international scholarship reveals that the present study simultaneously confirms, extends, and challenges three major research streams. First, the findings confirm prior higher education digitalization research—including Mohamed Hashim, Tlemsani, and Matthews; Gkrimpizi, Peristeras, and Magnisalis; and Alenezi—which identifies funding shortfalls, governance bottlenecks, and institutional inertia as critical barriers to digital transformation.[22] Similarly, the observed vulnerability of climate and sustainability curricula corroborates empirical

[19] Pierson, "Increasing Returns, Path Dependence, and the Study of Politics," 251–67.
[20] John Sweller, Jeroen J. G. van Merriënboer, and Fred Paas, "Cognitive Architecture and Instructional Design: 20 Years Later," *Educational Psychology Review* 31, no. 2 (2019): 261–92, https://doi.org/10.1007/s10648-019-09465-5.
[21] Barry J. Zimmerman, "Becoming a Self-Regulated Learner: An Overview," *Theory Into Practice* 41, no. 2 (2002): 64–70, https://doi.org/10.1207/s15430421tip4102_2.
[22] Mohamed Hashim, Tlemsani, and Matthews, "Higher Education Strategy in Digital Transformation," 3171–95; Gkrimpizi, Peristeras, and Magnisalis, "Classification of Barriers to Digital Transformation," 746; Alenezi, "Digital Learning and Digital Institution in Higher Education," 88.

observations by Alenezi, Wardat, and Akour, Haleem et al., and Leal Filho, Salvia, and Eustachio regarding the fragility of university commitments to the UN Sustainable Development Goals under resource constraints.[23] However, this study challenges and extends the prevailing internalist paradigm of that literature. Whereas previous educational technology studies diagnose stalled modernization predominantly as an internal failure of university leadership, faculty digital literacy, or departmental readiness, the present structural model demonstrates that exogenous foreign policy realignments directly depress internal digital investment and curriculum updates—with nearly half of transformation delays mediated by state-coupled path dependency.

Second, within the learning analytics domain, the results confirm the diagnostic value of tracking LMS platform utilization and cumulative engagement hours to detect real-time instructional disruptions, aligning with Susnjak, Ramaswami, and Mathrani's framework on actionable analytics.[24] Yet our findings extend current learning analytics scholarship by revealing an underexamined source of analytical bias: steep declines in student digital engagement do not invariably stem from individual motivational deficits, ineffective course design, or learner risk profiles. Instead, institutional LMS logs can register macro-political externalities—such as restricted live database access and frozen licensing—that masquerade as student disengagement unless governance covariates are integrated into analytical models. Likewise, the findings reinforce Prinsloo, Slade, and Khalil's argument that educational data governance cannot be treated as a purely technical exercise detached from broader political and institutional power structures.[25]

Third, in relation to International Relations and the geopolitics of higher education, the empirical results confirm the macro-level arguments of Marginson and Brøgger et al. that intensifying geopolitical competition and state securitization constrain university autonomy and transnational knowledge circulation.[26] The primary difference and added value of the current study lie in its methodological architecture: by translating structural neorealism and institutional path dependency into longitudinal LMS and administrative metrics within an SEM framework, this research provides quantitative empirical

[23] Alenezi, Wardat, and Akour, "The Need of Integrating Digital Education," 4782; Haleem et al., "Understanding the Role of Digital Technologies in Education," 275–85; Leal Filho, Salvia, and Eustachio, "An Overview of the Engagement of Higher Education Institutions," 135694.
[24] Susnjak, Ramaswami, and Mathrani, "Learning Analytics Dashboard," 12.
[25] Prinsloo, Slade, and Khalil, "The Answer Is (Not Only) Technological," 876–93.
[26] Marginson, "What Drives Global Science?," 1566–84; Brøgger et al., "Introduction: The Shifting Geopolitics of Higher Education," 1–9.

verification of operational classroom consequences that prior qualitative IR scholarship only theorized at the diplomatic level.

3. Global Elevation, Complex Interdependence, and Boundary Conditions

Although the empirical evidence derives from a panel of 20 public universities across 2023–2025, the structural dynamics identified carry direct relevance across diverse global higher education systems. Cross-system variance within the dataset highlights a critical structural divide: public universities embedded in centralized or corporatist political-administrative regimes exhibit the sharpest contractions in digital course updates and student engagement because institutional budgets, procurement approvals, and curriculum mandates remain tightly coupled to national security and foreign policy directives. In contrast, higher education systems characterized by decentralized governance, diversified funding streams, and stronger institutional autonomy possess greater buffering capacity during interstate crises. This structural divide mirrors broader public-sector governance dynamics documented by Umam and Head, who demonstrate that entrenched political and state vested interests routinely test the limits of institutional autonomy unless buffered by durable countervailing forces and diversified governance coalitions.[27]

Applying complex interdependence theory clarifies how universities worldwide can build structural insulation against state-centric policy lock-in.[28] Rather than relying on single-channel state sponsorship, higher education systems that cultivate dense transnational academic networks, interoperable open-source LMS standards, and autonomous funding pipelines create multiple institutional channels that buffer instructional continuity against unilateral geopolitical shocks. Safeguarding these digital sustainability infrastructures directly advances global policy agendas—most notably Sustainable Development Goal 4 (Quality Education) and SDG 13 (Climate Action)—while protecting the human-capital foundations of the global digital economy during periods of macroeconomic and geoeconomic volatility.

Establishing clear boundary conditions is essential for interpreting the external validity of these findings. The quantified contraction mechanism operates most strongly

[27] Ahmad Khoirul Umam and Brian Head, "Testing the Limits of Public Integrity: The Impact of Vested Interests and Countervailing Forces on Indonesia's KPK," *Asian Politics & Policy* 12, no. 3 (July 2020): 384, https://doi.org/10.1111/aspp.12548.
[28] Robert O. Keohane and Joseph S. Nye Jr., *Power and Interdependence*, 4th ed. (Boston: Longman, 2012), 20–31.

in state-funded public universities whose operational budgets and software procurement depend on annual ministerial appropriations. Its algorithmic and governance transferability is likely attenuated in privately endowed research universities, fully online commercial higher education providers, or academic disciplines directly prioritized by national defense agendas (such as cybersecurity or military engineering), where geopolitical crises may paradoxically stimulate rather than suppress digital investment. Furthermore, universal LMS interoperability and cross-border open educational data standards serve as key moderating boundary conditions: institutions anchored to proprietary, domestically restricted licensing architectures face far steeper crisis-induced disruptions than those utilizing federated open-access platforms.

4. Theoretical Contributions and Actionable Managerial-Policy Implications

This study contributes to theory across three intersecting domains. In learning analytics, it introduces a macro-to-micro contextual layer demonstrating that external geopolitical and fiscal shocks act as systematic exogenous drivers of LMS behavioral variance, challenging purely learner-centric or course-centric predictive models. In educational technology and higher education management, it establishes institutional path dependency as a quantifiable mediating mechanism (42% variance) linking national policy realignments to operational delays in curriculum modernization. In International Relations, it extends structural neorealism, neoliberal institutionalism, and complex interdependence beyond traditional diplomatic arenas by demonstrating their measurable operational reach inside university digital classrooms.

Translating these verified empirical findings into practice yields targeted, actionable recommendations for four key stakeholder groups:

a. Educators and Curriculum Designers: Embed modular, resilient course architectures within sustainability curricula by pairing proprietary analytical tools with open-access environmental repositories and cached dataset backups. When live institutional databases or software licenses face sudden crisis restrictions, pre-configured open-source fallbacks preserve instructional continuity and prevent abrupt spikes in student cognitive load. Emerging evidence on AI-assisted platform development by Ekananda further demonstrates that non-programmer academics can independently deploy and maintain lightweight, custom digital research and learning infrastructures at minimal cost, offering a pragmatic technical buffer against sudden commercial

software licensing freezes.[29]

b. Institutional Managers and University Boards: Establish decentralized administrative workflows and ring-fenced digital infrastructure funds dedicated specifically to instructional software licensing, LMS maintenance, and digital sustainability course modules. Concurrently, institutional analytics teams should integrate fiscal and platform-availability alerts (such as module update lag and database uptime) into executive dashboards so leadership can distinguish infrastructure-induced engagement drops from pedagogical disengagement.

c. EdTech Developers and Investors: Engineer interoperable, open-standards LMS platforms featuring flexible crisis-tier licensing structures, low-bandwidth delivery modes, and federated access to international climate datasets. Positioning educational platforms as crisis-resilient infrastructure aligns commercial sustainability with institutional risk management across volatile regions.

d. Education Policymakers and Ministries: Enact multi-year statutory funding firewalls that insulate core university digital modernization and climate education pipelines from ad hoc emergency defense or security budget reallocations. Complementing national funding with transnational research consortia and university-industry sustainability alliances further diversifies capital streams, reinforcing institutional resilience across both developed and developing education systems.

5. Limitations and Directions for Future Research

Several methodological and analytical limitations warrant candid acknowledgment when interpreting these findings. First, because the study relies on an observational longitudinal panel across 20 public universities (2023–2025) without a randomized or quasi-experimental control group, causal attribution remains subject to potential unobserved confounding factors—such as concurrent macroeconomic inflation, domestic labor disputes, or institution-specific leadership transitions. Comparable governance research in the corporate sustainability domain by Dhar, Harymawan, and Sarkar

[29] Bintang Ekananda, "Vibe Coding in Production: A 104-Day Repository Study of a Research Platform Built by a Non-Programmer with AI Tools," *Preprints*, 2026, 2026101871. https://doi.org/10.20944/preprints202610.1871.v1.

similarly demonstrates that executive leadership stability and financial expertise significantly shape institutional accountability toward environmental mandates, underscoring the need to control for leadership turnover in future university governance models.[30] Second, the aggregation of LMS clickstream metrics at the institutional and course-cohort levels—while necessary to ensure student privacy—precludes granular examination of demographic, socioeconomic, or disciplinary equity disparities, introducing potential aggregation bias. Third, while the present analysis reports longitudinal mean contractions and the 42% path mediation share, fuller disclosure of disaggregated measurement model indices (e.g., factor loadings, Average Variance Extracted, and global SEM goodness-of-fit statistics) across independent institutional panels is needed to strengthen psychometric replicability. Fourth, restricting the empirical scope to public universities and sustainability curricula limits direct generalizability to privately funded institutions or non-environmental academic domains.

Future research should address these limitations along four concrete avenues. First, comparative multi-country studies employing quasi-experimental designs (such as difference-in-differences across centralized, federal, and privately governed higher education systems) should evaluate how specific political regimes moderate the severity of foreign policy lock-in. Second, multilevel learning analytics investigations should combine macro-level geopolitical risk indices with anonymized, student-level LMS event logs and Epistemic Network Analysis to trace how crisis-induced resource cuts alter collaborative discourse and cognitive engagement across diverse learner cohorts. Third, longitudinal intervention studies should empirically test the protective efficacy of specific governance insulation mechanisms—such as ring-fenced technology endowments and open-source LMS consortia—during active fiscal or geopolitical shocks. Finally, expanding the analytical scope to compare sustainability programs against defense-adjacent STEM fields would clarify how state security realignments redistribute digital modernization unevenly across academic disciplines.

[30] Bablu Kumar Dhar, Iman Harymawan, and Sabrina Maria Sarkar, "Impact of Corporate Social Responsibility on Financial Expert CEOs' Turnover in Heavily Polluting Companies in Bangladesh," *Corporate Social Responsibility and Environmental Management* 29, no. 3 (May 2022): 701–11, https://doi.org/10.1002/csr.2230.

D. CONCLUSION

Geopolitical crisis realignments and state-level foreign policy lock-in systematically constrain digital transformation within public higher education sustainability curricula, driving statistically significant contractions across digital curriculum updates, institutional resource allocation, platform module utilization, and student digital engagement ($p < 0.001$). Structural equation modeling confirms a strong negative direct effect of foreign policy lock-in on digital curriculum modernization, while quantitative path mediation demonstrates that institutional path dependency accounts for 42% of transformation delay variance, with the steepest operational disruptions occurring in centralized and corporatist university systems. Safeguarding continuous climate and sustainability education during geopolitical turbulence therefore requires autonomous university governance, interoperable open-standards learning platforms, and ring-fenced digital infrastructure funding insulated from emergency security budget reallocations. Future comparative research across diverse political regimes and private higher education systems should deploy quasi-experimental and multilevel learning analytics designs to evaluate which institutional insulation mechanisms most effectively protect digital academic resilience.

REQUIRED STATEMENTS

CRediT authorship contribution statement. A.A.: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Supervision. N.P.S.: Conceptualization, Data curation, Software, Validation, Formal analysis, Writing – review & editing.

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Data availability. The de-identified longitudinal institutional records and aggregated learning platform datasets analyzed during the current study are not publicly available due to institutional data governance and privacy agreements across the participating universities, but are available from the corresponding author on reasonable request for

scholarly verification.

Ethics statement. This study analyzed strictly de-identified, institutionally aggregated archival and digital course platform datasets in accordance with institutional research ethics standards and applicable data protection regulations, ensuring complete institutional confidentiality and zero collection of personally identifiable student data.

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