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# SHAPING DIGITAL SCIENTIFIC CULTURE: PLATFORM ENGAGEMENT AND DIGITAL LITERACY AS DRIVERS OF TECHNOLOGY ADOPTION IN INDONESIAN HIGHER EDUCATION

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## ABSTRACT

*The digital transformation of higher education demands more than infrastructure it requires cultivating a digital scientific culture in which students engage critically with knowledge through technology. This study examines Platform Engagement (PE) and Digital Literacy (DL) as co-determinants of Technology Adoption (TA) among Indonesian university students (N = 1,083). Data from open-ended surveys were coded through AI-assisted content analysis, then analysed using Spearman rank correlation and bootstrapped mediation analysis (5,000 iterations, 95% CI). All bivariate associations were significant: PE-DL ( $r_s = 0.178, p < .001$ ), PE-TA ( $r_s = 0.130, p < .001$ ), and DL-TA ( $r_s = 0.138, p < .001$ ). Path analysis confirmed significant direct effects of PE on DL ( $\beta = 0.167, p < .001$ ) and on TA ( $\beta = 0.090, p = .001$ ), and of DL on TA ( $\beta = 0.129, p < .001$ ). Bootstrapped mediation revealed a significant indirect effect ( $\beta = 0.021, 95\% \text{ CI } [0.010, 0.035]$ ), confirming DL as a partial mediator accounting for 19.3% of the total PE-TA effect. Platform engagement alone does not sustain technology adoption; digital literacy is the necessary bridge. These findings contribute to the technopedagogy framework by demonstrating that critical literacy development must be embedded within digital engagement strategies to cultivate durable academic technology adoption in Indonesian higher education.*

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**KEYWORDS:** Digital Scientific Culture, Platform Engagement, Digital Literacy, Technology Adoption, Technopedagogy, Indonesian Higher Education.

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## 1 INTRODUCTION

Talk to any lecturer at an Indonesian university today, and the story tends to go the same way. Classrooms are equipped, students carry smartphones, and institutional platforms are in place, yet meaningful digital learning remains uneven (Lei et al., 2023; Mhlongo et al., 2023; Sibghatullah Shah, 2024). Behind this paradox lies something that policy documents rarely address: the difference between having access to digital tools and knowing what to do with them. Following the rollout of the *Merdeka Belajar-Kampus Merdeka* (MBKM) policy and the disruptions of the COVID-19 pandemic, Indonesian higher education has invested heavily in digital infrastructure (Kurniawan, 2025; Makmun et al., 2025; Teguh Akbari et al., 2022). What has received far less attention is whether students have developed the competencies to engage with that infrastructure in ways that support genuine academic work (Dirckinck-Holmfeld et al., 2023; Goodyear, 2021).

At stake is what scholars have called digital scientific culture, the set of practices and dispositions that orient a learning community toward using digital tools for critical inquiry and knowledge construction, rather than passive consumption (Hali, 2025; Mugnaini et al., 2023). Building such a culture requires that students engage actively and purposefully with digital environments and, through that engagement, develop the evaluative and synthetic competencies that constitute digital literacy (Georgopoulou et al., 2025). Platform Engagement: The breadth and purposiveness of students' involvement with digital platforms is widely considered a precondition for literacy development. Digital Literacy, in turn, is increasingly identified as the cognitive mechanism through which platform use translates into academic technology adoption (Arangurí et al., 2025; Rusman et al., 2025).

This theoretical chain engagement feeding literacy, literacy enabling adoption forms the basis of the technopedagogy framework, which holds that digital competency development is a prerequisite for meaningful technology use in education, not a by-product of it. Yet, despite growing attention to these questions in the broader educational technology literature, empirical studies that test the mediating role of digital literacy between platform engagement and technology adoption in Indonesia remain scarce. Most existing Indonesian work has focused either on adoption barriers at the system level or has treated digital literacy as an outcome variable rather than a mediating mechanism (Cahyadi et al., 2021; Setiawardani et al., 2026; Suparman et al., 2025). This

study fills that gap.

Using open-ended survey data from 1,083 students across Indonesian higher education institutions, subjected to AI-assisted content analysis coding and analysed through bootstrapped mediation analysis, this study tests three hypotheses: (H1) Platform Engagement significantly predicts Digital Literacy; (H2) Digital Literacy significantly predicts Technology Adoption; and (H3) Digital Literacy partially mediates the relationship between Platform Engagement and Technology Adoption. The results are situated within the broader discourse on the formation of digital scientific culture in Indonesian universities and carry direct implications for curriculum design under the MBKM framework.

## 2 RESEARCH METHOD

This study employed a quantitative, cross-sectional research design. Data were collected through an online open-ended survey administered in Indonesian. The survey link was distributed through academic networks across Indonesian higher education institutions. A total of 1,083 university students responded fully, constituting the final sample. Table 1 presents the demographic profile of the sample.

**Table 1: Demographic profile of respondents (N = 1,083).**

Characteristic	N (%)
Institution type	
Universitas Pendidikan Indonesia	367 (33.9%)
Universitas Negeri Jakarta	33 (3.0%)
Universitas Padjadjaran	52 (4.8%)
Institut Teknologi Bandung	26 (2.4%)
Telkom University	20 (1.8%)
Universitas Pasundan	22 (2.0%)
Other institutions (≥388)	563 (52.0%)
Field of study	
Management/ Accounting/ Economics	258 (23.8%)
Education	244 (22.5%)
Engineering/Information Technology	146 (13.5%)
Social Sciences	127 (11.7%)
Health/Natural Sciences	67 (6.2%)
Other	241 (22.3%)

Open-ended survey items were used to elicit naturalistic descriptions of participants' digital behaviours across three domains: platform engagement patterns, digital literacy practices, and technology adoption experiences in academic settings. The choice of open-ended items over Likert scales was deliberate to preserve the contextual nuance of students' digital lives while still enabling systematic quantification through content analysis. Raw text responses were transformed into ordinal scores (1 = Low, 2 = Moderate, 3 = High) through AI-assisted content analysis guided by a theory-based

coding rubric developed a priori (Table 2). The coding was conducted using Claude, with the language model evaluating each response against the rubric criteria. Because this procedure classifies observable behavioral descriptors rather than generating factual claims, the AI's role was functional rather than interpretive, consistent with the computational content analysis tradition of Grimmer and Stewart (Mettler & Mettler, 2025; Williams, 2024).

Reliability was assessed by having the first author independently code a random subsample ( $n = 30$ ) and compare scores with AI-generated coding using percentage agreement and Cohen's kappa. Results confirmed acceptable reliability (agreement = 83.3%,  $\kappa = 0.64$ ,  $p < .001$ ), meeting established standards for content analysis (Krippendorff, 2018). Each construct was measured by two indicators: PE1 (platform diversity) and PE2 (knowledge-platform use) for Platform Engagement; DL1 (information verification) and DL2 (critical reading) for Digital Literacy; TA1 (learning platform use) and TA2 (learning mode) for Technology Adoption. Two indicators per construct are acknowledged as the minimum and reflect the constraints of working with open-ended items as a limitation.

**Table 2: Ordinal Coding Rubric for Construct Indicators.**

Indicator	Construct	Score 1 (Low)	Score 2 (Moderate)	Score 3 (High)
PE1 (Platform diversity)	Platform Engagement	1-2 passive platforms	3 platforms	4+ diverse platforms
PE2 (Knowledge platform)	Platform Engagement	Google/WhatsApp only	YouTube + Google	e-Journal/Scholar/Zenius
DL1 (Info verification)	Digital Literacy	No verification	Peer inquiry/general search	Cross-check authoritative sources
DL2 (Critical reading)	Digital Literacy	Passive screening	Full reading	Comparative sourcing
TA1 (Learning platform)	Technology Adoption	Resistance / WhatsApp only	Zoom/ Google Classroom standard	e-Learning/multiple platforms
TA2 (Learning mode)	Technology Adoption	Passive/resistance	Basic video explanation	Interactive/blended learning

Construct composite scores were computed as the mean of their respective indicators. Given the ordinal 1–3 measurement scale and non-normal distributions across several indicators, parametric methods were not appropriate. Bivariate associations were examined using Spearman rank-order correlation

(rs). Path coefficients were estimated via ordinary least squares, which is appropriate for  $N = 1,083$  when distributional assumptions are less consequential (Igartua & Hayes, 2021). Mediation was tested using bootstrapped confidence intervals (5,000 iterations, 95% percentile CI) following Tibbe & Montoya (2022). All analyses were conducted in jamovi with independent verification in R v4.4 using the mediation package (Song et al., 2024). Analysis scripts and the cleaned data file are provided as supplementary material to support reproducibility.

### 3 RESULTS AND DISCUSSION

#### Results

##### Descriptive Statistics

Table 3 presents descriptive statistics for the three construct composites.

**Table 3: Descriptive Statistics for Construct Composite Scores.**

Descriptives	PE	DL	TA
N	1083	1083	1083
Missing	0	0	0
Mean	1.83	2.37	1.80
Median	2.00	2.50	2.00
Standard deviation	0.525	0.459	0.476
Minimum	1.00	1.00	1.00
Maximum	3.00	3.00	3.00

Platform Engagement ( $M = 1.83$ ,  $SD = 0.525$ ) and Technology Adoption ( $M = 1.80$ ,  $SD = 0.476$ ) both clustered near the lower end of the 1–3 scale, with medians of 2.00. Digital Literacy scored somewhat higher ( $M = 2.37$ ,  $SD = 0.459$ , Median = 2.50), suggesting that students reported more developed critical information practices relative to their platform engagement behaviors, a gap worth investigating.

Individual indicators revealed notable distributional asymmetries. DL2 (critical reading) showed a pronounced ceiling effect: 86.8% of respondents scored at level 3, indicating that the vast majority claimed to actively seek multiple sources when evaluating information. This pattern suggests that students may perceive critical reading as a socially desirable or academically expected behaviour. The clustering of responses in the highest category also reduces score dispersion, making it harder to distinguish among participants' varying levels of competence. Such concentration at the upper end of the scale may therefore inflate perceived proficiency while masking meaningful individual differences. Yet PE2 (knowledge-platform use) showed the opposite pattern, with 67.0% scoring at level 1, indicating they rarely used academic digital tools such as e-journals or databases. The contrast between

high self-reported critical reading intent and low engagement with the very platforms that would support that intent points to a practised gap that curriculum designers should take seriously. These distributional asymmetries confirm the appropriateness of non-parametric analysis.

**Spearman Rank Correlations**

All three pairwise Spearman correlations were statistically significant at  $p < .001$  (Table 4).

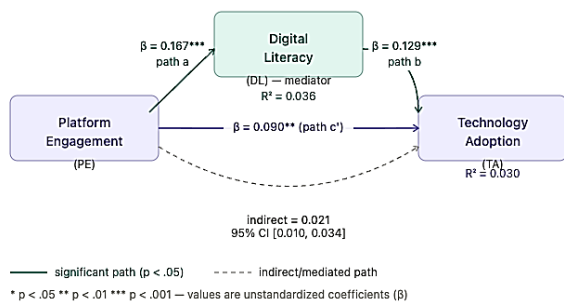
**Table 4: Spearman Rank-Order Correlation Matrix.**

		PE	DL	TA
PE	Spearman's rho	-		
	df	-		
	p-value	-		
DL	Spearman's rho	0.178	-	
	df	1081	-	
	p-value	<.001	-	
TA	Spearman's rho	0.130	0.138	-
	df	1081	1081	-

PE was positively associated with DL ( $r_s = 0.178$ ,  $df = 1,081$ ) and with TA ( $r_s = 0.130$ ,  $df = 1,081$ ). DL was also significantly associated with TA ( $r_s = 0.138$ ,  $df = 1,081$ ). Effect magnitudes are modest and expected given the constrained variance in a 1–3 ordinal scale, yet the directional coherence of all three associations aligns precisely with the hypothesized mediation model. All null hypotheses of zero association are rejected.

**Mediation Analysis**

Figure 1 and Table 5 present the bootstrapped mediation results.



**Figure 1: Mediation Model: Digital Literacy as Partial Mediator between Platform Engagement and Technology Adoption.**

**Table 5: Mediation Estimates.**

Effect	95% Confidence Interval					p
	Estimate	SE	Lower	Upper	Z	
Indirect	0.0214	0.00623	0.0102	0.0347	3.44	<.001
Direct	0.0896	0.02850	0.0350	0.1469	3.14	0.002
Total	0.1110	0.02840	0.0568	0.1676	3.91	<.001

Path a (PE → DL) was positive and significant ( $\beta = 0.167$ ,  $t = 6.387$ ,  $p < .001$ ), confirming H1. Path b (DL

→ TA | PE) was significant ( $\beta = 0.129$ ,  $t = 4.060$ ,  $p < .001$ ). The direct effect of PE on TA controlling for DL (path c') remained significant ( $\beta = 0.090$ ,  $t = 3.238$ ,  $p = .001$ ), as did the total effect ( $\beta = 0.111$ ,  $t = 4.058$ ,  $p < .001$ ). H2 and the direct-path component of H3 are thus supported.

The indirect effect of the quantity at the heart of H3 was 0.0214 (SE = 0.00623), with a 95% bootstrap CI of [0.0102, 0.0347]. This interval excludes zero, confirming statistical significance. With path c' also remaining significant, the pattern qualifies as partial mediation (Baron and Kenny, 1986; Hayes, 2018): Digital Literacy mediates the PE–TA relationship without fully accounting for it. The proportion of the total effect mediated through DL was 19.3%, roughly one-fifth. H3 is supported. Variance explained was  $R^2 = 0.036$  for the DL equation and  $R^2 = 0.030$  for the TA equation. These figures reflect the ordinal 1–3 scale's measurement constraints rather than weak substantive effects: at constrained variance, even genuinely meaningful relationships produce low  $R^2$  (Cohen, 1988), and the consistent statistical significance of all path coefficients speaks to the robustness of the findings.

**4 DISCUSSION**

The finding that platform engagement predicts digital literacy ( $r_s = 0.178$ ;  $\beta = 0.167$ ,  $p < .001$ ) carries an important nuance. The constructs in this study capture not just how many platforms students use, but whether that use extends to knowledge-production tools. Students who scored high on PE were those who engaged with academic databases, e-journals, and scholarly platforms, not simply those who spent more time online. It is this qualitative shift, from consumption to production orientation, that appears to generate literacy gains. This is consistent with Sánchez-Canut et al. (2023) argument that strategic digital skill development depends on usage diversity rather than frequency.

The gap between PE1 (M = 2.25) and PE2 (M = 1.40) scores suggests that while students engage with a variety of digital platforms, the majority still limit their knowledge-seeking to general-purpose tools. Two-thirds of respondents (67.0%) reported minimal use of academic digital resources. This is not simply a finding about skill levels, it reflects an infrastructure and habit problem that policy must address. Reviewed digital technology impacts across multiple countries and found consistently that the nature of digital engagement, rather than its intensity, was the primary predictor of competency outcomes (Aldhaen, 2024; Luís et al., 2025). Indonesian institutions operating under the MBKM

framework should explicitly attend to the types of platforms students are directed toward, rather than merely whether they are digitally active.

The mediation chain PE → DL → TA describes, in quantitative terms, the process by which a digital scientific culture is cultivated not simply by providing tools, but by building, through engagement with those tools, the critical competencies that make technology adoption durable. Merton's epistemic norms of science universalism, communism, and organized skepticism look different in a digital age, but they are no less relevant (Bright & Heesen, 2023; Macfarlane, 2024). A student who engages with academic platforms, learns to verify information and compare sources, and then adopts learning technologies as a habitual practice is, in a meaningful sense, internalising a scientific culture. UNESCO has called for precisely this capacity-building in developing country universities, arguing that infrastructure without literacy merely relocates inequality rather than resolving it (Bergman et al., 2022; Bosire, 2025). For Indonesian higher education specifically, the implication is that digital literacy development should be embedded as a cross-cutting competency within discipline-specific digital engagement activities, research assignments requiring the use of academic databases, collaborative projects on knowledge-production platforms, and reflective exercises on source evaluation, rather than segregated as a standalone technical skills module. The MBKM framework, with its emphasis on experiential and project-based learning, provides a natural institutional vehicle for this integration (Musyriyah et al., 2025; Saa, 2025). The floor effect on PE2 scores observed in this study, with the majority of students rarely engaging with academic digital resources, suggests that equitable access to knowledge-production platforms must also be addressed as a prerequisite, particularly for students

from less-resourced institutional contexts (Omodan, 2025).

## 5 CONCLUSION

This study set out to test whether Digital Literacy mediates the relationship between Platform Engagement and Technology Adoption among Indonesian university students, and whether this pathway illuminates the formation of digital scientific culture. The answer to both questions is yes. All three hypotheses are supported: PE significantly predicts DL ( $\beta = 0.167$ ,  $p < .001$ ); DL significantly predicts TA ( $\beta = 0.129$ ,  $p < .001$ ); and DL partially mediates the PE-TA relationship (indirect = 0.021, 95% CI [0.010, 0.035], proportion mediated = 19.3%). The central theoretical implication is that digital scientific culture in Indonesian universities is not formed by platform access or by literacy training alone, it emerges from the interplay between engagement and literacy, where each reinforces the other in a developmental chain that ultimately sustains technology adoption as an academic habit. This has direct and practical consequences for the design of digital learning programmes under the MBKM framework: embedding students in purposive knowledge-platform engagement is not supplementary to literacy development; it is the condition for it.

Future research should pursue longitudinal designs, representative national samples, and validated multi-item instruments to confirm and extend these findings. The roles of self-efficacy, institutional support, and peer learning norms as co-mediators or moderators of the PE-TA relationship deserve particular attention. Qualitative follow-up studies tracing how individual students' platform engagement histories shape digital literacy over time would add important depth to the quantitative picture reported here.

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