



Investigating Students' Learning Efficacy in Private Universities: An Extended Technology Acceptance Model

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ABSTRACT

The conventional Technology Acceptance Model (TAM) is widely adopted in educational technology research yet suffers notable limitations: it mainly predicts educational technology adoption intentions and lacks sufficient explanatory power for actual learning outcomes. Rooted in Vygotsky's sociocultural theory and learning analytics research, this study develops an extended TAM by incorporating three constructs: Digital Teaching Model (DTM), Learning Analytics Engagement (LAE), and Learning Self-Efficacy (LSE), to address the theoretical deficits of the original model. Questionnaire data were collected from 512 undergraduate students at Shandong Xiehe College, and structural equation modelling (SEM) was employed to test direct and mediating relationships among latent variables. The empirical results indicate that DTM exerts significantly positive effects on students' perceived usefulness, perceived ease of use, and LAE. Furthermore, LAE serves as a critical mediator that transforms learners' technology perceptions into improved learning efficacy. This study contributes to the literature in three ways. Theoretically, it extends TAM by integrating sociocultural perspectives and learning analytics to better predict learning performance. Empirically, it verifies the mediating role of LAE and clarifies the causal path linking technology acceptance to effective learning. Practically, it provides context-specific evidence for private higher education in China and delivers actionable strategies for implementing data-driven digital teaching.

Keywords: Technology Acceptance Model; Learning Efficacy; Learning Analytics; Sociocultural Theory; Private Universities; Structural Equation Modeling (SEM); China

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1. Introduction

Digital educational technologies have undergone rapid global proliferation, thoroughly reshaping higher education systems worldwide and accelerating the shift toward data-backed, technology-enabled instructional environments (Bond et al., 2020; Zawacki-Richter et al., 2021). This transformative shift carries unique implications for China's private universities, many of which rely heavily on digital learning platforms to offset inherent resource shortages and constraints on faculty development (Huang et al., 2022; Li & Wong, 2023). The widespread integration of learning management systems, artificial intelligence tools, and learning analytics platforms has not only overhauled traditional instructional delivery modes but also redefined how students interact with and internalize academic knowledge (Ifenthaler & Schumacher, 2021; Viberg et al., 2020). Despite these widespread technological upgrades, academics remain concerned about whether investments in digital tools genuinely translate into measurable improvements in student learning efficacy. Learning efficacy describes learners' self-perceived ability to complete academic tasks competently, and prior literature has established it as a robust predictor of long-term academic achievement and learning persistence (Honicke & Broadbent, 2016; Teng & Zhang, 2022). Nevertheless, emerging empirical evidence consistently confirms that mere technological uptake does not automatically yield superior learning results, underscoring the urgent need for more holistic theoretical frameworks to unpack this complex relationship (Granić & Marangunić, 2019; Bower, 2021).

Since its inception, the Technology Acceptance Model (TAM) has stood as the dominant theoretical lens for explaining user uptake of educational technologies, centering perceived usefulness (PU) and perceived ease of use (PEOU) as the primary drivers of adoption intentions (Davis, 1989; Scherer et al., 2019). Though TAM reliably forecasts users' behavioral willingness to utilize digital tools, scholars have repeatedly documented its limited applicability to explaining concrete learning outcomes (Teo et al., 2020; Abdullah & Ward, 2016). Contemporary critiques note that TAM overprioritizes individual cognitive perceptions while overlooking critical behavioral engagement patterns and contextual institutional factors that shape real-world learning (Cheng, 2021; Nikolopoulou et al., 2021).

Compounding these limitations, the rise of learning analytics has introduced new dimensions of student engagement entirely unaccounted for within the original TAM architecture (Ifenthaler & Yau, 2020; Viberg et al., 2020). Learning Analytics Engagement (LAE)—which encompasses students' active exploration of data dashboards, automated performance feedback, and predictive learning insights—has proven capable of strongly shaping academic attainment (Jivet et al., 2021; Matcha et al., 2020). Even so, few empirical studies have integrated LAE into extended TAM variants, particularly within the understudied context of private higher education in China.

While prior TAM extensions have incorporated external predictors such as social influence and facilitating conditions (Venkatesh et al., 2003; Dwivedi et al., 2020), few studies have systematically unified digital teaching models and learning analytics engagement within a single integrated framework designed to predict student learning efficacy (Scherer et al., 2021; Ifenthaler, 2022). Additionally, the vast majority of existing TAM-based research draws samples from public universities or Western educational contexts, restricting the generalizability of its conclusions to private tertiary institutions within emerging education systems like China's (Zawacki-Richter et al., 2021; Huang et al., 2022). From a theoretical standpoint, TAM's explanatory scope is further constrained by its failure to incorporate core tenets of sociocultural learning theory. Vygotsky's framework emphasizes mediated tools, peer social interaction, and cultural context as foundational forces shaping cognitive growth (Vygotsky, 1978; Wertsch, 1991). Recent scholarship has validated the relevance of this

perspective for digital learning settings, framing educational technologies as mediating artifacts that structure students' knowledge-building processes (Lantolf et al., 2020; Rienties et al., 2022). Yet meaningful integration between sociocultural theory and TAM remains largely underexplored in current literature.

Addressing the above theoretical and contextual gaps, this study develops and statistically validates an extended TAM embedded within a sociocultural analytical framework, incorporating Digital Teaching Model (DTM), Learning Analytics Engagement (LAE), and Learning Self-Efficacy (LSE). Specifically, the research pursues four core objectives: Examine the predictive impacts of DTM on students' perceived usefulness, perceived ease of use, and learning analytics engagement (Bower, 2021; Ifenthaler, 2022); Unpack the mediating role of LAE in linking traditional TAM constructs to final learning efficacy outcomes (Jivet et al., 2021; Matcha et al., 2020); Quantify how learning self-efficacy shapes student academic performance within digitally mediated classrooms (Teng & Zhang, 2022; Honicke & Broadbent, 2016); Construct a holistic extended TAM capable of explaining variations in learning efficacy specific to China's private higher education sector (Scherer et al., 2021; Dwivedi et al., 2020).

2. Literature Review

2.1 The Technology Acceptance Model (TAM)

First proposed by Davis (1989), the Technology Acceptance Model remains one of the most influential theoretical paradigms across information systems and educational technology research. Rooted in the Theory of Reasoned Action, TAM posits that an individual's willingness to adopt a technology stems fundamentally from two core subjective judgments: perceived usefulness (the belief that a tool improves task performance) and perceived ease of use (the belief that operating the tool requires minimal cognitive effort). These two constructs jointly shape user attitudes and behavioral intentions, which ultimately determine consistent system usage. Its streamlined structure and robust predictive power have cemented TAM's widespread application across domains, ranging from general e-learning platforms and learning management systems to artificial intelligence-assisted educational software. Within educational research, TAM has been extensively deployed to investigate faculty and student acceptance of digital learning tools. Large-scale bibliometric analyses covering 2020 to 2024 confirm TAM's enduring dominance in online learning adoption scholarship, testifying to its adaptability amid rapidly evolving digital learning environments. Multiple empirical studies further corroborate that perceived usefulness and ease of use remain statistically significant predictors of students' willingness to adopt learning technologies, spanning LMS platforms, mobile learning applications, and AI tutoring tools alike.

Nevertheless, modern scholarship has increasingly highlighted critical blind spots in the standalone TAM framework when applied to complex digital learning contexts. Most notably, the model overemphasizes isolated cognitive perceptions while neglecting social, affective, and institutional contextual variables. Researchers argue TAM fails to adequately account for social peer influence, cultural norms, and institutional resource support—all decisive factors shaping technology uptake within educational environments. Furthermore, TAM's predictive strength fluctuates drastically across technological and cultural contexts, especially in emerging fields such as AI-enhanced learning, where ethical concerns and contextual barriers heavily impact user behavior.

An equally substantial limitation lies in TAM's inability to explain learning-related processes and end outcomes. While the model reliably forecasts whether students intend to use digital tools, it offers little insight into how technological usage translates into sustained

learning engagement or improved academic results. Recent work identifies student engagement, self-efficacy, intrinsic motivation, and learning enjoyment as key moderators and predictors of both technology adoption and academic success—variables entirely absent from Davis's original TAM architecture. This gap becomes especially pronounced within digital learning ecosystems, where meaningful learning relies not merely on tool acceptance but on sustained cognitive interaction and self-regulated study behaviors.

In response to these identified weaknesses, academics have proposed successive iterations and integrative extensions of TAM. Revised models including TAM2, TAM3, and the Unified Theory of Acceptance and Use of Technology (UTAUT) integrate additional latent variables such as social influence and facilitating conditions to boost explanatory capacity. Post-2020 scholarship continues to expand TAM's boundaries by incorporating self-efficacy, digital literacy, and intrinsic learner motivation, signaling a broader shift toward learner-centered, multi-dimensional analytical frameworks. Empirical evidence confirms that self-efficacy and social normative beliefs reshape students' perceptions of usefulness and usability, indirectly altering their adoption behaviors; similarly, stronger digital literacy correlates with higher perceived ease of use and greater learner confidence when interacting with AI educational tools. Crucially, contemporary research emphasizes a paradigm shift: scholars now argue technology adoption should be treated as an intermediate process rather than an endpoint of analysis. This perspective aligns with emergent educational research trends that merge TAM with constructs measuring learning engagement, analytics interaction, and learning efficacy. By integrating these additional dimensions, expanded TAM frameworks can answer not only whether students utilize digital technologies but also how such usage generates substantive, high-quality learning experiences.

In summary, TAM delivers a solid foundational framework for understanding technology uptake, yet its inherent limitations necessitate targeted extensions for educational research. A growing consensus among modern academics advocates integrated models that weave psychological, behavioral, and contextual factors together to create a complete portrait of technology-enhanced learning. Against this backdrop, the present study develops an extended TAM incorporating learning analytics engagement and learning efficacy to untangle the complex dynamics of digital instruction within higher education settings.

2.2 Learning Analytics Engagement (LAE)

Learning analytics has emerged as a transformative force within modern higher education, enabling institutions to aggregate and analyze large-scale learner datasets to optimize instructional processes (Ifenthaler & Yau, 2020; Viberg et al., 2020). Conceptually, learning analytics refers to the systematic measurement, collection, analysis, and reporting of data tracking learners and their learning contexts, with the core objective of decoding and refining learning activities and their supporting environments (Ifenthaler & Yau, 2020; Viberg et al., 2023). Amid the widespread digitalization of tertiary education, learning analytics has become the cornerstone of data-driven pedagogy, allowing universities to track student learning trajectories, deliver personalized feedback, and support evidence-based instructional decision-making (Jivet et al., 2021; Siemens & Baker, 2022).

Building upon this definition, Learning Analytics Engagement (LAE) captures the degree to which students actively interact with, interpret, and apply outputs from analytics tools—including real-time performance dashboards, predictive learning indicators, and automated feedback systems—to guide their own studies. Traditional student engagement frameworks typically focus on behavioral participation, emotional investment, and cognitive involvement; LAE distinguishes itself by centering data-informed learning practices, wherein

learners leverage analytical insights to adjust their academic planning and self-regulation strategies (Matcha et al., 2020; Viberg et al., 2023).

Post-2020 empirical research frames LAE as an indispensable bridge between technological tool affordances and tangible learning gains. Students who regularly engage with learning analytics resources are better positioned to monitor personal progress, identify knowledge gaps, and iteratively refine their learning tactics—core tenets of self-regulated learning (SRL), a framework that positions learners as active planners, monitors, and evaluators of their own academic work. Quantitative evidence demonstrates that regular dashboard usage significantly strengthens students' metacognitive awareness, goal-setting capabilities, and final academic grades (Jivet et al., 2021; Viberg et al., 2023; Maldonado-Mahauad et al., 2022). Beyond improved academic performance, LAE exerts a dual direct and indirect positive influence on overall student engagement and learning efficacy. Studies show that learners who consistently review and reflect on analytical feedback demonstrate stronger sustained classroom participation and academic persistence alongside higher assessment scores (Ifenthaler, 2022; Matcha et al., 2020). Furthermore, data-backed feedback systems grant students an increased sense of agency and competence, reinforcing their self-efficacy beliefs and intrinsic learning motivation (Schumacher & Ifenthaler, 2021; Wise & Jung, 2023).

That said, LAE's positive impacts are not universal; their magnitude hinges heavily on students' data literacy, intrinsic motivation, and institutional instructional support. A key challenge documented in recent literature is widespread insufficient data literacy among student populations: without structured guidance, learners frequently underutilize or misinterpret analytics dashboards, severely limiting their capacity to drive learning improvements (Jivet et al., 2021; Viberg et al., 2023). This observation underscores the value of embedding structured instructional scaffolding and data literacy training within digital teaching models to maximize student benefits from analytics tools. Additionally, the usability and design architecture of analytics platforms directly shape LAE levels. Research identifies intuitive user interfaces, individualized feedback, and actionable analytical takeaways as critical design features that sustain long-term student interaction with analytics systems (Matcha et al., 2020; Wise & Jung, 2023). By contrast, overly convoluted, opaque analytics interfaces trigger cognitive overload and disengagement. Accordingly, aligning pedagogical design priorities with analytics platform functionality is essential to unlock LAE's full educational potential. A prominent emerging research trend spanning 2022–2026 centers on integrating artificial intelligence into learning analytics workflows, enabling sophisticated predictive modeling and adaptive real-time feedback. AI-enhanced analytics platforms deliver customized learning pathways and instant targeted recommendations, further amplifying students' self-regulatory capacity and engagement with analytical data (Ifenthaler & Schumacher, 2023; Holmes et al., 2022). These technological advancements simultaneously raise critical ethical concerns around student data privacy, algorithmic transparency, and responsible data usage—factors that shape student trust and willingness to engage with analytics resources in the first place.

Collectively, Learning Analytics Engagement constitutes a pivotal construct for unpacking student interactions within data-centric digital learning environments. It expands conventional engagement scholarship by spotlighting how analytical data shapes self-regulated learning behaviors and academic attainment. While LAE carries immense potential to boost learning effectiveness, its ultimate impact depends on three interrelated conditions: learners' ability to interpret quantitative performance data, the quality of analytics platform design, and structured pedagogical support embedded within digital teaching models. For this study, LAE is operationalized as a core mediating variable linking Digital Teaching Models (DTM) to final learning efficacy outcomes, offering granular insight into how data-driven engagement translates into superior academic performance.

2.3 Digital Teaching Model (DTM)

Digital Teaching Models (DTM) encompass a diverse spectrum of pedagogical frameworks that systematically integrate digital technologies into instruction to elevate teaching quality, deepen student engagement, and strengthen academic outcomes. This broad category includes blended learning, flipped classroom designs, fully online and hybrid instruction, adaptive learning systems, and AI-supported tutoring models (Bower, 2021; Huang et al., 2022). Fueled by advances in artificial intelligence, learning analytics, and cloud-based learning infrastructure, modern DTMs have evolved far beyond simple digital content delivery tools to form interconnected, interactive, data-driven learning ecosystems (Bond et al., 2020; Zawacki-Richter et al., 2021).

From a pedagogical perspective, DTMs prioritize learner-centered instruction designed to foster active participation, collaborative knowledge construction, and autonomous self-regulated learning. The flipped classroom paradigm, for example, shifts foundational knowledge transmission to pre-class digital modules, freeing in-person class time for higher-order cognitive activities including collaborative problem-solving and critical dialogue. Similarly, AI-powered adaptive learning systems deliver personalized study pathways and instantaneous feedback to boost learning efficiency and instructional customization (Huang et al., 2022; Holmes et al., 2022). Post-2020 empirical studies confirm these models significantly enhance university students' cognitive engagement and critical thinking capabilities, correlating with improved final academic performance (Bond et al., 2020; Lai & Bower, 2023).

Crucially, DTMs exert a formative influence on students' subjective perceptions of educational technologies, rendering them highly relevant within the TAM analytical framework. Well-structured digital learning environments elevate both perceived usefulness (PU) and perceived ease of use (PEOU) by delivering streamlined interfaces, meaningful task-based learning activities, and clear instructional guidance (Teo et al., 2020; Scherer et al., 2021). For instance, studies confirm core instructional design qualities—including logically organized content, interactive functionality, and built-in feedback mechanisms—directly reshape students' judgments of platform utility and usability, smoothing technology adoption processes (Cheng & Yuen, 2022; Nikolopoulou et al., 2021).

Beyond shaping technology acceptance, DTMs are increasingly recognized as foundational drivers of multi-dimensional student engagement, a critical intermediate variable connecting instructional design to end learning outcomes. Engagement within digital classrooms operates across three mutually reinforcing dimensions: behavioral, cognitive, and emotional involvement. Empirical results verify that interactive, adaptive DTMs strengthen engagement across all three spheres, particularly when augmented with collaborative digital tools, gamified learning elements, and instant feedback loops (Bond et al., 2020; Fredricks et al., 2021). Moreover, collaborative social features built into digital learning platforms align closely with sociocultural learning principles, highlighting the centrality of mediated interaction to knowledge construction.

A rapidly expanding body of literature documents the causal relationship between DTM architecture and Learning Analytics Engagement (LAE). Embedded analytics tools within digital platforms capture, organize, and visualize student performance data to surface actionable learning insights. Instructional design quality emerges as a decisive factor determining whether students actively utilize these analytical resources: DTMs featuring clear learning guidance, structured feedback cycles, and dedicated reflective activities consistently encourage students to leverage analytics dashboards for self-monitoring and strategic learning adjustment (Ifenthaler, 2022; Matcha et al., 2020). Recent findings spanning 2021–2025 further demonstrate that embedding real-time dashboards and predictive analytics within standard

DTM frameworks heightens student awareness of personal learning progress, fostering deeper analytical engagement and stronger academic results (Jivet et al., 2021; Viberg et al., 2023).

Furthermore, DTMs exert indirect effects on learning outcomes through layered mediating pathways spanning student engagement, learning motivation, and self-efficacy. Digital technologies alone cannot guarantee academic improvements; their educational value hinges entirely on thoughtful pedagogical integration. Poorly designed digital teaching models risk cognitive overload, disengagement, and superficial surface-level learning, whereas rigorously structured DTMs cultivate sustained meaningful interaction and deep conceptual understanding (Scherer et al., 2021; Lai & Bower, 2023). This contrast underscores the necessity of aligning digital tool functionality with evidence-based pedagogical principles.

Contemporary research trends (2020–2026) signal a widespread shift toward intelligent, data-informed DTM architectures that deploy AI and learning analytics to dynamically adjust instructional strategies to match individual learner needs. These modernized models deliver stronger personalization while equipping both educators and students with data-backed decision support (Ifenthaler & Yau, 2020; Holmes et al., 2022). Such innovations carry particular relevance for China's private higher education sector, where student cohorts exhibit highly diverse academic backgrounds and uneven baseline digital literacy levels. In aggregate, Digital Teaching Models function as a foundational pillar of contemporary educational practice, simultaneously shaping core TAM perceptions (PU and PEOU), driving student engagement with learning analytics, and ultimately determining final learning outcomes. Accordingly, this study positions DTM as the primary exogenous antecedent within the proposed conceptual model, predicting both Learning Analytics Engagement (LAE) and overall learning efficacy through overlapping direct and indirect causal pathways.

2.4 Learning Efficacy (LE)

Rooted in Bandura's foundational self-efficacy theory, learning efficacy refers to learners' subjective conviction that they can organize and execute the actions required to successfully complete targeted academic tasks. Within social cognitive theory, self-efficacy is more than a passive cognitive judgment: it constitutes a core mechanism of human agency, governing how learners think, regulate emotion, sustain motivation, and behave throughout their studies. Within educational research, learning efficacy stands out as an impactful non-cognitive variable that robustly predicts academic achievement alongside motivation, learning persistence, and self-regulatory capacity. Consistent empirical results confirm that students with elevated learning efficacy engage more proactively with coursework, demonstrate greater resilience amid academic challenges, and attain superior assessment results. Efficacy beliefs shape learners' goal-setting standards, willingness to invest sustained effort, and persistence through setbacks—all of which directly impact academic performance and learning quality. Recent research further validates self-efficacy's dual role as both an independent predictor and mediating variable structuring tertiary learning processes, especially within technology-supported digital classrooms. Within digital learning ecosystems, the construct of learning efficacy has expanded to incorporate technology-specific dimensions, commonly labeled online learning self-efficacy or digital learning efficacy. These variants center learners' confidence in navigating digital platforms, participating in virtual collaborative spaces, and managing autonomous self-directed online studies. Studies confirm students' perceived competence with digital learning tools strongly predicts their overall engagement and success within fully online or hybrid learning environments. Prior technological experience, equitable access to digital infrastructure, and intuitive platform usability emerge as key formative predictors of digital learning self-efficacy.

Post-2020 scholarship illustrates that digital learning efficacy emerges from the combined influence of technological affordances and internal psychological processes. On one hand, well-designed digital teaching models—including learning management systems, adaptive tutoring platforms, and AI-assisted instruction—provide structured scaffolding and personalized feedback that generate mastery experiences, the primary source of self-efficacy growth identified by Bandura. Adaptive motivational support embedded within multimedia learning environments has been empirically linked to measurable gains in academic and online self-efficacy. On the other hand, psychological processes including self-regulation, intrinsic motivation, and sustained engagement mediate the relationship between digital tool usage and evolving efficacy beliefs.

The proliferation of learning analytics has introduced an additional pathway for strengthening student learning efficacy. Analytics platforms deliver instant performance feedback, visual progress tracking, and predictive learning recommendations that enable learners to monitor growth and adjust study strategies autonomously. This data-driven feedback fosters a heightened sense of personal agency and competence, reinforcing positive efficacy perceptions. While isolated analytics tool usage yields only modest direct improvements in exam scores, robust evidence confirms analytics-driven student engagement strongly correlates with elevated self-efficacy and consistent classroom participation.

Notably, learning efficacy is not a static personal trait; it evolves dynamically through continuous reciprocal interaction between learners and their surrounding learning environments. Aligning with sociocultural theoretical logic, digital learning platforms operate as mediational cognitive tools that scaffold learners within their zone of proximal development, supporting gradual internalization of academic skills and concurrent growth in learning confidence. As such, rigorous analysis of learning efficacy within digital instructional settings demands an integrated perspective that accounts for both technological platform affordances and active learner engagement behaviors. To conclude, learning efficacy represents an indispensable construct for decoding student academic outcomes within modern higher education. It acts as a key psychological mediator through which digital teaching models and analytics engagement jointly shape student performance. For the purposes of this research, learning efficacy is conceptualized not merely as a terminal outcome variable but as a fluid psychological state co-constructed through continuous interaction between digital pedagogical design and active student data engagement.

2.5 Theoretical Integration: TAM, Sociocultural Theory, Learning Analytics, and Learning Efficacy

Analyzing complex digital learning processes demands a multi-layered theoretical framework capable of synthesizing technological, psychological, and social dimensions. While individual theories including the Technology Acceptance Model, Vygotsky's sociocultural theory, and learning analytics scholarship each deliver valuable partial insights, none independently capture the full scope of digitally mediated learning when deployed in isolation. This study therefore proposes an integrated conceptual framework unifying TAM, sociocultural theory, learning analytics, and learning efficacy to explain how digital teaching models shape student academic outcomes within higher education.

2.5.1 Merging TAM with Digital Instructional Contexts

The Technology Acceptance Model delivers a foundational analytical lens for understanding student uptake of digital learning technologies. Its core latent variables—perceived usefulness (PU) and perceived ease of use (PEOU)—explain the cognitive reasoning guiding learners' decisions to interact with digital platforms (Davis, 1989; Scherer et al., 2021).

Within digital teaching environments, thoughtfully designed instructional frameworks boost perceived usefulness by clearly demonstrating tangible academic benefits, while streamlined interfaces and structured learning sequences improve perceived ease of use (Teo et al., 2020; Nikolopoulou et al., 2021). Nevertheless, post-2020 research widely recognizes that technology acceptance alone cannot produce substantive learning gains; rather, adoption functions as a necessary precondition enabling deeper analytical engagement and sustained academic development (Cheng & Yuen, 2022; Lai & Bower, 2023). Accordingly, this study positions TAM as an entry-stage mechanism explaining how digital teaching models shape students' initial willingness to interact with educational technologies, rather than treating acceptance as a final explanatory endpoint.

2.5.2 Sociocultural Theory as a Mediation-Centered Analytical Lens

Vygotsky's sociocultural theory complements TAM by centering the mediating roles of social interaction, cultural tools, and guided support in cognitive development. The theory's defining concept—the Zone of Proximal Development (ZPD)—posits that learners reach higher levels of conceptual understanding through structured external guidance and collaborative peer exchange. Within digital learning ecosystems, learning management systems and analytics dashboards operate as formal mediational artifacts facilitating multi-way interaction between students, instructors, and academic knowledge (Viberg et al., 2023; Holmes et al., 2022). Viewed through this theoretical lens, digital teaching models are not passive content delivery channels but socially embedded learning environments that scaffold student growth through structured feedback, peer collaboration, and data-backed learning insights. Recent scholarship further establishes that AI and analytics-enhanced digital tools expand traditional sociocultural mediation by delivering adaptive, real-time instructional scaffolding tailored to individual learner progress (Ifenthaler & Schumacher, 2023). In this capacity, sociocultural theory provides the pedagogical and interactional foundation needed to explain how digital learning environments drive deep learning beyond superficial tool usage.

2.5.3 Learning Analytics as an Interconnecting Mechanism

Learning analytics (LA) serves as the critical theoretical bridge linking technology acceptance (TAM) to socioculturally mediated learning processes. By generating instant feedback, visualized performance data, and predictive learning guidance, analytics platforms equip students to systematically monitor and regulate their own study behaviors. Within the integrated framework advanced in this paper, Learning Analytics Engagement (LAE) operationalizes the behavioral and cognitive manifestations of socioculturally mediated digital learning. When students actively interpret and act upon analytical data dashboards, they engage in data-supported reflective practice and strategic academic decision-making—core activities aligned with self-regulated learning principles (Jivet et al., 2021; Matcha et al., 2020). Empirical research spanning 2020–2026 verifies that analytics tools strengthen learners' metacognitive awareness, support structured goal-setting, and lift overall academic performance, especially when paired with intentional instructional scaffolding (Viberg et al., 2023; Wise & Jung, 2023). For this reason, LAE is designated as a central mediating construct that translates technological platform affordances into deep, effective learning processes.

2.5.4 Learning Efficacy as a Psychological Outcome Metric

Grounded in Bandura's self-efficacy theory, learning efficacy (LE) captures the psychological end product of the full integrated digital learning process. It encapsulates learners' self-assessed capacity to complete academic tasks successfully and serves as a robust predictor of learning motivation, persistence, and long-term achievement. Within the unified conceptual model proposed here, learning efficacy develops through three distinct interwoven

pathways: Technological pathway (TAM): Favorable perceptions of platform usefulness and usability build student confidence in navigating digital learning tools; Social pathway (Sociocultural Theory): Mediated peer and instructor interaction plus structured instructional scaffolding cultivate feelings of academic competence; Behavioral pathway (LAE): Sustained data-driven analytical engagement strengthens self-regulatory skills and generates repeated mastery experiences. Recent empirical work confirms student self-efficacy receives significant positive influence from structured feedback, collaborative digital interaction, and successful iterative learning experiences within digital classrooms (Schumacher & Ifenthaler, 2021; Maldonado-Mahauad et al., 2022). The study therefore frames learning efficacy as the primary dependent variable, measuring the overall effectiveness of digitally supported teaching and learning processes.

2.5.5 Conceptual Synthesis and Proposed Research Model

Drawing together the above theoretical strands, this paper advances a unified conceptual framework structured around the following logical hierarchy:

Digital Teaching Model (DTM): The exogenous instructional and contextual foundation shaping all downstream variables;

Core TAM latent constructs (PU, PEOU): Capture student cognitive perceptions governing technology acceptance;

Learning Analytics Engagement (LAE): Represents data-centered active learning behaviors; Learning Efficacy (LE): The ultimate psychological and academic outcome variable.

The integrated model advances the following testable logical relationships: DTM exerts direct positive effects on students' perceived usefulness and perceived ease of use (core TAM dimensions);

DTM facilitates socioculturally mediated learning via digital scaffolding tools; LAE carries a mediating function linking DTM to final learning efficacy outcomes; Learning efficacy emerges as the cumulative result of overlapping technological, social, and engagement-based influences. This multi-theory integrated framework addresses key limitations of single-theory analytical approaches by delivering a multi-dimensional account of digital learning that unites technology acceptance, social mediation, active data engagement, and psychological learning outcomes. Collectively, this synthesized theoretical foundation provides rigorous analytical grounding for investigating how digital teaching models boost student learning efficacy via the mediating channel of learning analytics engagement, closing the persistent research gap separating technology adoption research from scholarship on substantive learning gains.

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