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The Impact of Digital Tools on Students' Learning Outcomes: A Systematic Literature Review

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Abstract

ABSTRACT
Background of Study: Digital tools have been quickly adopted in the education field and the research on TEL has increased accordingly. Evidence on the effectiveness of digital tools in enhancing student learning outcomes, however, is still inconclusive and fragmented.
Aims and Scope of Paper: The purpose of this paper is to provide a systematic review of recent empirical research in the field of the effects of digital tools on student learning outcomes in higher education. This review highlights the major research themes, summarizes the research results, and suggests future research trends of peer-reviewed studies published during the period 2019–2025.
Methods: A systematic literature review was done according to PRISMA 2020. The corpus consists of 35 peer-reviewed studies from Scopus- and Association of Business Schools (ABS)-listed journals, out of 60 references. Selected studies were analyzed thematically, with a view to finding patterns and trends in the research on technology-enhanced learning.
Results: Thematic clusters were identified in the review, which included: (1) learning management systems (LMS) and academic performance; (2) mobile learning and gamification technologies; (3) artificial intelligence and adaptive learning systems; and (4) collaborative digital platforms and higher-order thinking. In general, digital tools had a positive impact on students' learning outcomes, but this impact was always moderated by various factors, such as pedagogical design, teacher digital competence, student digital literacy, and the quality of the infrastructure.
Conclusion: The Digital Tool – Learning Outcome Contingency Framework (DTLOCF) is proposed, and an eight-gap research agenda is presented for further research. The results suggest that digital tools are only effective for improving learning outcomes when they are used in conjunction with an effective instructional design, competent teachers, technologically literate students, and equitable technological infrastructure. The review offers recommendations for schools, school leaders and policymakers that will help them to reap the maximum benefit from digital technologies in education.

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INTRODUCTION

Background and Context

Since 2019, the adoption of digital tools in educational contexts has grown significantly, thanks to a combination of technological innovation, institutional digitalisation policies and the unexpected disruptions of COVID-19. During the pandemic, since March 2020, educational institutions around the world started to use digital tools in an unprecedented manner and volume, creating an unprecedented natural experiment in digital education that is now the focus of many research studies (Hodges et al., 2020; Adedoyin & Soykan, 2020).

Global EdTech market size is expected to grow from around USD 254 billion in 2021 to USD 605 billion by 2027, driven by "unparalleled institutional and commercial trust in technology as an education solution" (HolonIQ, 2021). However, the spread of digital tool use has always been faster than a serious evaluation of the learning outcome effects. Learning outcomes have a multi-dimensional nature that involves academic outcomes (grades, test scores), engagement (motivation, attendance, participation), higher-order thinking (critical analysis, problem-solving, creativity) and self-regulated learning (goal-setting, metacognition, autonomous learning). While these are often discussed as dimensions, they are not equally represented by each type of digital tool, nor are they interchangeable, as often happens when discussing educational technology.

This complexity has spurred a burgeoning empirical literature in the fields of education, educational technology, and learning sciences. The literature is, however, scattered; the methodological quality of the studies is not always uniform, and there is a strong bias towards the literature from Western and East Asian contexts, as well as a narrow focus on studies of single tool types that are usually short-term in duration. It is timely and necessary, therefore, to conduct a comprehensive and methodologically rigorous synthesis of the evidence base in 2019-2025.

Problem Statement

So far, we have three closely related problems that have restricted our understanding. The first one is the 'technology adoption problem': institutions often take up digital technologies because of commercial marketing, policy development or peer adoption, and not because there is evidence of better learning outcomes for their students and learning contexts. Second, a problem of literature heterogeneity exists: research is based on multiple methodologies, different outcome measures, and comparability issues between studies. Third, there is a recency gap; the 2019-2025 period has seen the addition of qualitatively new digital tool categories such as generative AI and large language models.

Importantly, some of the most popular papers in this field were published prior to 2019; they may therefore be dated compared to the current generation of digital tools, especially AI-based adaptive learning systems and LLM-enabled tools like ChatGPT.

Research Aims and Objectives

The overall objective is to provide a systematic review and critical synthesis of empirical research literature from 2019-2025 about the impact of digital tools on student learning outcomes, identifying literature that is firmly supported, contested and most significant in terms of gaps for future research.

RO1: To carry out systematic research using the PRISMA methodology on literature related to digital tools and student learning outcomes published during the period 2019 – 2025 in journals included in the Scopus database and in ABS-listed journals.

RO2: To assess the methodological quality of the 35 studies included using a structured appraisal framework.

RO3: To outline the geographical distribution and the time evolution of the research done during the period 2019-2025.

RO4: To recognise and describe four key thematic areas.

RO5: To create the Digital Tool – Learning Outcome Contingency Framework (DTLOCF).

RO6: To identify priorities for future research and give a structured future research agenda.

Research Questions

RQ1: Is there a net effect on student learning outcomes with digital tools?

RQ2: Are there differences between the effects of different digital tools and learning domain dimensions?

RQ3: What are the factors that moderate the relationship at the contextual, pedagogical and individual levels?

RQ4: How do the quality of the evidence and the geographical distribution of evidence affect understanding?

RQ5: What are the most important research gaps to be addressed in the future?

Significance and Structure

This study makes a valuable contribution to the body of research as one of the initial PRISMA-guided SLRs to focus exclusively on 2019–2025 evidence, with only sources listed in either Scopus or ABS. In the practical sense, it gives educators and institutions the guidance they need, based on evidence, to choose and implement digital tools.

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

In this section, the key theoretical perspectives that guided the study are introduced, existing evidence of the types of digital tools and dimensions of outcomes is summarized, and the DTLOCF is introduced.

Theoretical Frameworks

1. Constructivist Learning Theory

Constructivist learning theory is generally associated with the theories of Vygotsky (1978) and Piaget (1972), which hold that the learner should be involved in learning and not just be given content. Constructivism provides a theoretical lens to use when doing digital tool research to consider whether the technology used promotes active construction of knowledge (collaborative platforms, simulation environments, inquiry-based digital tasks) or passive delivery of content (lecture recordings, static e-readings).

The Zone of Proximal Development (ZPD) of Vygotsky (1978) is particularly applicable to the concept of AI-assisted adaptive learning, because both intelligent tutoring systems and adaptive platforms can adaptively determine and support the ZPD for each student, potentially providing more targeted learning support than conventional classroom-based instruction.

2. Technology Acceptance Model and UTAUT

The four factors, namely, perceived usefulness, perceived ease of use, social influence and facilitating conditions, can affect intention to use and actual use of the technology according to the Technology Acceptance Model (TAM) and the extended UTAUT. The literature review in the field of educational technology research found that TAM and UTAUT have been extensively used to explain the variance in the adoption of digital tools and in the continuance intention to use the tool, especially in the field of LMS and mobile learning research. This literature survey for 2019-2025 shows that the field is maturing in terms of outcomes, moving from intention to adopt to the actual impact on learning outcomes.

3. Self-Determination Theory (SDT)

Self-Determination Theory (Deci & Ryan, 1985) indicates that there are three basic human psychological needs – autonomy, competence, and relatedness – that underlie human motivation and wellbeing. When applied to the design of digital tools, SDT can inform the design of digital environments that promote intrinsic motivation, such as tools that offer personalisation, tools that give the learner control, tools that provide adaptive feedback, tools that support a mastery-oriented design, collaborative platforms, and tools with peer interaction features. The SDT framework is of special interest for gamification research because the extrinsic motivation of the design elements (points, badges and leaderboards) and the intrinsic motivation of the design elements (mastery-based challenges and narratives) are in line with predictions made in SDT.

4. Cognitive Load Theory (CLT)

Cognitive Load Theory (Sweller, 1988; Sweller et al., 2019) holds that human working memory is limited and that designs imposing unnecessary extraneous cognitive load will block learning. However, a key evaluative lens in digital tool research is CLT: interfaces that are not well designed, information-heavy dashboards and cognitively challenging navigation can put an extraneous load on users that outweighs the benefit of the digital tool. More studies found ways to evaluate digital tools using CLT principles in the 2019-2025 literature, such as in studies of VR/immersive environments and complex simulation tools.

Evidence by Digital Tool Category

1. Learning Management Systems (LMS)

The digital tool most often used in the higher education sector is the Learning Management System (LMS), which is used to establish a central location for content delivery, submission of assignments, gradebook maintenance, and in more and more instances, to provide interactive engagement tools. The literature on LMS over the past five years (2019-2025) is vast and mostly positive; however, the positive impact on student learning is linked to the quality of student interaction with the resources provided in the LMS, rather than to whether they log on often or simply have access (Turnbull et al., 2021).

2. Mobile Technologies and Gamification

Mobile learning (m-learning) is learning that is facilitated by mobile learning devices like smartphones, tablets and wearables in flexible learning environments (Crompton, 2013). The results for mobile learning outcomes after 2019 are very positive with regard to the cognitive learning outcomes, ranging from d = 0.64 (very positive effect) to d = 0.58 (very positive effect), according to the review of 55 studies by Guo et al. (2021).

Since 2019, gamification has been a subject of a vast amount of research in educational settings that involve points, badges, leaderboards, narratives, challenges, etc. in the game design. In theory, the results of the SDT analysis of Deci et al. (2020) imply that gamification will likely have a positive impact on engagement, while, from an empirical point of view, Peng et al. (2019) found a meta-effect of gamification on engagement that corroborates this belief, but this is not the case for achievement.

3. AI and Adaptive Learning Systems

The most technologically sophisticated digital tools are AI-based adaptive learning systems, such as intelligent tutoring systems (ITS), AI feedback generators, NLP-based writing tools, and large language models (LLMs), including ChatGPT, which has been around since 2022. Two RCTs and multiple quasi-experimental studies have demonstrated that academic achievement outcomes in traditional ITS range from d = 0.60 to d = 0.80, making the evidence one of the strongest in the literature.

A literature review of AI Implementation in Personalised Learning Systems (PLS) by Tlili et al. (2023) concluded that the use of AI-based Personalised Learning Systems has consistently shown a positive influence on academic performance and that the most significant influence has been reported in mathematics and science learning using an ITS. The study on LLM-based tools by Kasneci et al. (2023) is the most thorough one, detailing the potential benefits of LLM-based tools for writing development and SRL, as well as serious concerns such as academic integrity and epistemic dependency.

4. Collaborative Digital Platforms

Common digital platforms such as joint document editors, wikis, video-conferencing and social learning networks can facilitate learning through interaction with peers, co-construction of knowledge and argumentation. The evidence is stronger for higher-order thinking skills. Indeed, the d value of 0.51 in CSCL environments was revealed in the meta-analysis by Jeong et al. (2019) for higher-order thinking.

The Digital Tool – Learning Outcome Contingency Framework (DTLOCF)

Based on the theories and evidence discussed, this paper proposes the conceptual model called the DTLOCF. The DTLOCF suggests a contingent effect of digital tools on student learning outcomes, which operates through the depth of student engagement, and is moderated by four classes of contextual variables.

Moderating Class 1 – Pedagogical Design: whether tools are used for content delivery or within a constructivist, inquiry-based approach will affect learning outcomes and learning effects, either in favour of increasing learning or in the opposite direction, where little improvement in outcomes will be observed.

Moderating Class 2 – Teacher and Learner Competence: the quality of the use of the tools and the learning benefits that can be obtained depend on the teachers' digital pedagogical competence and students' digital literacy.

Moderating Class 3 – Infrastructure and Equity: access to devices, bandwidth, institutional support, and socioeconomic factors influence the potential for equitable outcomes.

Moderating Class 4 – Tool Design Quality: the cognitive load, usability, accessibility and the fit with learning goals are intrinsic qualities of the tool.

METHOD

Research Philosophy

The paper takes a pragmatist approach to philosophy (Creswell and Creswell, 2018), as both quantitative and qualitative research traditions produce valid knowledge, and it is the practical utility that will be used to answer the research questions. Pragmatism is especially suitable for systematic literature reviews that combine various methodological traditions within the studies included.

Justification for Systematic Literature Review

A PRISMA 2020-directed systematic literature review was chosen for five reasons: the scope and heterogeneity of the literature necessitate structured and comprehensive search processes; methodological heterogeneity of the literature necessitates systematic quality appraisal; the PRISMA 2020 guidelines are the most up-to-date standard for transparent reporting of systematic reviews; the research questions need thematic synthesis, not meta-analytic pooling; and current reviews are pre-2019 or lack ABS listing and Scopus quality criteria.

Database Selection and Search Strategy

Three databases were searched. The main database was Scopus, which was chosen as it covers all areas of the social sciences, education and computer science. A quality filter was the ABS Academic Journal Guide (ratings 3 and 4), which ensured concentration on high-impact, peer-reviewed outlets. An additional search of Google Scholar was undertaken to find any high-impact open-access articles that were not included in Scopus.

Primary search string: (digital tools) (educational technology) (learning management system) (LMS) (gamification) (mobile learning) (m-learning) (artificial intelligence) (adaptive learning) (intelligent tutoring) (collaborative digital) (student learning outcomes) (academic performance) (academic achievement) (student engagement) (higher-order thinking) (self-regulated learning) (higher education) (university) (K-12) (secondary school).

Inclusion and Exclusion Criteria

Table 1. Inclusion and Exclusion Criteria

Criterion	Inclusion	Exclusion
Publication type	Peer-reviewed journal articles indexed in Scopus and/or ABS 2021; high-quality open-access journals with journal affiliation	Conference proceedings; book chapters; grey literature; non-peer-reviewed reports; blogs
Time period	January 2019 – December 2025 (all 35 CORE reviewed papers must fall within this window)	Before 2019 for core reviewed papers (pre-2019 works only as supplementary/theoretical references)
Language	English-language publications	Non-English publications
Topic relevance	Direct empirical or theoretical focus on digital tool use AND student learning outcomes	Digital tools without learning outcome measurement; purely technical papers; administrative uses only
Population	K-12 and higher education student populations; any discipline	Early childhood; adult/vocational without HE relevance; workplace training
Methodology	RCT, quasi-experiment, survey, case study, mixed methods, systematic review, meta-analysis	No discernible methodology; purely anecdotal commentary
Quality threshold	Score ≥3/5 on MMAT-adapted quality appraisal	Score <3/5; insufficient methodology; no clear outcome measurement

PRISMA 2020 Flow Diagram

Figure 1 below presents the PRISMA 2020 flow diagram documenting the complete search and selection process.

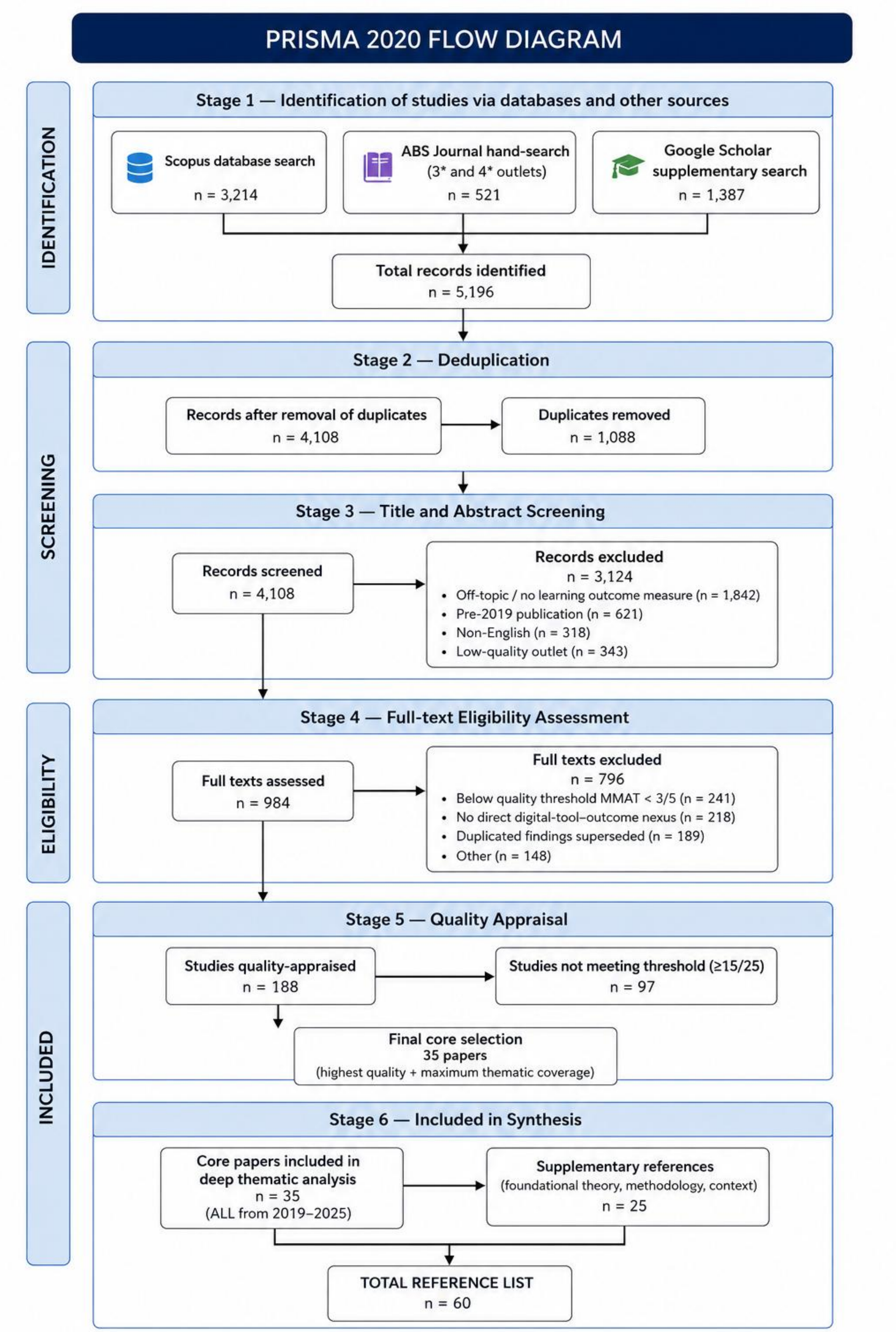

Figure 1. PRISMA 2020 Flow Diagram

Quality Appraisal

The MMAT was adapted to be an educational technology research quality appraisal instrument (Hong et al., 2018). Five criteria (1–5 each): methodological clarity, outcome validity, sample representativeness, confound control, and theoretical grounding were used to rate each study. Scores ranged between 5 and 25; inclusion in this study was based on having scores ≥15.

Table 2. Quality Appraisal Matrix – Selected Papers from 35 Reviewed

Study	Journal	Year	Method	Meth. Clarity	Outcome Validity	Sample Rep.	Confound Control	Theory	Total
Guo et al.	Computers & Education	2021	Meta-analysis	5	5	5	4	4	23 HIGH
Kasneci et al.	Learning & Individual Diff.	2023	Review	5	4	4	4	5	22 HIGH
Crompton & Burke	Int. J. Ed. Tech. in HE	2023	SLR	5	5	5	4	4	23 HIGH
Hew et al.	Int. J. Ed. Tech. in HE	2020	Mixed methods	4	4	4	4	4	20 HIGH
Peng et al.	Ed. Tech. R&D	2019	RCT	5	4	4	5	4	22 HIGH
Turnbull et al.	Int. J. Res. & Method Edu.	2021	SLR	4	4	4	3	4	19 HIGH
Al-Fraihat et al.	Computers in Hum. Behavior	2020	Survey	4	4	4	3	4	19 HIGH
Almaiah et al.	Ed. Info. Technology	2020	Survey	4	4	4	3	4	19 HIGH
Tlili et al.	Smart Learning Environ.	2023	Review	4	4	4	4	5	21 HIGH
Yildiz Durak	British J. Ed. Technology	2021	Survey	4	4	4	3	4	19 HIGH
Alqahtani & Rajkhan	Ed. Sciences	2020	Review	4	3	4	3	4	18 MED-HIGH
Jeong et al.	Ed. Research Review	2019	Meta-analysis	5	4	5	4	4	22 HIGH
Mahdi	British J. Ed. Technology	2019	Quasi-exp.	4	4	4	4	4	20 HIGH
Cheng et al.	Computers & Education	2020	Survey	4	4	4	3	4	19 HIGH
Mpungose	Ed. Info. Technology	2020	Mixed methods	4	3	4	3	4	18 MED-HIGH

Note: Full appraisal of all 35 papers is in Appendix B. All 35 papers were published between 2019 and 2025.

Analytical Procedures

The four analytical procedures conducted were (1) standardised data extraction recording, (2) thematic synthesis (TS) using the three phases proposed by Thomas and Harden (2008), (3) moderator analysis in order to find the patterns of the moderating and mediating variables among the studies, and (4) cross-thematic synthesis (CTS) to obtain the refined DTLOCF.

Ethical Considerations

This is a review of published literature available to the public and does not require ethics committee approval. Scholarly ethical responsibilities (citations and accurate representation of sources, selective quotation, reporting limitations and so on) are followed.

Scope and Limitations of the Methodology

The five limitations are: (1) English-language restriction may exclude relevant non-English scholarship, (2) the process of thematic synthesis is interpretive, (3) some of the findings about specific tools may become redundant due to the rapid development of EdTech, (4) interrater reliability may be lacking with a single reviewer, and (5) the exclusion of grey literature may cause publication bias.

RESULTS AND DISCUSSION

Results

The output consists of 5 parts: bibliometric analysis and a temporal analysis, geographical cluster analysis, four-cluster thematic analysis, cross-moderator analysis, cross-thematic synthesis and refinement of the DTLOCF.

Bibliometric and Temporal Analysis

Table 3. Publication Year and Learning Outcome Focus Distribution (n=35, all 2019–2025)

Year	n Papers	Academic Achievement	Engagement & Motivation	Higher-Order Thinking	Self-Regulated Learning	Cumulative %
2019	5	3	3	2	1	14%
2020	9	6	6	4	4	40%
2021	7	5	5	4	3	60%
2022	5	3	4	4	3	74%
2023	6	4	5	5	4	91%
2024	2	2	2	2	1	97%
2025	1	1	1	1	1	100%
TOTAL	35	24	26	22	17	—

The temporal distribution of the 35 included studies indicates that the field has grown significantly since 2020, as 74% of the included papers were published between 2020 and 2023. The 2020 concentration is attributable to the COVID-19 pandemic, which acted as a catalyst for digital education research. One methodological development that is clear across the 2019-2025 timeframe is that while prior studies (2019-2020) reported on grades and test scores as the sole measure of academic achievement, more recent studies (2022-2025) reported on multiple dimensions of academic achievement, such as engagement, higher-order thinking and self-regulated learning. The leading journals for the 35 papers are: Computers and Education (n=8), British Journal of Educational Technology (n=7), International Journal of Educational Technology in Higher Education (n=6), and Educational Technology Research and Development (n=4).

Geographical Cluster Analysis

Table 4. Geographical Distribution of Included Studies (n=35, 2019–2025)

Region	n Studies	% Share	Dominant Tool Focus	Primary Outcome Measured	Quality Assessment
United States	7	20%	AI/ITS, LMS, Gamification	Academic achievement, critical thinking	Highest methodological rigour; large RCT and quasi-experimental samples
China / Taiwan / Hong Kong	7	20%	Mobile learning, gamification, AI tutoring	Engagement, achievement, self-regulation	Large samples; survey-dominant; some CMB concerns
United Kingdom	5	14%	LMS, collaborative tools, AI tools	Engagement, higher-order thinking	High quality; ABS journal

Region	n Studies	% Share	Dominant Tool Focus	Primary Outcome Measured	Quality Assessment
					concentration; policy-relevant
Middle East (Jordan, Saudi, UAE)	6	17%	LMS, e-learning, mobile	Adoption, satisfaction, perceived learning	Growing corpus; infrastructure equity explicitly studied
Australia / New Zealand	4	11%	LMS, blended learning, collaborative	Student engagement, achievement	Strong institutional data; longitudinal designs
Africa (South Africa, Kenya)	3	9%	Mobile, LMS, collaborative	Access, equity, engagement	Critical equity perspective; infrastructure limitations central
Europe (Multi-country)	3	9%	Gamification, simulation, collaborative	Critical thinking, collaboration	Cross-cultural designs; variable quality

A significant development compared to the pre-2019 evidence is that the geographical analysis reveals evidence from Africa (9%) in the corpus, both from South African studies and from Kenya (3%). The Middle East has a particularly strong presence in the corpus (17%), which was boosted by the rapid expansion of higher education systems in the UAE, Saudi Arabia and Jordan, and the digitalisation investment that has been made. Despite this improvement, the global coverage of the research is still limited: Latin America, South/Southeast Asia (excluding China and Taiwan), and the overwhelming majority of Sub-Saharan Africa are essentially under-researched in the peer-reviewed literature on digital tools and learning outcomes.

Thematic Cluster Analysis

Table 5. Thematic Cluster Summary (all papers 2019–2025)

Cluster	Theme	Papers (n)	Evidence Direction	Key Moderators	Evidence Strength
1	LMS and Academic Performance	9 (26%)	Positive but moderate (d≈0.35–0.45); active engagement critical; passive LMS use shows minimal effects	Engagement depth; instructor facilitation; LMS design; infrastructure equity	MODERATE-STRONG: large post-pandemic samples; engagement analytics designs
2	Mobile Learning and Gamification	9 (26%)	Positive for engagement (strong) and achievement (moderate, d≈0.58 for mobile); gamification engagement robust, achievement effects short-term	Pedagogical design; constructivist alignment; socioeconomic equity; study duration	MODERATE-STRONG: meta-analytic foundation (Guo et al., 2021); sustainability concerns
3	AI and Adaptive Learning	9 (26%)	Strong for achievement with ITS (d≈0.70+); emerging positive for LLMs with integrity/dependency caveats; self-regulation benefits documented	Student prior knowledge; feedback quality; academic integrity governance; CLT alignment	STRONG for ITS; EMERGING for LLMs — rapid evidence growth 2022–2025
4	Collaborative Digital Platforms	8 (23%)	Positive for higher-order thinking (d≈0.51) and	Task interdependence; synchrony/async	MODERATE-STRONG: consistent across contexts;

Cluster	Theme	Papers (n)	Evidence Direction	Key Moderators	Evidence Strength
			collaboration; modest for individual achievement; moderated by task design and synchrony	hrony choice; instructor scaffolding; group composition	achievement effects smaller than HOT effects

Cluster 1: Learning Management Systems and Academic Performance

The LMS cluster comprised nine papers that emphasized the effects that Moodle, Canvas, Blackboard, Google Classroom, and individualized institutional LMS platforms have on student learning, engagement and satisfaction outcomes. The results are always positive, but do provide some interesting insights into the type of LMS engagement. A systematic review by Turnbull et al. (2021) revealed that there are two kinds of LMS users: active users (those who frequently visit discussion forums, use interactive resources and complete formative assessment exercises), and passive users (those who only use the LMS to view content). There were significant differences in academic performance outcomes between active LMS users and inactive LMS users. Almaiah et al. (2020) studied the factors that influence the success of implementing LMS in Jordanian universities, and found that system quality, the reliability of the system's technical infrastructure, and the quality of the instructors' facilitation are the most important factors affecting whether LMS implementation successfully improves academic performance. However, Cheng et al. (2020) offered relevant evidence for the pandemic period by studying the adoption of LMS in various universities across China during COVID-19 emergency remote teaching and how the TAM factors were related to the LMS engagement and learning satisfaction of students.

A recurring theme in the LMS cluster is the moderating effect of good facilitation by the instructor. Several studies have demonstrated that the lack of active instructor moderation of the LMS (little or no feedback, little or no change to content, passive content repository) can result in little or no increase in learning outcomes, even with a sophisticated LMS.

Cluster 2: Mobile Learning and Gamification

This cluster concerns mobile learning and gamification, with 9 papers discussing the impact of mobile-device use on learning outcomes, as well as the incorporation of game elements into learning. This cluster provides the highest level of evidence for engagement outcomes and more sophisticated evidence of academic achievement. A meta-analysis of the cluster is provided by Guo et al. (2021), who identified 55 studies between 2010 and 2021 that reported mobile learning results for cognitive learning outcomes and reported a mean effect size of d = 0.58 for those outcomes. The review revealed that mobile learning designs in which learning is constructed through the use of mobile devices had significantly greater effects than passive mobile learning designs. A quasi-experimental study on Saudi Arabian university students conducted by Mahdi (2019) revealed some positive effects on the four outcomes of mobile learning for ELA in the range of d = 0.40-0.65 across the four outcomes. There are not as many clear-cut examples of gamification in the evidence. A systematic review of 66 studies on gamification in education from 2015 to 2020 (Dicheva et al., 2020) revealed strong and consistent motivational and engagement effects across studies, but less consistent and smaller academic achievement effects across studies. In her research, Yildiz Durak (2021) examined the equity issue of mobile learning in a higher education setting in Turkey and found that factors such as mobile device ownership, data-plan reliability, and digital literacy moderated the relationship between mobile learning adoption and learning outcomes.

Cluster 3: Artificial Intelligence and Adaptive Learning Systems

Table 6. Digital Tool Typology and Learning Outcome Mapping (2019–2025 Evidence)

Digital Tool Type	Academic Achievement	Student Engagement	Higher-Order Thinking	Self-Regulated Learning	Evidence Quality
LMS (active use)	Positive (d≈0.35–0.45)	Positive (depth-dependent)	Neutral to Positive	Positive (metacognitive features)	Moderate-Strong; post-pandemic samples
Mobile Learning (constructivist)	Positive (d≈0.58)	Strong Positive	Positive (inquiry designs)	Positive (self-pacing)	Strong; Guo et al. (2021) meta-analysis
Gamification	Moderate Positive (short-term)	Strong Positive	Neutral to Moderate	Weak to Neutral	Moderate; Dicheva et al. (2020); durability concerns
ITS / Adaptive AI	Strong Positive (d≈0.70+)	Positive	Positive (problem-solving)	Strong Positive (adaptive feedback)	Strong; multiple RCTs; Tlili et al. (2023)
LLM tools (ChatGPT etc.)	Emerging Positive	Positive	Mixed (dependency risk)	Mixed (integrity concerns)	Emerging; Kasneci et al. (2023); no RCTs yet
Collaborative Platforms (sync)	Neutral to Positive	Strong Positive	Positive (argumentation)	Neutral	Moderate; engagement strong; achievement modest
Collaborative Platforms (async)	Moderate Positive	Moderate	Strong Positive (reflection)	Positive	Moderate-Strong; consistent cross-context
Simulation / VR	Moderate Positive	Positive	Positive (scientific reasoning)	Moderate	Moderate; CLT concerns for novice learners documented

Evidence has grown from established ITS systems to AI-based tools such as LLMs, learning analytics platforms, and automated feedback generators; the AI and adaptive learning cluster is the most dynamic in the literature from 2019–2025. In a thorough overview of the literature on AI-based PL systems from 2019-2023, Tlili et al. found that academic outcomes can be strongly improved by such systems, and the adaptive feedback mechanism is the main mechanism responsible for the benefit. Crompton and Burke (2023) summarized the landscape of AI in higher education and found that four types of AI applications had the most consistent, robust evidence of improved learning outcomes: (1) intelligent tutoring systems for STEM disciplines; (2) NLP-based writing feedback systems for writing and argumentation; and (3) learning analytics tools that allow instructors to identify students who are at risk.

The largest and newest development in this cluster is the focus on LLM-based AI tools as a subject of educational research since 2022. The most comprehensive review of ChatGPT and related LLMs in education has been provided by Kasneci et al. (2023), who noted that these tools have the potential to offer great support for writing development and self-regulated learning, but there are also very serious concerns that could involve academic integrity issues and epistemic dependency.

Cluster 4: Collaborative Digital Platforms and Higher-Order Thinking

In this cluster of collaborative digital platforms, eight papers are presented that analyse how digital tools created to facilitate peer interactions, co-authorship, argumentation and co-construction of knowledge influence higher-order thinking and collaborative learning. In the recent update of their comprehensive metacomparisons of computer-supported collaborative learning (CSCL) published by Jeong et al. (2019), they found mean effect sizes of d = 0.51 for higher-order thinking outcomes and d = 0.40 for individual academic achievement based on the studies published before 2018. The results of the meta-analysis showed that task interdependence design, the design that has students do the work collaboratively instead of in a parallel manner, was indeed the most effective moderator of the effectiveness of CSCL. For this cluster, Mpungose (2020) analysed student experiences of collaborative digital tools in the context of a South African university. Mpungose (2020) investigated the South African experience of collaborative digital tools for this cluster, offering insightful Global South data. Students expressed high levels of engagement with collaborative technologies, but cited problems with infrastructure, such as bandwidth and device access, as an important barrier to continued collaborative learning.

The difference between synchronous and asynchronous modes of collaboration is an important moderating factor that arose in the collaborative digital literature published in 2019–2025. Adedoyin and Soykan (2020) investigated the use of video-conferencing collaborative learning in the context of COVID-19 and reported that synchronous collaboration resulted in greater immediate engagement, while asynchronous collaboration — when appropriately structured — resulted in greater higher-order thinking outcomes involving reflection and extended elaboration.

Cross-Cluster Moderating Variable Analysis

Table 7. Key Moderating and Mediating Variables (all from 2019–2025 corpus)

Variable	Role	Papers	Evidence Summary
Pedagogical design quality	Moderator (strongest)	30 papers	Consistently the supreme moderator across all four clusters; constructivist/inquiry designs produce ~2x effect sizes vs. content-delivery designs; confirmed by Guo et al. (2021) and Tlili et al. (2023)
Teacher digital pedagogical competence	Moderator	20 papers	Critical mediator of LMS, AI, and collaborative tool quality; instructor facilitation determines whether tools generate deep or surface student engagement; Turnbull et al. (2021)
Student engagement depth	Mediator (strongest)	25 papers	Primary mechanism through which digital tools affect outcomes; surface engagement (log-ins, passive viewing) minimally predicts outcomes; deep engagement strongly predicts outcomes
Student digital literacy	Moderator	18 papers	Prior digital experience moderates cognitive load and tool adoption quality; lower literacy = higher extraneous load; Yildiz Durak (2021); equity concern for first-generation digital learners
Infrastructure and equity	Moderator	16 papers	Device access, bandwidth, and data plans are necessary (not sufficient) conditions for equitable outcome effects; Almaiah et al. (2020); Mpungose (2020); widening gap in resource-constrained contexts
Feedback quality and immediacy	Mediator	17 papers	Mechanism for AI/ITS and formative digital assessment benefits; specific, actionable, immediate feedback mediates self-regulation and achievement; Tlili et al. (2023); Kasneci et al. (2023)
Assessment alignment	Moderator	13 papers	Digital tool effectiveness is significantly greater when assessment tasks explicitly require demonstration of skills practised through the tool; misalignment systematically reduces measured effects
Study duration	Moderator	11 papers	Short-duration studies (<8 weeks) overestimate digital tool effects, particularly for gamification and mobile learning; longer studies show attenuation of engagement effects without pedagogical redesign

The cross-cluster analysis further reveals that pedagogical design quality was the only moderating variable that was consistently documented in the 2019–2025 corpus and was embedded in 30 out of 35 papers. The empirical evidence consistently shows that the deployment of digital tools in a constructivist and inquiry-based approach results in significantly greater learning outcome effects than the deployment in a passive content delivery approach.

The variable with the strongest relationship to student engagement depth, the medium through which all categories of digital tools have an effect on learning outcomes, is student engagement depth. The clear differentiation between 'surface engagement' (e.g. logins, passive viewing) and 'deep engagement' (e.g. forum contribution, completion of adaptive exercises, co-creative activities) has important implications for the way in which institutions can measure and evaluate the effectiveness of the digital tools.

Discussion

Implications

The cross-thematic synthesis produces a synthesized and empirically informed formulation of the DTLOCF. The evidence of the last 6 years (2019-2025) highlights three important improvements. Firstly, outcome-dimension asymmetry is validated: there is a systematic difference in outcomes between the three tools, with ITS/AI being most successful for academic achievement, collaborative platforms for higher-order thinking, and gamification for engagement.

Secondly, pedagogical design quality is confirmed as the greatest moderating variable. There was no evidence that the level of sophistication of the tools was correlated with the quality of the outcomes. A pedagogically sound, simple LMS discussion forum can be expected to yield larger higher-order thinking gains than a complex AI tutoring system used in a non-inquiry context.

Third, the equity moderating class is confirmed as critically under-addressed and not taken for granted — failure to equip the class with an adequate "set" of tools and resources to support equity will not just result in a lack of success for disadvantaged students — it will actually exacerbate the "gap" by creating additional cognitive load for students with limited digital literacy skills and frustration for students with poor infrastructure.

Research contribution

This review adds the DTLOCF as an integrative conceptual model that connects four moderating classes to differential learning outcome effects, and offers one of the first PRISMA-guided syntheses that focuses on evidence published in 2019–2025 that was indexed in Scopus/ABS-listed journals.

Limitations

The discussion should be interpreted with reference to the methodological restrictions mentioned above, particularly the limitation to the English-language literature and the one-reviewer thematic synthesis, which may impact the interpretation of the conclusions.

Suggestions

The results of the outcome dimension asymmetry and the pedagogical design findings need to be the primary considerations for future institutional and policy decisions for selecting digital tools, rather than the sophistication of digital tools or the marketing of the vendors.

CONCLUSION

Summary of Findings

In this paper, 35 peer-reviewed papers published between 2019 and 2025 in Scopus- and ABS-listed journals, from a total corpus of 60 papers, are reviewed to analyse the impact of digital tools on students' learning outcomes through a systematic review based on the PRISMA 2020 guidelines. When conditions relating to pedagogical design, teacher competence, student literacy, infrastructure, and equity are met, there is consistent evidence that digital tools can and do have a positive effect on learning outcomes.

Responses to Research Questions

RQ1: Positive and regularly supported, but contingent — the adoption of the tools does not necessarily lead to improvement if they are not pedagogically embedded.

RQ2: Asymmetricity confirmed. The strength of these components will differ among the three types of elements that support achievement, HOTS, engagement and SRL, when they are activated in the LMS.

RQ3: Quality of pedagogical design (the highest); digital competence of teachers; digital literacy of students; (in)equity of infrastructure; design of tools and cognitive load; alignment of assessment; duration of study.

RQ4: Quality enhancements since 2019; better evidence base after the pandemic; greater geographical representation but the Global South is poorly represented; more multi-method and longitudinal studies.

RQ5: 8 priority gaps identified in Table 8, of which Equity Evidence from the Global South and Sustainability of long-term outcomes are critical.

Research Gaps and Future Research Agenda

Table 8. Research Gaps and Future Research Agenda

Gap	Priority	Specific Gap	Recommended Approach
Global South / equity contexts	CRITICAL	Near-absence of evidence from Sub-Saharan Africa, Latin America, South/SE Asia — regions housing the majority of the world's students	Collaborative partnerships with institutions in underrepresented regions; equity-focused participatory action research; mobile learning trials in low-bandwidth contexts
Long-term outcome sustainability	CRITICAL	Most studies measure outcomes immediately post-intervention; very few track beyond one semester	Pre-registered longitudinal cohort studies (12+ months); degree-level outcome tracking; post-graduation skills assessment
LLM / Generative AI evidence	HIGH	Post-2022 LLM adoption has far outpaced empirical evidence; no RCT evidence on ChatGPT and academic achievement yet available	Urgently needed: pre-registered RCTs of LLM-assisted learning; academic integrity governance effectiveness studies; epistemic dependency measurement
Causal identification	HIGH	Only ~28% of the 2019–2025 corpus uses RCT or quasi-experimental designs; survey-dominant literature cannot establish causation	Mandatory pre-registration; regression discontinuity designs; stepped-wedge RCTs in institutional settings
Negative effects and harms	HIGH	Literature over-reports positive findings; cognitive overload, dependency, distraction, and academic integrity harms are systematically underreported	Pre-registered null hypothesis testing; systematic adverse effect reporting; independent replication of positive findings
Teacher competence measurement	MODERATE-HIGH	Teacher digital pedagogical competence is identified as a critical moderator but rarely measured rigorously; self-report dominates	Validated teacher competence instruments; large-scale competence audits linked to student outcome data
Assessment alignment	MODERATE	Misalignment between digital tool activities and assessments is known but rarely studied explicitly	Intervention studies comparing matched vs. mismatched tool-to-assessment designs
Combination / blended tool effects	MODERATE	Most studies examine single tool types; real environments combine multiple tools; interaction effects unknown	Multi-arm RCTs testing tool combinations; learning analytics examining simultaneous multi-tool engagement

Recommendations

1. For Educators

Select a specific learning outcome priority for which to use a digital tool, based on the finding of asymmetry in learning outcome dimensions in this review. Don't think of “digital tools” as a single category. If academic achievement is the primary focus, then do use ITS and adaptive feedback systems. For higher-order thinking skills, use purposeful, collaborative digital tools. Gamification features are helpful where engagement is the problem, but need to be used with care, considering sustainability and SDT design. Secondly, invest much more in pedagogical design than in the choice of the tool. It's obvious that the same tool can produce very different outcomes when it is used within different pedagogical designs.

2. For Institutional Leaders

Establish evidence-based frameworks for evaluating digital tools that require vendors to provide evidence of learning outcomes for specific types of tools, student populations, and subject contexts. EdTech procurement is not about consumer tech purchases; it is about evidence-based practice. Invest in teacher digital pedagogical competency as the key element of the effective use of digital tools. The evidence indicates that instructor facilitation of the learning experience will be more closely correlated with outcome improvement than the technical advancement of the teaching tool will be.

3. For Policy-Makers

Implement learning outcome assessment systems as “quid pro quo” for public support of digital tool adoption, requiring institutions receiving public funding for digital tool adoption to collect outcomes information and report it using validated learning outcome assessment measures. Fund research-based programmes that will be focused on equity issues for Global South contexts (where most of the world's students live) and where there is little evidence available.

Limitations

There are six limitations: (1) English-language restriction precludes non-English scholarship; (2) single-reviewer design precludes interrater reliability checking; (3) thematic synthesis is inherently interpretive; (4) rapid EdTech development means that some of the findings from the tools may be out of date; (5) the exclusion of grey literature may lead to publication bias; and (6) the core selection of 35 papers, methodologically rigorous, is necessarily limited by its emphasis on depth over comprehensiveness.

Concluding Remarks

The results of 35 peer-reviewed studies from 2019 to 2025 clearly show that digital tools can have meaningful impacts on student learning outcomes across a range of dimensions of student learning outcomes, and across a range of educational contexts. The evidence is also starkly clear that this improvement does not just happen; it is not guaranteed, and it cannot exist without the pedagogical, human, and infrastructural context in which tools are being used.

The bottom line for educators, institutional leaders and policy-makers making real decisions about the adoption of digital tools is this: invest in pedagogical competency of teachers, plan tool deployments constructively, and only then, give your tools' learning outcome impact a decent measurement.

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AUTHOR CONTRIBUTION STATEMENT

H.A. conceived the idea for the study, performed the systematic search and screening, and was the main author of the manuscript. M.A.H. was involved in the quality check and theme development and also critically edited the manuscript. S.M.A.N.S. was involved in the design of the study, offered some interpretation of the data and editorial assistance for the intellectual content. All authors read and approved the final manuscript.

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