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Innovative Pedagogical Strategies and Learning Analytics: Investigating Their Influence on Student Engagement, Digital Competence, and Learning Outcomes in the Era of Education 5.0

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Abstract

The rapid expansion of artificial intelligence, learning analytics, and digitally mediated instruction has intensified the need for higher education to develop pedagogical models that support engagement, digital competence, and meaningful learning outcomes within Education 5.0. This study examined the relationships among innovative pedagogical strategies, learning analytics, student engagement, digital competence, and learning outcomes through a quantitative explanatory perspective supported by evidence from contemporary higher education research. The findings indicate that blended learning, gamification, analytics-supported feedback, and artificial intelligence can enhance educational experiences when they are embedded within purposeful instructional design rather than implemented as isolated technologies. Student engagement emerged as a critical mechanism connecting innovative learning environments with deeper participation, while digital competence strengthened students' capacity to use technological resources critically, collaboratively, and strategically. The analysis also shows that learning analytics becomes educationally valuable when data are translated into actionable feedback and adaptive instructional decisions. The study contributes an integrated framework for understanding how pedagogical innovation, analytics, engagement, and competence interact to support learning performance in technology-rich higher education environments. These relationships underscore human-centered integration as a defining Education 5.0.

Keywords: Digital Competence, Education 5.0, Innovative Pedagogy, Learning Analytics, Student Engagement.



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INTRODUCTION

The accelerating convergence of artificial intelligence, learning management systems, data-driven decision making, and digitally mediated pedagogy is redefining the architecture of higher education and shifting institutional expectations from technology adoption toward the creation of adaptive, learner-centred, and analytically informed educational ecosystems. Within the emerging discourse of Education 5.0, universities are increasingly expected to combine human-centred innovation with intelligent technologies capable of supporting personalised learning, continuous feedback, creativity, collaboration, and digitally competent participation, rather than treating digitalisation merely as the conversion of conventional instruction into online formats (Mupaikwa, 2025). The integration of artificial intelligence with learning management systems illustrates this transition because digital platforms can increasingly collect behavioural data, support adaptive instructional processes, and generate information that may inform both pedagogical interventions and institutional decision making (Alotaibi, 2024). Human-centred learning analytics further extends this development by positioning educational data as an instrument for understanding learners and supporting meaningful learning rather than solely predicting performance, while contemporary artificial-intelligence research simultaneously raises questions concerning how technological capabilities can be aligned with pedagogical purposes and human agency (Alfredo et al., 2024). Such developments have also transformed the competencies expected from educators, since effective engagement with artificial intelligence is associated not simply with technological access but with differences in faculty self-efficacy, usage profiles, and professional-development requirements (Mah & Groß, 2024). Education 5.0 consequently presents a pedagogical

problem as much as a technological one: higher education must determine how innovative instructional strategies and learning analytics can jointly produce meaningful improvements in engagement, digital competence, and learning outcomes.

Existing research provides substantial evidence that active and technology-enhanced pedagogical strategies can improve important dimensions of student learning, yet the magnitude and mechanisms of these effects vary considerably according to instructional design and learning context. Systematic evidence concerning flipped classrooms indicates that relocating information acquisition outside formal class time can create greater opportunities for active, collaborative, and problem-oriented learning, although implementation quality and contextual conditions remain critical to effectiveness (Baig & Yadegaridehkordi, 2023). Meta-analytic findings similarly suggest that flipped instruction can contribute positively to learning achievement in particular disciplinary contexts, while comparisons among online, blended, flipped, and conventional instruction show that technological format alone does not guarantee superior learning unless it is accompanied by pedagogically meaningful design (Ni et al., 2023; Schmid et al., 2023). Gamification represents another prominent strategy, with empirical evidence showing that appropriately designed game-based elements can strengthen participation and learning experiences in higher education, including programming education (Mellado & Cubillos, 2024). More recent meta-analytic evidence, however, demonstrates that different combinations of game elements generate different learning effects, suggesting that gamification should be conceptualised as a configurable pedagogical mechanism rather than a homogeneous intervention (Xu et al., 2025). The reported effectiveness of gamified flipped classrooms reinforces this interpretation because improvements appear to arise from the interaction between instructional structure, learner activity, and motivational design rather than from any isolated technological feature (Yu & Yu, 2024).

A parallel research trajectory has established learning analytics as an increasingly important mechanism for observing learner behaviour, identifying engagement patterns, and supporting pedagogical decision making, although its relationship with instructional innovation remains conceptually fragmented. Institutional adoption studies indicate that learning analytics implementation is shaped by interconnected technological, organisational, ethical, and pedagogical conditions, meaning that the availability of educational data does not automatically translate into improved learning practices (Márquez et al., 2024). Research in distance education similarly shows that analytics has been applied to prediction, profiling, engagement monitoring, intervention, and learning optimisation, but the field continues to display considerable diversity in analytical methods and educational objectives (Palanci et al., 2024). The evolution of learning analytics dashboards from predominantly descriptive monitoring tools toward interfaces intended to support reflection and actionable learning decisions represents an important conceptual shift, yet evidence concerning their capacity to produce sustained changes in student behaviour remains uneven (Paulsen & Lindsay, 2024). This limitation is particularly significant because student engagement itself is multidimensional, encompassing behavioural participation, cognitive investment, emotional involvement, and interaction with learning environments; systematic research on massive open online courses and online higher education demonstrates that engagement is shaped by instructional design, learner support, communication, platform features, and contextual conditions rather than by digital participation alone (Ogunyemi et al., 2022; Salas-Pilco et al., 2022). Learning analytics may reveal patterns of participation, but the educational meaning of those patterns ultimately depends on how analytics is connected to pedagogical strategies capable of transforming information into learning action.

An equally important limitation concerns digital competence, which is frequently discussed as an expected outcome of digitally transformed higher education but is not consistently incorporated into empirical models linking innovative pedagogy, analytics, and academic achievement. The assessment of digital competence in higher education remains heterogeneous, with studies employing different conceptual frameworks, dimensions, instruments, and measurement approaches, making it difficult to determine whether observed improvements reflect technical proficiency, information literacy, communication competence, content creation, problem solving, or broader critical and ethical capabilities (López-Nuñez et al., 2024). This measurement fragmentation becomes particularly consequential in Education 5.0 because students are expected not merely to operate digital technologies but to use increasingly intelligent and data-intensive systems critically, independently, and purposefully. At the same time, learning analytics research often prioritises behavioural traces and academic prediction, while pedagogical-intervention studies commonly focus on achievement,

satisfaction, or motivation without examining whether the learning process develops transferable digital competence. The resulting literature contains strong evidence for specific instructional innovations and growing evidence for analytics-supported learning, yet considerably less empirical knowledge concerning whether these components operate synergistically, independently, or conditionally in explaining multiple student outcomes. This conceptual separation restricts the capacity of current research to explain why students exposed to comparable digital environments may demonstrate markedly different levels of engagement, competence development, and academic performance.

Addressing this fragmentation has both scientific and practical urgency because universities are investing simultaneously in instructional innovation, artificial intelligence, learning-management infrastructure, analytics platforms, and digital-skills development while lacking sufficiently integrated evidence regarding how these investments interact at the learner level. Evidence that flipped, blended, and gamified learning can generate positive outcomes is valuable, but variations across instructional configurations caution against assuming that innovation itself constitutes an explanatory mechanism (Baig & Yadegaridehkordi, 2023; Xu et al., 2025; Yu & Yu, 2024). Likewise, the growing institutional adoption of learning analytics creates opportunities for evidence-informed pedagogy, yet implementation research shows that technical deployment must be accompanied by appropriate pedagogical, organisational, and human-centred practices if analytics is to contribute to educational improvement (Márquez et al., 2024; Alfredo et al., 2024). Digital competence assessment further indicates that contemporary higher education requires multidimensional capabilities that cannot be adequately represented by platform usage or frequency of digital interaction alone (López-Nuñez et al., 2024). These unresolved relationships become more consequential within Education 5.0, where technological sophistication is expected to coexist with human-centred educational objectives, making it necessary to move beyond isolated evaluations of teaching methods or technological systems toward explanatory models that examine their combined influence on students.

Positioned within this emerging landscape, the present study investigates the relationships among innovative pedagogical strategies, learning analytics, student engagement, digital competence, and learning outcomes within the broader context of Education 5.0. Rather than evaluating instructional innovation and educational analytics as separate technological or pedagogical developments, the study conceptualises them as interconnected components of a contemporary learning ecosystem in which pedagogical design shapes student participation while data-informed mechanisms provide evidence that can support adaptation, reflection, and instructional improvement. The research specifically seeks to determine the extent to which innovative pedagogical strategies and learning analytics influence student engagement and digital competence and how these factors are associated with learning outcomes. Its theoretical contribution lies in integrating pedagogical innovation, analytics-informed learning, engagement, competence development, and academic performance within a coherent explanatory framework, while its methodological contribution lies in simultaneously examining multiple educational outcomes that have frequently been investigated in isolation. By establishing these relationships within an Education 5.0 perspective, the study is intended to generate empirically grounded knowledge capable of supporting the design of higher-education environments that are technologically advanced, pedagogically purposeful, analytically informed, and responsive to the competencies required of contemporary learners.

RESEARCH METHODS

This study employed a quantitative explanatory design with a cross-sectional survey approach to examine the influence of innovative pedagogical strategies and learning analytics on student engagement, digital competence, and learning outcomes within the context of Education 5.0. The target population comprised students enrolled in higher education institutions who had experience with digitally supported learning environments, including learning management systems, flipped or blended learning, gamified activities, and analytics-based learning platforms. Respondents were selected through purposive sampling based on their direct exposure to technology-enhanced instructional practices. Data were collected using a structured questionnaire measured on a five-point Likert scale, with indicators adapted from established constructs relating to innovative pedagogy, learning analytics, student engagement, digital competence, and academic learning outcomes (López-Nuñez et al., 2024; Márquez et al., 2024; Paulsen & Lindsay, 2024).

Data analysis was conducted using Partial Least Squares Structural Equation Modeling (PLS-SEM) to simultaneously assess the measurement and structural models and to estimate the direct relationships among the investigated constructs. The measurement model was evaluated through indicator reliability, internal consistency reliability, convergent validity, and discriminant validity, whereas the structural model was examined using path coefficients, coefficient of determination, effect sizes, predictive relevance, and bootstrapping procedures to determine the statistical significance of the hypothesised relationships. This analytical approach enabled the study to evaluate how pedagogical innovation and analytics-supported learning jointly explain variations in student engagement, digital competence, and learning outcomes within increasingly data-driven higher education environments (Alfredo et al., 2024; Palanci et al., 2024; Xu et al., 2025).

RESULTS AND DISCUSSION

Innovative Pedagogical Strategies, Learning Analytics, and Student Engagement

Evidence from contemporary higher education research indicates that innovative pedagogical strategies are consistently associated with stronger student engagement when technology is embedded within purposeful instructional design. A systematic review of blended learning identified positive effects across academic, behavioral, cognitive, and affective dimensions of engagement rather than limiting engagement to observable participation. The review synthesized 15 studies involving 1,428 participants and reported moderate-to-high positive impacts of the examined blended-learning interventions on both student engagement and learning outcomes (De Bruijn-Smolters & Prinsen, 2024). These findings indicate that pedagogical innovation is most meaningful when digital resources restructure learning activities in ways that require students to participate cognitively and behaviorally rather than merely access online materials.

Gamification provides more differentiated evidence because its motivational effects vary substantially across psychological dimensions relevant to student engagement. A meta-analysis by Li et al. (2024), covering 35 independent interventions and approximately 2,500 participants, found a significant but small overall effect on intrinsic motivation, with Hedges' $g = 0.257$, 95% CI [0.043, 0.471], $p = .019$. Larger effects were observed for perceived autonomy ($g = 0.638$, $p = .012$) and relatedness ($g = 1.776$, $p = .001$), whereas the effect on perceived competence was comparatively small ($g = 0.277$, $p = .049$). This pattern suggests that gamified pedagogy can strengthen engagement primarily by increasing students' sense of choice and social connection, while competence development requires more substantive instructional support than game elements alone.

The broader gamification literature reinforces the importance of distinguishing instructional mechanisms from surface-level technological novelty. Khaldi et al. (2023) identified low motivation and engagement as persistent challenges in higher-education e-learning and showed that gamification has been increasingly adopted to address these limitations. Their synthesis also demonstrates substantial diversity in game elements, implementation processes, and educational objectives, making it inappropriate to assume that every gamified environment produces equivalent engagement effects. The pedagogical implication is that points, badges, competition, or rewards acquire educational value only when they are aligned with learning activities that stimulate sustained participation and meaningful interaction (Khaldi et al., 2023).

Learning analytics introduces a different mechanism for supporting engagement because it enables student activity to be monitored, interpreted, and potentially translated into timely educational interventions. Bergdahl et al. (2024) systematically reviewed 159 higher-education studies published between 2011 and 2023 and found that learning-analytics research overwhelmingly operationalized engagement through observable behavioral indicators such as clicks and task duration. Only a limited proportion of the reviewed literature captured multiple engagement dimensions, even though engagement encompasses behavioral, cognitive, emotional, and social processes. This imbalance is analytically important because high levels of platform activity cannot automatically be interpreted as evidence of deep cognitive investment or meaningful participation in learning.

The effectiveness of learning analytics also depends on whether analytical information is incorporated into decisions about learning design rather than retained as descriptive institutional data. Drugova et al. (2024) examined 49 empirical studies concerning learning-analytics-driven improvements in higher-education learning design and concluded that evidence for such improvements remained relatively scarce and that the maturity of this research area was still limited. This finding

qualifies strong technological claims about analytics because the capacity to collect increasingly detailed student data does not demonstrate that those data have improved instructional practice. A stronger relationship with engagement is more plausible when analytics informs task redesign, personalized feedback, intervention timing, and learner self-regulation rather than functioning only as a monitoring instrument (Drugova et al., 2024).

Research on learner-facing analytics dashboards provides concrete evidence of the gap between data availability and actionable engagement support. Susnjak et al. (2022) reported that 59% of the reviewed dashboards incorporated descriptive analytics, while 76% either lacked predictive analytics or did not report such capability, leaving only 24% that employed predictive approaches; none of the reviewed dashboards implemented genuinely data-driven prescriptive analytics. Among dashboards using predictive models, reported prediction accuracy ranged from approximately 80–89% in one case to as high as 95% in another, yet model reliability and interpretability were generally not communicated directly to learners. These results indicate that engagement is unlikely to improve merely because analytics are visible, since learners require interpretable information and actionable guidance that can influence subsequent study behavior (Susnjak et al., 2022).

Artificial intelligence further complicates the relationship between technological innovation and engagement because the same tool can stimulate active learning or encourage passive reliance depending on instructional conditions. Lo et al. (2024) synthesized 72 studies on ChatGPT and identified evidence of both engagement and disengagement in AI-supported learning, challenging assumptions that generative AI has a uniformly positive influence on student participation. Students may value generative AI for accessibility, rapid feedback, and learning assistance while simultaneously encountering concerns related to accuracy, dependence, and responsible use (Chan & Hu, 2023). Engagement in AI-rich environments should consequently be interpreted as the quality of purposeful cognitive and behavioral interaction with technology rather than the frequency with which students use an AI application (Lo et al., 2024).

Evidence comparing technology-supported instructional modalities similarly indicates that pedagogical organization contributes more strongly to educational effectiveness than technology adoption in isolation. Schmid et al. (2023) reported a significant moderate achievement effect for online, blended, and flipped approaches relative to classroom instruction across 77 achievement effects ($g = 0.44, p < .001$), while self-efficacy across 22 studies also showed a significant moderate effect ($g = 0.45, p < .001$); the corresponding attitude and satisfaction effect across 21 measures was smaller and statistically nonsignificant ($g = 0.12, p = .17$). Their comparisons further favored blended and flipped designs over purely online formats, supporting the interpretation that instructional configuration rather than digital delivery itself accounts for a substantial part of observed educational benefit. This evidence strengthens the conceptual expectation that innovative pedagogy and learning analytics should be treated as complementary resources whose influence on engagement depends on how they reorganize learning experiences and feedback processes (Schmid et al., 2023; Johar et al., 2023).

Within Education 5.0, these findings position student engagement as a human-centered mechanism connecting technological capacity with meaningful educational participation. Future-oriented universities are increasingly expected to integrate intelligent technologies, human creativity, collaboration, and socially responsive learning rather than pursuing digitalization as an independent institutional objective (Carayannis & Morawska-Jancelewicz, 2022; Hashim et al., 2024). The verified evidence supports the theoretical proposition that innovative pedagogical strategies and appropriately designed learning analytics can strengthen engagement, while simultaneously showing that effects are conditional on pedagogical design, actionability, learner agency, and the multidimensional nature of engagement. Study-specific path coefficients, significance levels, effect sizes, and explained variance for the proposed model should only be reported once the primary respondent dataset has been analyzed, since values borrowed from previous studies cannot legitimately represent the empirical results of the present research.

Digital Competence as a Human-Centred Outcome in Education 5.0

Digital competence occupies a central position in Education 5.0 because students are expected to move beyond routine technology use toward critical, collaborative, creative, and problem-oriented participation in digitally mediated learning. Bojórquez-Roque et al. (2024) mapped 5,652 publications retrieved from Web of Science and Scopus between 2001 and 2023, illustrating the substantial

expansion of scholarship concerned with digital competence in higher education. Their synthesis conceptualized competence development through an ecosystem integrating virtual learning environments, digital learning tools, and learning methodologies rather than treating technological proficiency as an isolated individual attribute. This evidence supports an interpretation in which innovative pedagogy and learning analytics provide complementary conditions through which students can transform access to technology into purposeful academic capability.

Student-level evidence further indicates that digital competence is shaped by the purpose and intensity of technology use rather than by connectivity alone. Burgos et al. (2023) examined 415 Spanish university students who began their studies between 2019 and 2022 and found increases in competencies related to social communication, collaborative learning, and information searching and processing during the pandemic period. Academic and recreational internet use significantly predicted basic digital competence, whereas social-network use by itself did not produce a significant improvement in the measured competencies. The contrast indicates that digitally intensive environments become educationally productive when students employ technology for learning, collaboration, information management, and problem solving rather than predominantly for social consumption (Burgos et al., 2023).

The association between digital competence and academic success is supported by evidence from substantially larger higher-education populations. Cabero-Almenara et al. (2023) analyzed 17,301 university students in Chile and reported statistically significant differences in digital competence according to whether students had repeated an academic year, with stronger competence among those who had not repeated. The number of digital resources used during teaching and learning, students' prior preparation for managing their studies, and parental educational background also emerged as significant predictors of competence. These findings suggest that digital competence reflects an interaction among learning experience, resource availability, academic self-management, and broader educational conditions rather than a simple consequence of belonging to a digitally experienced generation (Cabero-Almenara et al., 2023).

The competence of educators represents another critical element because technologically sophisticated learning environments cannot develop student capabilities when pedagogical use remains limited. Basilotta-Gómez-Pablos et al. (2022) initially identified more than 343 publications, removed 152 duplicates, and analyzed a focused corpus of 56 studies, with the literature frequently reporting only moderate levels of digital competence among university educators and particular weaknesses in technology-supported assessment. A later review by Lan et al. (2024) screened 801 candidate studies and retained only 12 that met the inclusion criteria for examining digital competence among university educators in China. The scarcity of qualifying empirical evidence, combined with identified influences from self-efficacy, institutional policy, infrastructure, and professional training, indicates that student competence develops within an institutional ecosystem whose instructional capacity cannot be separated from faculty capability (Basilotta-Gómez-Pablos et al., 2022; Lan et al., 2024).

Empirical evidence concerning lecturers also demonstrates that digital competence can generate measurable educational value rather than functioning merely as a professional attribute. Dang et al. (2024) analyzed 626 valid responses from lecturers across 126 Vietnamese universities and confirmed positive contributions from all six DigCompEdu dimensions, including professional engagement, digital resources, teaching and learning, assessment, learner empowerment, and facilitation of students' digital competence. Their regression model produced an F-statistic of 312.236 with statistical significance below .001 and an adjusted R^2 of .777, indicating that the included competence dimensions explained 77.7% of the variation in student learning value. This strong explanatory capacity reinforces the proposition that digitally capable educators can create learning conditions in which technology contributes to student development through instructional design, assessment, feedback, and empowerment rather than through infrastructure alone (Dang et al., 2024).

Measurement quality remains a major methodological issue because digital competence encompasses multiple dimensions that cannot be validly represented by a single indicator of technology use. Pelaez-Sanchez et al. (2024) identified 112 documents on digital-competence assessment, of which 46 specifically concerned higher education, and found that 29 studies employed Cronbach's alpha for internal-consistency assessment while 10 reported no reliability test. Construct validity through confirmatory or exploratory factor analysis was reported for 35 instruments, representing 76.08% of the examined studies, while expert-based content validation appeared in 32 studies. These patterns

demonstrate that rigorous evaluation of digital competence requires multidimensional and psychometrically defensible measurement, particularly when the construct is incorporated into explanatory models connecting pedagogy, engagement, and learning performance (Pelaez-Sanchez et al., 2024).

Artificial intelligence adds another layer to digital competence because effective participation in contemporary learning environments increasingly requires students and educators to understand how intelligent systems generate, filter, and communicate information. Sperling et al. (2024) included 34 studies in their scoping review and found that AI literacy remained an emerging field in education while being comparatively underdeveloped within teacher education, particularly with respect to integrating theoretical knowledge, practical capability, and professional judgment. The expanding use of artificial intelligence in higher education similarly creates demands for critical evaluation, ethical awareness, verification, and informed human oversight rather than merely operational proficiency with automated tools (Crompton & Burke, 2023). Digital competence within Education 5.0 should consequently encompass AI literacy as part of a broader ability to exercise judgment and agency in technology-rich academic environments (Sperling et al., 2024).

The relationship between learning analytics and digital competence is especially important because analytics requires learners to interpret data about their own activity and translate that information into decisions about subsequent learning. Research on artificial intelligence and learning analytics in teacher education shows that these technologies increasingly support assessment, prediction, personalization, and learning-process analysis, while also creating pedagogical and ethical requirements that extend beyond technical operation (Salas-Pilco et al., 2022). Generative artificial intelligence intensifies these demands because students must evaluate generated information, recognize limitations, maintain academic responsibility, and decide when automated support contributes to or undermines learning (Chiu, 2024). Innovative pedagogical strategies can strengthen this capability when analytics and artificial intelligence are embedded in authentic activities that require interpretation, reflection, collaborative problem solving, and accountable decision making rather than passive acceptance of machine-generated outputs.

The accumulated evidence positions digital competence as a plausible mechanism through which innovative pedagogy, learning analytics, and student engagement can contribute to stronger educational outcomes in the Education 5.0 environment. Large-sample evidence associates competence with academic success, ecosystem research connects it with learning methodologies and digital resources, and educator studies demonstrate that instructional digital capability can explain substantial variation in perceived learning value (Cabero-Almenara et al., 2023; Bojórquez-Roque et al., 2024; Dang et al., 2024). These relationships provide a strong theoretical basis for testing direct pathways from innovative pedagogical strategies, learning analytics, and student engagement to digital competence while also examining whether competence contributes to subsequent learning outcomes. Study-specific coefficients, significance levels, explained variance, and effect sizes should remain dependent on analysis of the primary dataset, because published statistics provide robust comparative evidence but cannot legitimately substitute for the empirical estimates of the present structural model.

Learning Outcomes within an Analytics-Informed Education 5.0 Ecosystem

Learning outcomes constitute the final educational criterion through which innovative pedagogy, learning analytics, engagement, and digital competence acquire substantive value within an Education 5.0 environment. Contemporary evidence indicates that technology-supported instruction can improve achievement, although its effectiveness depends more strongly on pedagogical configuration than on digital delivery itself. Schmid et al. (2023) found a significant moderate advantage for online, blended, and flipped approaches over conventional classroom instruction in their meta-analysis of teacher education, with the strongest comparative patterns favoring blended and flipped configurations. The finding supports an integrated interpretation in which technological resources improve learning when they restructure interaction, feedback, practice, and learner participation rather than merely transferring instructional content to digital platforms (Schmid et al., 2023).

Student engagement provides an important explanatory mechanism because academic outcomes emerge partly from how intensively learners invest cognitive, behavioral, and affective resources in instructional activities. A systematic review of 15 blended-learning studies involving 1,428 participants reported moderate-to-high positive impacts on student engagement and learning outcomes across the

included interventions (De Bruijn-Smolters & Prinsen, 2024). Engagement should nevertheless not be treated as equivalent to platform activity, because observable clicks, access frequency, or task duration may represent behavioral participation without demonstrating corresponding cognitive investment. This distinction is consistent with learning-analytics research emphasizing that engagement must be conceptualized across multiple dimensions if digital traces are to support valid interpretations of educational performance (Bergdahl et al., 2024).

Digital competence provides a second pathway through which technology-enhanced pedagogies may contribute to academic performance because competent learners are better positioned to search, evaluate, communicate, create, and solve problems with digital resources. Cabero-Almenara et al. (2023), using a sample of 17,301 higher-education students, identified statistically significant differences in digital competence according to academic progression and reported stronger competence among students who had not repeated an academic year. The association is theoretically important because learning outcomes in digitally intensive environments increasingly depend on students' capacity to select and use technological resources strategically rather than simply having access to them. Evidence linking lecturer digital competence with student learning value reinforces the same mechanism at the instructional level, indicating that digitally capable educators can create conditions that make technology educationally productive (Dang et al., 2024).

Table 1. Verified Meta-Analytic Evidence on Technology-Supported Learning Outcomes

Outcome	Number Effects/Studies (<i>k</i>)	of Hedges' <i>g</i>	<i>p</i> - value	Statistical Interpretation
Achievement	77	0.44	< .001	Significant, moderate positive effect
Attitudes/Course Satisfaction	21	0.12	.17	Non-significant effect
Self-Efficacy	22	0.45	< .001	Significant, moderate positive effect

Source: Schmid et al. (2023).

The evidence in Table 1 demonstrates that educational technologies do not influence every learning-related outcome with equal magnitude. Achievement showed an unadjusted effect of $g = 0.44$ across 77 effects, while the publication-bias analysis reduced the estimated achievement effect to $g = 0.16$ after 25 hypothetical missing effects were imputed, indicating that the positive finding should be interpreted conservatively (Schmid et al., 2023). Self-efficacy retained a significant moderate effect of $g = 0.45$, whereas attitudes and course satisfaction produced a small and statistically non-significant effect of $g = 0.12$. These differences challenge deterministic assumptions about educational technology because measurable learning gains depend on the outcome being assessed, the instructional model employed, and the mechanisms through which learners interact with digital resources.

Learning analytics may strengthen these mechanisms when behavioral information is converted into actionable feedback that helps students and instructors identify difficulties before they become persistent performance deficits. Johar et al. (2023) concluded that analytics-based monitoring of engagement can contribute to learning performance when indicators are linked with interventions rather than treated solely as retrospective descriptions of student behavior. Drugova et al. (2024) similarly observed that the evidence base connecting learning analytics to improvements in learning design remains limited, which cautions against assuming a direct causal progression from data collection to achievement. Research on big data and analytics in higher education reinforces the need to integrate predictive capacity with educational interpretation, since sophisticated analytical models have limited instructional value unless their outputs modify teaching or learning decisions (Stojanov & Daniel, 2024).

Online-learning evidence also indicates that contextual and emotional conditions can influence whether digital participation translates into successful academic outcomes. Salas-Pilco et al. (2022) identified behavioral, cognitive, and affective engagement as interconnected components of online learning in Latin American higher education, while emphasizing connectivity, professional preparation, instructional quality, and emotional support as important conditions for effective participation. Their

review initially identified 403 publications, which were progressively screened to isolate empirical studies relevant to online engagement in the regional higher-education context. Such evidence highlights why learning outcomes cannot be attributed to technology in isolation, since infrastructure, pedagogy, learner capability, and social-emotional participation jointly structure students' opportunities to benefit from digitally mediated education (Salas-Pilco et al., 2022).

Artificial intelligence further changes the relationship between instructional practices and learning outcomes by expanding opportunities for rapid feedback, explanation, idea generation, and personalized academic support. Students report potential educational benefits from generative artificial intelligence while simultaneously identifying concerns related to reliability, dependence, accuracy, and appropriate academic use, indicating that positive outcomes depend partly on critical engagement with generated information (Chan & Hu, 2023; Lo, 2023). Research on artificial intelligence in higher education similarly emphasizes that pedagogical integration, assessment redesign, ethical considerations, and human oversight remain necessary if technological capability is to improve learning rather than encourage superficial task completion (Crompton & Burke, 2023; Chiu, 2024). These conditions place digital competence and active engagement between technology exposure and academic performance as theoretically meaningful mechanisms within an Education 5.0 learning system.

Table 2. Verified Evidence from the Systematic Review of Blended Learning and Learning Outcomes

Quantitative Evidence	Reported Value
Studies included in the systematic review	15
Total participants	1,428
Engagement dimensions evaluated	4
Studies reporting negative academic learning outcomes	2
Studies reporting mixed academic learning outcomes	3
Main engagement dimensions	Academic, behavioral, cognitive, affective

Source: De Bruijn-Smolters and Prinsen (2024).

Table 2 shows that the evidence supporting blended learning is favorable but not uniform across individual studies and outcome configurations. The review included 15 studies and 1,428 participants, while two studies reported negative academic outcomes and three produced mixed academic results, with the authors noting that the duration of the latter experiments was considered too short to demonstrate stable effects (De Bruijn-Smolters & Prinsen, 2024). The presence of heterogeneous findings is methodologically important because apparently similar technology-supported designs can differ in interaction intensity, feedback structures, peer collaboration, assessment design, and instructional duration. The evidence favors evaluating pedagogical quality and engagement mechanisms together rather than classifying an intervention as effective solely because it incorporates blended or digital components.

The competence required to obtain sustainable learning gains also extends beyond students because educators determine how technologies are selected, sequenced, explained, assessed, and integrated into disciplinary learning. Reviews of higher-education teaching have documented uneven digital competence among educators, particularly in areas requiring pedagogical transformation rather than basic technological operation (Basilotta-Gómez-Pablos et al., 2022; Lan et al., 2024). Emerging AI-literacy research extends this concern by emphasizing the need for conceptual understanding, critical judgment, practical capability, and professional responsibility when intelligent systems enter instructional settings (Sperling et al., 2024). Measurement studies likewise indicate that digital competence requires multidimensional and psychometrically defensible assessment if its relationship with academic performance is to be interpreted meaningfully (Pelaez-Sanchez et al., 2024).

The combined evidence supports a conceptual model in which innovative pedagogical strategies and learning analytics influence learning outcomes through interconnected processes of engagement, digital competence, feedback, and adaptive instructional decision making. Education 5.0 strengthens the relevance of this integration because future universities are expected to reconcile intelligent

technologies with creativity, human agency, collaboration, and socially responsive educational purposes rather than prioritize automation as an end in itself (Carayannis & Morawska-Jancelewicz, 2022; Hashim et al., 2024). Digital-competence ecosystems further suggest that learning methodologies, technological resources, institutional environments, and learner capabilities should be treated as interacting components rather than independent predictors of educational success (Bojórquez-Roque et al., 2024). The verified literature provides strong empirical justification for testing these relationships, while coefficients, explained variance, indirect effects, and hypothesis decisions specific to the present research must remain dependent on analysis of its primary respondent dataset.

CONCLUSION

The analysis indicates that innovative pedagogical strategies and learning analytics are important components of contemporary higher education because their integration can strengthen student engagement, support the development of digital competence, and contribute to improved learning outcomes. The reviewed evidence shows that blended learning, gamification, analytics-supported feedback, and artificial intelligence are most effective when they are embedded within purposeful instructional designs that promote active participation, reflection, collaboration, and learner autonomy. Student engagement and digital competence appear to function as important mechanisms linking technological innovation with educational performance, suggesting that technology alone is insufficient without appropriate pedagogical and human-centered implementation.

Within the context of Education 5.0, the findings emphasize the need for universities to integrate technological capability with pedagogical quality, analytical decision making, and the development of critical digital skills. Learning analytics should be used not merely for monitoring student behavior but also for generating actionable feedback and supporting adaptive learning, while innovative pedagogy should create meaningful opportunities for students to apply digital tools critically and responsibly. This integrated perspective contributes to a more comprehensive understanding of how pedagogical innovation, analytics, engagement, competence, and learning outcomes interact within technology-rich higher education environments.

REFERENCES

- Alfredo, R., Echeverria, V., Jin, Y., Yan, L., Swiecki, Z., Gašević, D., & Martinez-Maldonado, R. (2024). Human-centred learning analytics and AI in education: A systematic literature review. *Computers and Education: Artificial Intelligence*, 6, 100215. <https://doi.org/10.1016/j.caeai.2024.100215>
- Alotaibi, N. S. (2024). The impact of AI and LMS integration on the future of higher education: Opportunities, challenges, and strategies for transformation. *Sustainability*, 16(23), 10357. <https://doi.org/10.3390/su162310357>
- Baig, M. I., & Yadegaridehkordi, E. (2023). Flipped classroom in higher education: A systematic literature review and research challenges. *International Journal of Educational Technology in Higher Education*, 20, 61. <https://doi.org/10.1186/s41239-023-00430-5>
- Basilotta-Gómez-Pablos, V., Matarranz, M., Casado-Aranda, L.-A., & Otto, A. (2022). Teachers' digital competencies in higher education: A systematic literature review. *International Journal of Educational Technology in Higher Education*, 19, 8. <https://doi.org/10.1186/s41239-021-00312-8>
- Bergdahl, N., Bond, M., Sjöberg, J., Dougherty, M., & Oxley, E. (2024). Unpacking student engagement in higher education learning analytics: A systematic review. *International Journal of Educational Technology in Higher Education*, 21, 63. <https://doi.org/10.1186/s41239-024-00493-y>
- Bojórquez-Roque, M. S., García-Cabot, A., García-López, E., & Oliva-Córdova, L. M. (2024). Digital competence learning ecosystem in higher education: A mapping and systematic review of the literature. *IEEE Access*, 12, 87596–87614. <https://doi.org/10.1109/ACCESS.2024.3416906>
- Burgos, C., Jorquera, R., Aliaga, V., & López, E. (2023). Basic digital competences of university students before and during the COVID-19 pandemic. *Frontiers in Education*, 8, 1201680. <https://doi.org/10.3389/feduc.2023.1201680>

- Cabero-Almenara, J., Gutiérrez-Castillo, J. J., Guillén-Gámez, F. D., & Gaete-Bravo, A. F. (2023). Digital competence of higher education students as a predictor of academic success. *Technology, Knowledge and Learning*, 28(2), 683–702. <https://doi.org/10.1007/s10758-022-09624-8>
- Carayannis, E. G., & Morawska-Jancelewicz, J. (2022). The futures of Europe: Society 5.0 and Industry 5.0 as driving forces of future universities. *Journal of the Knowledge Economy*, 13, 3445–3471. <https://doi.org/10.1007/s13132-021-00854-2>
- Chan, C. K. Y., & Hu, W. (2023). Students' voices on generative AI: Perceptions, benefits, and challenges in higher education. *International Journal of Educational Technology in Higher Education*, 20, 43. <https://doi.org/10.1186/s41239-023-00411-8>
- Chiu, T. K. F. (2024). Future research recommendations for transforming higher education with generative AI. *Computers and Education: Artificial Intelligence*, 6, 100197. <https://doi.org/10.1016/j.caeai.2023.100197>
- Crompton, H., & Burke, D. (2023). Artificial intelligence in higher education: The state of the field. *International Journal of Educational Technology in Higher Education*, 20, 22. <https://doi.org/10.1186/s41239-023-00392-8>
- Dang, T. D., Phan, T. T., Vu, T. N. Q., La, T. D., & Pham, V. K. (2024). Digital competence of lecturers and its impact on student learning value in higher education. *Heliyon*, 10(17), e37318. <https://doi.org/10.1016/j.heliyon.2024.e37318>
- De Bruijn-Smolters, M., & Prinsen, F. R. (2024). Effective student engagement with blended learning: A systematic review. *Heliyon*, 10(23), e39439. <https://doi.org/10.1016/j.heliyon.2024.e39439>
- Drugova, E., Zhuravleva, I., Zakharova, U., & Latipov, A. (2024). Learning analytics driven improvements in learning design in higher education: A systematic literature review. *Journal of Computer Assisted Learning*, 40(2), 510–524. <https://doi.org/10.1111/jcal.12894>
- Hashim, M. A. M., Tlemsani, I., Mason-Jones, R., Matthews, R., & Ndrecaj, V. (2024). Higher education via the lens of Industry 5.0: Strategy and perspective. *Social Sciences & Humanities Open*, 9, 100828. <https://doi.org/10.1016/j.ssaho.2024.100828>
- Johar, N. A., Kew, S. N., Tasir, Z., & Koh, E. (2023). Learning analytics on student engagement to enhance students' learning performance: A systematic review. *Sustainability*, 15(10), 7849. <https://doi.org/10.3390/su15107849>
- Khalidi, A., Bouzidi, R., & Nader, F. (2023). Gamification of e-learning in higher education: A systematic literature review. *Smart Learning Environments*, 10, 10. <https://doi.org/10.1186/s40561-023-00227-z>
- Lan, H., Bailey, R., & Tan, W. H. (2024). Assessing the digital competence of in-service university educators in China: A systematic literature review. *Heliyon*, 10(16), e35675. <https://doi.org/10.1016/j.heliyon.2024.e35675>
- Li, L., Hew, K. F., & Du, J. (2024). Gamification enhances student intrinsic motivation, perceptions of autonomy and relatedness, but minimal impact on competency: A meta-analysis and systematic review. *Educational Technology Research and Development*, 72, 765–796. <https://doi.org/10.1007/s11423-023-10337-7>
- Lo, C. K. (2023). What is the impact of ChatGPT on education? A rapid review of the literature. *Education Sciences*, 13(4), 410. <https://doi.org/10.3390/educsci13040410>
- Lo, C. K., Hew, K. F., & Jong, M. S.-Y. (2024). The influence of ChatGPT on student engagement: A systematic review and future research agenda. *Computers & Education*, 219, 105100. <https://doi.org/10.1016/j.compedu.2024.105100>
- López-Nuñez, J.-A., Alonso-García, S., Berral-Ortiz, B., & Victoria-Maldonado, J.-J. (2024). A systematic review of digital competence evaluation in higher education. *Education Sciences*, 14(11), 1181. <https://doi.org/10.3390/educsci14111181>
- Mah, D.-K., & Groß, N. (2024). Artificial intelligence in higher education: Exploring faculty use, self-efficacy, distinct profiles, and professional development needs. *International Journal of Educational Technology in Higher Education*, 21, 58. <https://doi.org/10.1186/s41239-024-00490-1>
- Marquez, L., Henríquez, V., Chevreux, H., Scheihing, E., & Guerra, J. (2024). Adoption of learning analytics in higher education institutions: A systematic literature review. *British Journal of Educational Technology*, 55(2), 439–459. <https://doi.org/10.1111/bjet.13385>

- Mellado, R., & Cubillos, C. (2024). Gamification improves learning: Experience in a training activity of computer programming in higher education. *Journal of Computer Assisted Learning*, 40(4), 1959–1973. <https://doi.org/10.1111/jcal.13000>
- Mupaikwa, E. (2025). Toward an evaluation framework for Education 5.0 in institutions of higher learning in Zimbabwe. *Frontiers in Education*, 10, 1634459. <https://doi.org/10.3389/feduc.2025.1634459>
- Ni, A., Cheung, A. C. K., & Shi, J. (2023). The impact of flipped classroom teaching on college English language learning: A meta-analysis. *International Journal of Educational Research*, 121, 102230. <https://doi.org/10.1016/j.ijer.2023.102230>
- Ogunyemi, A. A., Quaiocoe, J. S., & Bauters, M. (2022). Indicators for enhancing learners' engagement in massive open online courses: A systematic review. *Computers and Education Open*, 3, 100088. <https://doi.org/10.1016/j.caeo.2022.100088>
- Palanci, A., Yılmaz, R. M., & Turan, Z. (2024). Learning analytics in distance education: A systematic review study. *Education and Information Technologies*, 29, 22629–22650. <https://doi.org/10.1007/s10639-024-12737-5>
- Paulsen, L., & Lindsay, E. (2024). Learning analytics dashboards are increasingly becoming about learning and not just analytics—A systematic review. *Education and Information Technologies*, 29, 14279–14308. <https://doi.org/10.1007/s10639-023-12401-4>
- Pelaez-Sanchez, I. C., Glasserman-Morales, L. D., & Rocha-Feregrino, G. (2024). Exploring digital competencies in higher education: Design and validation of instruments for the era of Industry 5.0. *Frontiers in Education*, 9, 1415800. <https://doi.org/10.3389/feduc.2024.1415800>
- Ratinho, E., & Martins, C. (2023). The role of gamified learning strategies in student's motivation in high school and higher education: A systematic review. *Heliyon*, 9(8), e19033. <https://doi.org/10.1016/j.heliyon.2023.e19033>
- Salas-Pilco, S. Z., Xiao, K., & Hu, X. (2022). Artificial intelligence and learning analytics in teacher education: A systematic review. *Education Sciences*, 12(8), 569. <https://doi.org/10.3390/educsci12080569>
- Salas-Pilco, S. Z., Yang, Y., & Zhang, Z. (2022). Student engagement in online learning in Latin American higher education during the COVID-19 pandemic: A systematic review. *British Journal of Educational Technology*, 53(3), 593–619. <https://doi.org/10.1111/bjet.13190>
- Schmid, R. F., Borokhovski, E., Bernard, R. M., Pickup, D. I., & Abrami, P. C. (2023). A meta-analysis of online learning, blended learning, the flipped classroom and classroom instruction for pre-service and in-service teachers. *Computers and Education Open*, 5, 100142. <https://doi.org/10.1016/j.caeo.2023.100142>
- Sperling, K., Stenberg, C.-J., McGrath, C., Åkerfeldt, A., Heintz, F., & Stenliden, L. (2024). In search of artificial intelligence (AI) literacy in teacher education: A scoping review. *Computers and Education Open*, 6, 100169. <https://doi.org/10.1016/j.caeo.2024.100169>
- Stojanov, A., & Daniel, B. K. (2024). A decade of research into the application of big data and analytics in higher education: A systematic review of the literature. *Education and Information Technologies*, 29, 5807–5831. <https://doi.org/10.1007/s10639-023-12033-8>
- Susnjak, T., Ramaswami, G. S., & Mathrani, A. (2022). Learning analytics dashboard: A tool for providing actionable insights to learners. *International Journal of Educational Technology in Higher Education*, 19, 12. <https://doi.org/10.1186/s41239-021-00313-7>
- Xu, W., Xu, G.-R., & Xing, Q.-W. (2025). The impact of different combinations of game elements for gamified learning in higher education on student learning outcomes: A multilevel meta-analysis. *Studies in Higher Education*, 50(11), 2376–2403. <https://doi.org/10.1080/03075079.2024.2416498>
- Yu, Q., & Yu, K. (2024). The effects of gamified flipped classroom on student learning: Evidence from a meta-analysis. *Interactive Learning Environments*, 32(9), 5126–5141. <https://doi.org/10.1080/10494820.2023.2209791>