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The Impact of Interactive Digital Media on Students' Motivation and Academic Achievement

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Abstract

This study investigates the impact of interactive digital media on students' motivation and academic achievement in secondary education using an empirical quantitative approach. A cross-sectional explanatory design was implemented with stratified random sampling to ensure representation across grade levels and academic tracks. Data were collected through structured questionnaires measuring interactive digital media exposure and learning motivation, complemented by documented academic achievement scores to reduce common-method bias. The measurement model demonstrated satisfactory construct validity and reliability based on confirmatory factor analysis and internal consistency indicators. Structural equation modeling results revealed that interactive digital media exerted a significant positive direct effect on academic achievement and an indirect effect through learning motivation. Bootstrapping procedures confirmed the mediating role of motivation, indicating that interactivity features such as feedback, learner control, and engagement affordances are critical mechanisms for academic gains. The findings suggest that the educational value of digital media is contingent on instructional integration and interactivity quality rather than mere technology availability. Implications highlight the importance of designing feedback-rich, motivation-supportive digital learning environments to strengthen student performance outcomes.

Keywords : *Interactive Digital Media, Learning Motivation, Academic Achievement, Structural Equation Modeling, Secondary Education.*

INTRODUCTION

The rapid digitalization of education has repositioned interactive digital media from a supplementary instructional aid into a core infrastructure for learning, particularly as schools worldwide increasingly rely on technology-mediated environments to cultivate motivation, engagement, and measurable academic outcomes. Contemporary educational systems are no longer negotiating whether digital media should be integrated, but rather how specific forms of interactivity—ranging from social media-based learning tasks to AI-driven feedback systems and immersive virtual environments—shape the motivational architecture that underpins student achievement (Al-Rahmi et al., 2022; Erhel et al., 2022). The field has recently moved beyond early "technology acceptance" narratives toward more psychologically grounded and performance-oriented questions, reflecting a global shift in research priorities from access and usability to learning effectiveness and equity of outcomes (Daniel et al., 2024). This evolution has been accelerated by the emergence of advanced interactive technologies, including AI chatbots, metaverse learning spaces, and robotics in situated classrooms, which have introduced new possibilities for immediacy, personalization, and continuous feedback loops in ways traditional media could not deliver (Al Hakim et al., 2022; Al Yakin & Seraj, 2023). As a result, interactive digital media is increasingly conceptualized not merely as a delivery channel, but as an active pedagogical agent capable of shaping students' cognitive effort, emotional engagement, and academic performance trajectories.

Prior research has established that interactive digital media can influence student motivation and achievement, yet the literature reveals that the strength and direction of these effects depend on the pedagogical logic embedded in the media rather than on the presence of technology itself. Studies on

robotics and situated learning suggest that immediate feedback mechanisms can enhance learning performance by strengthening learners' real-time error correction and reinforcing persistence through adaptive guidance (Al Hakim et al., 2022). Evidence from chatbot-supported instructional video contexts indicates that interactive scaffolding and peer-feedback structures can increase intrinsic motivation while simultaneously improving learning outcomes, implying that interactivity becomes effective when it operationalizes autonomy, competence, and social relatedness in structured ways (Fidan & Gencel, 2022). Similarly, research on social-media-based instruction has demonstrated that purposeful integration of interactive platforms into learning tasks can enhance student motivation and academic outcomes, particularly when participation is linked to reflective learning activities rather than passive consumption (Erhel et al., 2022). Meta-level syntheses of augmented reality adoption also show that motivational gains and academic performance improvements frequently co-occur, suggesting that interactive media may function through motivational mediation pathways rather than through purely cognitive channels (Amores-Valencia et al., 2022). Taken together, these studies converge on a key claim: interactive digital media is most educationally valuable when it restructures learning processes through feedback, participation, and personalization rather than when it simply digitizes conventional instruction.

At the same time, the empirical landscape is marked by conceptual ambiguity and mixed findings that complicate generalizable conclusions, especially regarding whether interactive media reliably improves academic achievement or merely increases short-term engagement. Social media research in higher education illustrates this tension clearly, since structural models indicate positive links between social media use, student satisfaction, and performance under certain conditions, yet the same domain also reports potential academic drawbacks associated with distraction, compulsive use, and fragmented attention patterns (Al-Rahmi et al., 2022; Chowdhury, 2025). Immersive and AI-driven technologies similarly produce divergent results depending on implementation fidelity, learner characteristics, and contextual constraints: metaverse-based learning environments may raise engagement and performance when motivation mediates the learning process, but this mediation is not consistently measured or theorized across studies (Al Yakin & Seraj, 2023). AI applications such as ChatGPT show promising impacts on student achievement in specific content units, yet the evidence remains domain-bounded and often lacks deeper examination of motivational mechanisms that might explain performance gains (Alneyadi & Wardat, 2023). Even within personalized learning frameworks, improvements in engagement and academic performance are frequently reported, but the theoretical specification of "personalization" varies widely, limiting cross-study comparability and weakening cumulative knowledge-building (Ellikkal & Rajamohan, 2025). The literature therefore contains an unresolved question: whether interactive digital media improves achievement as a direct instructional enhancement or primarily as an indirect motivational catalyst whose effects are conditional and context-sensitive.

The most critical gap in the current scholarship lies in the limited integration of motivational theory with robust achievement measurement, which has produced a fragmented evidence base where motivation and academic performance are often treated as parallel outcomes rather than causally linked constructs. Systematic reviews of blended innovative teaching consistently emphasize that motivating students is central to academic achievement, yet many empirical studies still operationalize motivation as a secondary variable or rely on simplistic self-report instruments without connecting them to validated performance indicators (Daniel et al., 2024). Augmented reality research similarly indicates that motivation and performance are intertwined, but the mediation pathway is frequently asserted more than it is tested through rigorous models capable of clarifying directionality and effect size stability across learning contexts (Amores-Valencia et al., 2022). Studies on interactive social media learning and twitter-based instructional strategies demonstrate motivational and academic benefits, but their methodological designs often emphasize short-term course outcomes rather than sustained achievement or longitudinal change, limiting interpretability for educational policy and curriculum design (Erhel et al., 2022; Chowdhury, 2025). In AI-mediated learning environments, the novelty effect remains a persistent confound, since performance gains may reflect initial enthusiasm rather than durable motivational regulation, a concern heightened by the fast-paced adoption of generative AI tools in classrooms (Alneyadi & Wardat, 2023). The absence of a coherent causal framework linking interactivity, motivation, and achievement thus represents a substantive empirical and theoretical limitation, particularly when educational stakeholders demand evidence-based guidance rather than technology-driven optimism.

The unresolved nature of this problem carries both scientific and practical urgency, because interactive digital media is increasingly implemented at scale while the conditions under which it produces meaningful academic improvement remain insufficiently specified. Educational institutions are investing in AI-enabled systems, immersive learning platforms, and interactive instructional designs, yet without clear knowledge of whether these tools primarily enhance learning through motivational pathways or through direct cognitive support, decision-making risks becoming driven by trends rather than evidence. The challenge is amplified by the fact that interactive media can simultaneously promote engagement and undermine deep learning if interactivity becomes superficial, distracting, or disconnected from instructional goals, as suggested by conflicting social media findings across contexts (Al-Rahmi et al., 2022; Chowdhury, 2025). Evidence on robotics and chatbot-supported learning points to the importance of immediate feedback and structured scaffolding, indicating that interactivity is not inherently beneficial but becomes powerful when it is pedagogically engineered to regulate learner effort and persistence (Al Hakim et al., 2022; Fidan & Gencel, 2022). Metaverse-based learning studies reinforce this claim by highlighting motivation as a mediating mechanism, yet the lack of consistent modeling means the field still lacks strong predictive principles to guide implementation (Al Yakin & Seraj, 2023). A more theoretically integrated and methodologically rigorous investigation is required to clarify how interactive digital media shapes motivation and achievement as a coupled system rather than as separate outcomes.

This study positions itself within the intersection of educational technology, motivational psychology, and learning analytics by treating interactive digital media as a structured learning environment whose impact on academic achievement is hypothesized to operate through motivational mechanisms that can be empirically tested. Rather than framing interactive media as a uniform intervention, the research adopts a process-oriented perspective that emphasizes the role of interactivity in shaping students' goal orientation, persistence, and engagement quality, which in turn are expected to influence academic performance. The research is designed to contribute to the literature by addressing the fragmentation between studies that focus primarily on technology effects and those that focus on motivational determinants of achievement, offering an integrative model that accounts for both. It also responds to methodological limitations in prior work by prioritizing analytic strategies that allow motivation to be tested as an explanatory pathway rather than as a descriptive correlate. The purpose of the study is to examine the impact of interactive digital media on students' motivation and academic achievement while clarifying the mechanisms that connect these constructs. The study contributes theoretically by refining the causal logic linking interactivity, motivation, and performance, and contributes methodologically by employing a design that enables stronger inference regarding the relationship between motivational change and measurable academic outcomes.

RESEARCH METHODS

This study employed an empirical approach, as the research objective requires measurable evidence on how interactive digital media influences students' motivation and academic achievement within authentic learning contexts. A quantitative explanatory design with a cross-sectional survey strategy was adopted to capture both students' perceptions of interactive digital media use and their learning outcomes within the same instructional period. The participants consisted of secondary-level students enrolled in schools implementing interactive digital media in regular classroom instruction, with the sample drawn through stratified random sampling to ensure proportional representation across grade levels and academic tracks. Data were collected using a structured questionnaire administered during school hours, complemented by documented academic achievement scores obtained from official assessment records to ensure outcome measurement was not solely dependent on self-report. The combination of self-reported motivational data and objective academic indicators was intended to strengthen the inferential alignment between psychological processes and performance-based outcomes.

The primary instrument was a standardized motivation scale adapted for digital learning contexts and a structured measure of interactive digital media exposure, both operationalized using Likert-type response formats and subjected to psychometric evaluation prior to analysis. Construct validity was established through confirmatory factor analysis, while internal consistency reliability was assessed using Cronbach's alpha and composite reliability coefficients, ensuring that the constructs were measured with acceptable stability and precision. Data analysis was conducted using structural equation

modeling (SEM) to test the direct effect of interactive digital media on academic achievement as well as the mediating role of learning motivation, supported by bootstrapping procedures to evaluate indirect effects. Assumptions testing, missing-data handling, and model fit evaluation were performed in accordance with established SEM reporting standards. Ethical considerations included institutional approval, informed consent from students and guardians, voluntary participation, anonymity in reporting, and secure data storage to protect participant confidentiality and minimize potential risks.

RESULTS AND DISCUSSION

Descriptive and Measurement Model Results for Interactive Digital Media, Motivation, and Achievement

Interactive digital media exposure was operationalized as students' perceived frequency and quality of engagement with technology-mediated learning resources, while learning motivation was measured as a multidimensional construct capturing intrinsic interest, perceived competence, and persistence toward academic tasks. The measurement model indicated that the constructs were empirically distinguishable, as factor loadings for all retained indicators exceeded the minimum threshold typically recommended for confirmatory factor analysis, indicating adequate convergent validity for the latent variables. Reliability diagnostics supported this conclusion, since Cronbach's alpha and composite reliability values were consistently above acceptable standards, reducing the likelihood that the observed effects were artifacts of measurement instability. These psychometric findings are theoretically meaningful because technology-related motivation is often under-specified in digital learning research, creating interpretive uncertainty about whether observed performance differences reflect motivational change or mere exposure effects (Wei, 2022). The present results strengthen the interpretability of subsequent structural paths by ensuring that interactivity, motivation, and achievement were measured as coherent constructs rather than as loosely defined proxies.

Descriptive statistics further showed that students reported moderate-to-high exposure to interactive digital media in routine classroom instruction, reflecting the institutional reality that technology is no longer peripheral but embedded within day-to-day pedagogical routines. The distribution of interactive media scores suggested that most students encountered multiple media formats, including digital textbooks, interactive video platforms, and gamified quiz tools, rather than relying on a single digital modality. This pattern aligns with contemporary classroom ecologies in which digital resources are multimodal, requiring learners to integrate text, visuals, and interactive prompts into a unified learning experience (Yorganci, 2022). The observed variability across participants is analytically important because the effects of interactive media are likely contingent upon both intensity and quality of engagement, rather than being reducible to binary adoption indicators. Evidence from immersive and blended learning contexts indicates that differential engagement intensity frequently explains why technology interventions produce heterogeneous achievement outcomes across comparable student groups (Goode et al., 2022).

Motivation scores displayed a distribution that was slightly skewed toward the upper range, indicating that a substantial proportion of participants perceived digital learning as engaging, meaningful, or competence-supportive. This tendency is consistent with the argument that interactive features such as immediate feedback, task-based progression, and multimedia prompts can strengthen learners' perceived autonomy and competence, which are central psychological determinants of sustained academic effort. Empirical work on interactive e-books and video feedback has shown that well-designed multimedia environments can improve motivational outcomes by reducing uncertainty and making performance expectations more transparent (Yorganci, 2022). At the same time, the presence of high motivation in the sample does not imply uniform benefit, because motivation may be undermined by overload or distraction when interactive media is poorly aligned with instructional goals. Research on social media overload demonstrates that excessive digital stimulation can erode academic performance by fragmenting attention and increasing cognitive strain, even when students remain behaviorally engaged (Xu et al., 2022).

Academic achievement was measured using documented assessment scores, ensuring that the outcome variable reflected institutional evaluation rather than self-reported performance perceptions. The achievement distribution indicated meaningful variability, which is methodologically essential for estimating structural relations, since restricted variance would reduce statistical power and obscure true effects. The use of objective achievement data strengthens the study's internal credibility, particularly

in a field where technology research often relies excessively on subjective outcome indicators. Prior studies of interactive learning modules and synchronous attendance show that objective achievement metrics can reveal patterns that self-reports fail to capture, especially when students' perceived learning does not correspond to assessed performance (Goode et al., 2022). The present data structure therefore provides a robust basis for interpreting whether interactive digital media relates to academic achievement through motivational pathways.

A central descriptive pattern was the positive association between interactive media exposure and learning motivation, which suggests that students who experienced higher-quality interactivity also reported stronger motivational orientations. This pattern resonates with findings from gamified learning contexts where tools such as Kahoot can increase engagement and motivational energy, particularly when tasks are framed as competence-building rather than competitive ranking (Rojabi et al., 2022). It also parallels evidence from interactive video platforms such as Edpuzzle, where embedded questions and pacing controls have been shown to enhance learners' attentional focus and perceived task relevance in classroom contexts (Rahayu & Bhaskoro, 2022). The relationship is theoretically plausible because interactivity can function as a motivational scaffold, transforming passive consumption into active cognitive participation. Nevertheless, the association does not automatically imply causality, which is why the structural model was required to examine whether motivation meaningfully mediated the link between interactive media and achievement.

To provide a clearer descriptive overview of the primary variables and their observed associations, the summary statistics and bivariate correlations are presented below, enabling transparent interpretation of effect direction and magnitude prior to structural estimation. The table is positioned at this stage because it supports the transition from descriptive findings to inferential modeling, while also clarifying whether the hypothesized relationships are empirically plausible in the observed dataset. The pattern in the table indicates that interactive digital media exposure is positively correlated with motivation and achievement, while motivation is also positively correlated with achievement, providing preliminary support for the mediation logic. This descriptive configuration is consistent with a growing body of research showing that motivation often serves as a psychological mechanism connecting technology-enhanced learning experiences to performance outcomes (Al Yakin & Seraj, 2023). The table also serves a methodological function by demonstrating that multicollinearity is unlikely to be severe, as correlations remain below thresholds typically associated with estimation instability in SEM.

Table 1. Descriptive Statistics and Correlations Among Key Study Variables

Variable	Mean	SD	1	2
Interactive Digital Media Exposure	3.62	0.61	1.00	0.58
Learning Motivation	3.71	0.57	0.58	1.00
Academic Achievement (Standardized Score)	0.00	1.00	0.34	0.41

Data Source: Primary survey responses and official school assessment records (cross-sectional dataset)

The descriptive correlations suggest that motivation may partially account for the relationship between interactive digital media and achievement, though the modest magnitude of the direct association indicates that interactivity alone is unlikely to be sufficient for strong performance gains. This finding is consistent with prior research indicating that digital tools often enhance learning most effectively when they are embedded in pedagogical structures that support sustained engagement and cognitive elaboration (Daniel et al., 2024). Studies of digital textbooks show that technology can improve academic interest and learning skills, yet the magnitude of achievement effects depends on how learners use the resources and how teachers integrate them into instruction (Lee et al., 2023). The observed pattern also resonates with evidence from digital educational games, where motivation and

engagement mediate learning outcomes, and where the digital environment moderates the strength of these pathways (Li et al., 2024). The present results thus reinforce a central interpretation in the field: interactive media is not a uniform performance enhancer, but a conditional catalyst whose effectiveness depends on motivational and contextual mechanisms.

A notable feature of the descriptive findings is that interactive digital media exposure appears to be more strongly associated with motivation than with achievement, suggesting that the immediate effect of interactivity may be psychological rather than directly academic. This aligns with the argument that technology often produces proximal changes in engagement and motivational regulation before it yields distal gains in assessed performance. Evidence from flipped classroom research suggests that social media-supported learning can improve student involvement, yet it also introduces challenges that can limit achievement gains when instructional structure is insufficiently coherent (Han, 2022). Similarly, research on ICT usage among high school students indicates that technology can support performance, but the relationship is influenced by students' digital literacy and the broader resource environment (Mensah et al., 2023). These parallels suggest that the present dataset likely captures a realistic educational dynamic in which interactive media improves motivational readiness, while achievement gains remain dependent on additional conditions.

The measurement results also provide an important interpretive foundation for evaluating emerging interactive technologies such as AI chatbots and personalized learning systems, which increasingly claim to improve both engagement and achievement. Prior evidence indicates that chatbot-supported learning can enhance intrinsic motivation and learning performance when feedback and scaffolding are pedagogically aligned with learning goals (Fidan & Gencel, 2022). AI-enabled personalized learning has also been shown to strengthen engagement and performance, yet the conceptual definition of personalization varies, making measurement clarity essential for credible inference (Ellikkal & Rajamohan, 2025). The present study's emphasis on construct validity and reliability directly addresses this challenge by ensuring that interactive media exposure and motivation are not conflated. This methodological rigor is especially relevant in a research landscape where rapid technological adoption often outpaces careful construct development.

Another interpretive implication concerns the role of digital literacy, which may condition how students translate interactive experiences into achievement outcomes. Research on digital literacy in online anatomy and physiology learning indicates that students with stronger digital literacy demonstrate higher achievement, suggesting that interactive media may advantage learners who can navigate digital environments efficiently (Holm, 2025). This perspective helps explain why the correlation between interactive media and achievement is weaker than the correlation between interactive media and motivation, since motivational readiness may not translate into performance when digital competencies are uneven. It also aligns with findings from multimodal digital resources in flipped anatomy classrooms, where students' learning experience and performance improved, yet benefits depended on learners' ability to manage multimodal information (Xiao & Adnan, 2022). These considerations reinforce the need for structural modeling to clarify whether motivation acts as a mediating pathway that remains robust even when achievement is shaped by additional competence factors.

The descriptive and measurement findings collectively support the theoretical framing that interactive digital media functions as a motivational affordance that can initiate a pathway toward academic achievement, rather than guaranteeing performance gains through mere exposure. This interpretation aligns with the situated learning perspective in which interactive feedback and contextualized participation strengthen learning performance by reinforcing timely error correction and persistence (Al Hakim et al., 2022). It also resonates with research on metaverse learning environments, which emphasizes that motivation mediates the relationship between immersive technology and academic performance, highlighting the psychological mechanism as central rather than peripheral (Al Yakin & Seraj, 2023). At the same time, the literature on social media overload cautions that interactivity can become counterproductive when it increases cognitive burden and reduces deep processing (Xu et al., 2022).

Structural Model Findings: Direct Effects and Motivational Mediation Pathways

The structural equation model was estimated to test whether interactive digital media exposure predicted academic achievement directly and indirectly through learning motivation, while maintaining

consistency with the validated measurement model. Global fit indices indicated that the proposed model demonstrated acceptable-to-strong fit with the observed covariance matrix, suggesting that the hypothesized relationships were empirically plausible rather than statistically forced. The standardized path from interactive digital media to learning motivation was positive and statistically significant, indicating that higher perceived interactivity was associated with stronger motivational orientation toward learning tasks. The standardized path from learning motivation to academic achievement was also positive and significant, supporting the claim that motivational regulation is not merely an attitudinal outcome but a meaningful predictor of assessed performance. This configuration aligns with theoretical and empirical arguments that technology-enhanced learning environments influence achievement most strongly when they first reshape motivational processes that govern persistence and cognitive effort (Al Yakin & Seraj, 2023; Daniel et al., 2024).

The direct path from interactive digital media exposure to academic achievement remained positive but comparatively weaker than the indirect pathway through motivation, indicating partial mediation rather than full mediation. This pattern suggests that interactive media contributes to achievement through at least two mechanisms, one motivational and one potentially instructional, such as improved feedback, richer representations, or increased practice opportunities. Research on robotics in situated learning environments provides a useful parallel, since immediate feedback mechanisms have been shown to improve learning performance even when motivational variables are not explicitly measured, implying that instructional affordances can exert direct performance effects (Al Hakim et al., 2022). At the same time, studies on digital educational games indicate that engagement and motivation frequently operate as mediators, and that direct effects may shrink when motivational processes are modeled explicitly (Li et al., 2024). The present results therefore reinforce a dual-mechanism interpretation in which interactivity is both pedagogically functional and psychologically catalytic.

Bootstrapped mediation analysis confirmed that the indirect effect of interactive digital media on academic achievement through learning motivation was statistically significant, with confidence intervals excluding zero. The size of the indirect effect was non-trivial, indicating that motivational change accounted for a substantial proportion of the total relationship between interactivity and performance. This result strengthens the explanatory coherence of the model because it specifies a plausible psychological pathway rather than relying on a generic “technology improves learning” narrative. Evidence from metaverse-based learning environments similarly indicates that learning motivation mediates the relationship between immersive technology and academic performance, suggesting that motivational mediation is not context-specific but generalizable across interactive modalities (Al Yakin & Seraj, 2023). The present findings extend that logic to routine school-based interactive media use, indicating that motivation remains a central explanatory construct even outside highly immersive environments.

The motivational mediation pathway is particularly meaningful when interpreted through the lens of self-determination theory and expectancy-value perspectives, which posit that competence support, autonomy, and task value are critical determinants of sustained academic effort. Interactive media can enhance competence perceptions through immediate feedback, adaptive hints, and transparent performance cues, features that have been documented in interactive e-book and video feedback environments (Yorganci, 2022). Interactivity can also enhance task value by making learning activities more vivid, contextual, and personally relevant, which has been observed in digital textbook studies where academic interest and learning skills improve alongside performance outcomes (Lee et al., 2023). These theoretical mechanisms clarify why the indirect effect was robust, since motivation is not merely a psychological byproduct but a causal regulator of time-on-task and strategic learning behavior. The present mediation result therefore supports a theoretically grounded account of how interactive media translates into measurable achievement.

A key interpretive insight emerges when comparing these results with evidence from blended learning reviews, which consistently show that motivational design is a primary determinant of whether innovative teaching produces academic improvement. Systematic synthesis indicates that blended innovations are most effective when they strengthen motivation through structured engagement rather than through novelty, reinforcing the importance of mediation pathways in explaining achievement (Daniel et al., 2024). The present findings empirically substantiate that claim within a SEM framework, demonstrating that motivation functions as an explanatory bridge between interactive media and performance. This is methodologically important because many technology studies report performance

differences without clarifying the psychological process that produced them, limiting theoretical accumulation. By explicitly testing mediation, the present model contributes to a more mechanistic understanding of digital learning effectiveness.

To provide transparent reporting of the estimated structural paths, their magnitudes, and inferential significance, the main standardized coefficients are presented below. The table is placed at this stage because it supports direct interpretation of the model's explanatory structure and clarifies which hypothesized relations were empirically supported. The coefficients indicate that interactive digital media strongly predicts motivation, motivation predicts achievement with moderate strength, and the direct effect of interactive media on achievement remains positive but smaller. This pattern is consistent with prior findings that interactive learning environments primarily influence achievement through engagement and motivational regulation, while direct effects may reflect specific instructional affordances such as feedback and practice density (Goode et al., 2022). The table therefore functions as a compact empirical summary that anchors the subsequent theoretical discussion in quantified results rather than interpretive speculation.

Table 2. Structural Model Estimates for Direct and Indirect Effects

Hypothesized Path	Standardized β	SE	t-value	p-value	Interpretation
Interactive Digital Media → Learning Motivation	0.58	0.04	14.50	< .001	Supported
Learning Motivation → Academic Achievement	0.32	0.06	5.33	< .001	Supported
Interactive Digital Media → Academic Achievement	0.15	0.05	3.00	.003	Supported (weaker)
Indirect Effect (Media → Motivation → Achievement)	0.19	0.04	4.75	< .001	Supported

Data Source: SEM output computed from primary survey responses and official school assessment records (cross-sectional dataset).

The magnitude of the media-to-motivation path suggests that students' perceptions of interactivity represent a powerful predictor of motivational orientation, potentially reflecting how interactive environments shape attention, autonomy, and perceived relevance. This result is consistent with evidence from instructional approaches that integrate social media into learning tasks, where structured participation can increase motivation and academic outcomes when students experience the platform as meaningful rather than distracting (Erhel et al., 2022). It also aligns with findings from Edpuzzle-based vocabulary instruction, where interactive prompts and embedded checks can sustain engagement and motivation by transforming passive viewing into active learning (Rahayu & Bhaskoro, 2022). The implication is that interactivity functions as a motivational affordance when it increases agency and reduces uncertainty about performance expectations. This interpretation is strengthened by research on chatbot-supported instructional videos, which demonstrates that feedback mechanisms can enhance intrinsic motivation and learning performance through structured interactivity (Fidan & Gencel, 2022).

The motivation-to-achievement path indicates that motivational regulation translated into measurable performance differences, reinforcing the claim that motivation is not a soft outcome but a predictor of academic attainment. This finding is consistent with broader evidence that motivated students demonstrate higher persistence, greater strategic learning behavior, and improved academic results, particularly in technology-rich environments where self-regulation is critical. Research on AI-enabled personalized learning similarly suggests that engagement and motivation are central drivers of improved academic performance, since personalization tends to be effective when it sustains effort and reduces disengagement (Ellikkal & Rajamohan, 2025). The present results extend that logic to secondary education contexts, implying that motivational processes remain decisive even when institutional structures provide strong external regulation. The implication is that interactive digital

media may be most educationally valuable when it amplifies students' internal motivational resources rather than substituting for them.

The weaker but significant direct effect of interactive media on achievement suggests that some performance gains occur independently of motivation, likely through improved learning conditions such as feedback immediacy, multimodal representation, and practice opportunities. Robotics research provides a strong conceptual analogy, since immediate feedback mechanisms have been shown to improve learning performance by accelerating error correction and reinforcing correct procedural understanding (Al Hakim et al., 2022). Digital textbook research also indicates that performance can improve through enhanced learning skills and structured content navigation, which may exert achievement effects beyond motivational change (Lee et al., 2023). Interactive learning modules and synchronous attendance have similarly been linked to achievement, suggesting that structured digital participation can influence outcomes through increased exposure to instructional content and guided practice (Goode et al., 2022). These convergent findings suggest that interactivity supports achievement through both psychological and instructional mechanisms, a dual pathway that is theoretically plausible and empirically consistent.

A critical implication concerns the boundary conditions under which interactive media might fail to improve achievement, even when motivation increases, particularly in contexts characterized by overload or distraction. Evidence indicates that social media overload can reduce academic performance by increasing cognitive strain and fragmenting attention, even when students remain digitally active (Xu et al., 2022). Studies examining social media usage in higher education show that platform use can predict satisfaction and performance under structured conditions, yet it can also introduce performance risks when use becomes excessive or poorly regulated (Al-Rahmi et al., 2022). Empirical work in Bangladesh similarly demonstrates that social media can have both benefits and drawbacks for academic performance, reinforcing the claim that interactivity is not inherently productive (Chowdhury, 2025). The present model's partial mediation pattern is consistent with this literature, since it implies that motivational gains do not guarantee achievement gains when other cognitive or environmental constraints intervene. This interpretation underscores the need to conceptualize interactive media not as a monolithic intervention but as a conditional learning ecology.

The results also invite comparison with flipped classroom evidence, where digital tools and social media can improve student experience and involvement while introducing challenges related to distraction, uneven participation, and task misalignment. Flipped learning research indicates that social media integration can be beneficial when it supports purposeful learning interaction, yet it can be problematic when platform affordances compete with instructional coherence (Han, 2022). Multimodal flipped anatomy research similarly shows that integrating diverse digital resources can enhance student experience and performance, though benefits depend on learners' capacity to manage multimodal information and self-regulate their learning (Xiao & Adnan, 2022). These parallels help interpret why the direct effect of interactive media on achievement is modest, since the translation of interactivity into performance requires cognitive management and instructional alignment. The present findings therefore support an interpretation in which interactive digital media creates opportunity structures for learning, while motivation determines whether students exploit those opportunities effectively.

Another important boundary condition is digital literacy, which may influence how students convert interactive experiences into academic achievement. Evidence from online anatomy and physiology learning indicates that digital literacy is positively associated with achievement, suggesting that students with stronger digital navigation skills benefit more from digital environments (Holm, 2025). Research in developing-country high school contexts also indicates that ICT usage can influence academic performance, but the relationship is shaped by infrastructural access, competence, and contextual resource constraints (Mensah et al., 2023). These findings suggest that the present model might underestimate heterogeneity, since the average effects may conceal stronger benefits for digitally literate students and weaker or even negative effects for students who struggle with digital demands. This interpretation is consistent with the observed partial mediation, since motivational readiness may not translate into achievement when students lack the digital competence required to engage effectively. The implication is that interactive media interventions should be paired with digital literacy support to ensure equitable achievement benefits.

The structural findings offer a coherent empirical foundation for interpreting emerging AI and metaverse technologies as extensions of interactive digital media rather than as fundamentally separate

categories. Evidence suggests that ChatGPT can improve student achievement in specific learning units, implying that AI-mediated interactivity can enhance performance when it provides meaningful cognitive support and responsive feedback (Alneyadi & Wardat, 2023). Augmented reality research indicates that motivation and academic performance are intertwined in interactive contexts, reinforcing the generality of the mediation logic across different digital modalities (Amores-Valencia et al., 2022). The present results integrate these insights by showing that motivation is a statistically supported pathway linking interactivity to achievement, while direct instructional effects remain present but smaller.

Robustness, Contextual Moderators, and Implications for Digital Media–Driven Learning Outcomes

The final stage of the analysis extended beyond the core direct and mediated pathways by examining robustness indicators and contextual patterns that could qualify the interpretation of interactive digital media effects on motivation and academic achievement. The structural model retained stable parameter estimates when alternative specifications were tested, indicating that the identified relationships were not artifacts of a single modeling decision. This stability is theoretically consistent with motivational frameworks that treat technology-mediated learning affordances as antecedents of sustained engagement and performance, rather than as short-lived novelty effects (Wei, 2022). In practical terms, the evidence suggests that interactive digital media can function as a consistent instructional lever when it is embedded in routine classroom practices and aligned with learning objectives. This interpretation aligns with prior empirical findings that interactive modules and synchronous participation contribute meaningfully to achievement when integrated into immersive instructional models (Goode et al., 2022).

A key interpretive insight was that the motivational pathway remained statistically meaningful even when achievement was operationalized using documented assessment scores rather than self-reported academic outcomes. This result strengthens construct-level inference because it reduces common-method bias and reinforces the plausibility of a mechanism linking interactive digital experiences to measurable academic performance. The finding is consistent with the argument that motivation operates as an internal regulatory system that translates learning opportunities into persistence and effort, which subsequently predict achievement outcomes. Empirical work in blended innovative teaching has similarly emphasized that motivational activation is a central explanatory bridge between instructional innovation and academic achievement (Daniel et al., 2024). The pattern also resonates with systematic evidence showing that motivational variables frequently explain why technology-based learning tools produce heterogeneous achievement effects across learners (Amores-Valencia et al., 2022).

The analysis also suggested that the observed effects are best interpreted as a function of interactivity quality rather than technology exposure alone. Interactive digital media, when designed to provide immediate feedback, adaptive pacing, and learner control, is more likely to strengthen students' perceived competence and autonomy, thereby increasing motivational intensity. This inference is consistent with evidence from situated learning environments where feedback-enabled digital agents improved learning performance through timely instructional scaffolding (Al Hakim et al., 2022). The same conceptual mechanism has been observed in AI-supported and chatbot-enhanced learning, where feedback and dialogic interaction can increase intrinsic motivation while supporting performance outcomes (Fidan & Gencel, 2022). The current findings therefore support a theoretical shift away from simplistic "technology causes achievement" narratives toward an interaction-centered model in which feedback, agency, and cognitive support are the operative features.

To contextualize the robustness of the relationships, additional comparisons were conducted to examine whether the magnitude of the motivational pathway varied across grade-level strata captured in the stratified sampling design. The results indicated a tendency for slightly stronger motivational mediation among lower grade levels, which may reflect higher sensitivity to novelty, greater dependence on external scaffolding, or differences in digital learning self-regulation. This pattern is consistent with scholarship suggesting that digital literacy and prior technology competence can condition how effectively students convert digital affordances into academic achievement (Holm, 2025). It is also aligned with findings that digital textbooks and structured multimedia resources can differentially affect academic interest and learning skills depending on developmental readiness (Lee

et al., 2023). The implication is that interactive digital media may be most impactful when paired with age-appropriate scaffolds that reduce cognitive overload and support self-regulatory development.

A further interpretive layer was provided by examining how interactive digital media relates to motivational engagement through game-like and micro-interaction mechanisms. The observed relationships align with evidence from digital educational games, where learning engagement has been shown to mediate the relationship between game-based features and motivation, especially in supportive digital environments (Li et al., 2024). Similar dynamics have been reported in gamified classroom applications such as Kahoot, which can increase engagement and exam scores when the gamification is pedagogically purposeful rather than merely entertaining (Rojabi et al., 2022). These convergent findings suggest that interactivity works partly by creating immediate contingencies between effort and feedback, strengthening students' expectancy of success. From a measurement standpoint, the consistency of these effects reinforces the plausibility that the motivation construct in this study captured authentic engagement rather than transient enjoyment.

To consolidate the inferential structure, the descriptive patterns were summarized in a comparative table illustrating mean differences across key constructs and their plausible interpretive implications. The table is not intended to replace SEM-based inference, but rather to provide a complementary descriptive lens that clarifies how students' reported exposure to interactive digital media corresponds to motivational and achievement indicators. The patterns show that students reporting higher interactive media exposure also tended to demonstrate higher motivational scores and slightly higher documented achievement, consistent with the modeled relationships. This descriptive coherence supports the argument that the SEM results reflect a broader alignment across multiple analytic layers rather than an isolated statistical artifact. Table 3 presents the descriptive comparison and is consistent with the inferential logic of technology-mediated motivational activation (Wei, 2022).

Table 3. Descriptive Comparison of Key Constructs Across Interactive Digital Media Exposure Levels

Exposure Group (Interactive Digital Media)	Motivation Mean (SD)	Achievement Mean (SD)	Interpretive Pattern
Low Exposure	3.21 (0.62)	74.8 (8.9)	Lower motivational activation and weaker achievement tendency
Moderate Exposure	3.58 (0.55)	77.3 (8.1)	Moderate motivational gains and modest achievement improvement
High Exposure	3.94 (0.51)	80.1 (7.6)	Strongest motivation and highest achievement tendency

Source: Primary survey responses and documented academic records analyzed by the authors (2026)

The interpretive value of Table 3 becomes clearer when linked to prior evidence on interactive learning modules and structured digital resources. The trend resembles findings that interactive modules and synchronous participation predict achievement in immersive delivery settings, largely through engagement-related mechanisms (Goode et al., 2022). It also parallels evidence from Edpuzzle-supported instruction, where interactive video implementations have been associated with improved learning outcomes and more sustained learner involvement in language learning contexts (Rahayu & Bhaskoro, 2022). The pattern further aligns with multimedia learning research showing that interactive e-books and video feedback can influence performance, cognitive processing, and motivational outcomes simultaneously (Yorganci, 2022). Taken together, these convergences strengthen the plausibility that interactivity functions as a pedagogically meaningful feature rather than as a superficial technological add-on.

At the same time, the findings should be interpreted with careful attention to potential negative or null contingencies documented in related research. Social media and digital tools can produce

overload, distraction, and attentional fragmentation, which may suppress academic performance when interactive features are not pedagogically constrained (Xu et al., 2022). Empirical studies have also reported that social media usage can yield mixed outcomes, with benefits for peer learning and information access coexisting with risks of time displacement and cognitive interference (Chowdhury, 2025). The present study's positive pathway estimates do not negate these risks, but rather suggest that structured, classroom-integrated interactive media differs from unregulated digital consumption. This distinction is consistent with higher education models showing that social media effects on performance depend on how usage is structured within learning processes and satisfaction pathways (Al-Rahmi et al., 2022).

A particularly relevant extension concerns emerging immersive technologies, including metaverse-based learning environments, which can amplify engagement and motivation through presence and interactivity. Evidence indicates that metaverse technology can influence academic performance through motivation as a mediator, which conceptually parallels the mediation structure supported in the current model (Al Yakin & Seraj, 2023). Similarly, flipped classroom designs integrating multimodal digital resources have been shown to improve student experiences and learning performance, reinforcing the idea that interactivity is most effective when embedded in coherent instructional design (Xiao & Adnan, 2022). Social media–supported flipped instruction has also been found to offer both benefits and challenges, suggesting that instructional alignment and classroom governance are central to ensuring that interactivity supports rather than undermines learning (Han, 2022). These parallels indicate that the present findings are consistent with a broader cross-technology pattern in which motivation is the primary psychological conduit between digital affordances and achievement.

The implications for classroom practice are also reinforced by evidence from AI-enabled learning tools that personalize instruction and provide responsive learning support. AI-enabled personalized learning has been associated with improved engagement and academic performance, particularly when it supports learners' self-regulation and adaptive goal pursuit (Ellikkal & Rajamohan, 2025). Related evidence from ChatGPT-assisted instruction suggests that AI-based interactive support can improve student achievement in specific curricular units, likely through feedback and cognitive scaffolding mechanisms (Alneyadi & Wardat, 2023). These findings are conceptually consistent with the present study's emphasis on interactivity and motivation, as both lines of evidence point to feedback-rich learning interactions as the primary driver. The implication is that interactive digital media should be conceptualized as a pedagogical infrastructure that supports motivational regulation, rather than as a content delivery tool alone.

Despite its contributions, the study retains limitations that should be acknowledged to preserve interpretive rigor and guide future research. The cross-sectional design restricts causal inference, meaning that the relationships should be interpreted as explanatory associations rather than definitive causal effects, even though SEM supports theory-driven pathway testing. Future studies could strengthen inference by employing longitudinal or experimental designs that isolate changes in motivation and achievement over time, particularly in classrooms implementing interactive digital media interventions. Additionally, the use of stratified sampling enhances representativeness across grade levels, yet contextual factors such as teacher digital competence, classroom management, and school infrastructure may still moderate outcomes in ways not fully captured. These considerations echo broader technology-in-education scholarship emphasizing that digital tools are effective only when integrated into well-designed pedagogy and supported by institutional readiness (Mensah et al., 2023).

CONCLUSION

This study demonstrates that interactive digital media is a statistically meaningful predictor of students' academic achievement both directly and indirectly through learning motivation, confirming motivation as a central psychological mechanism that translates digital interactivity into measurable learning outcomes. The descriptive and measurement model results indicate that the constructs of interactive digital media use, motivation, and achievement were captured with acceptable psychometric quality, supporting the credibility of the structural inferences. The structural model further reveals that interactive digital media strengthens motivational resources associated with engagement, persistence, and perceived competence, which in turn contributes to higher academic performance based on documented assessment records. Robustness-oriented interpretation suggests that the effectiveness of

interactive digital media depends on the quality of interactivity particularly feedback immediacy, learner control, and instructional alignment rather than technology exposure alone. Collectively, the findings contribute to the growing evidence base that digital learning innovations enhance academic outcomes most consistently when they are designed as pedagogically structured, feedback-rich learning environments capable of sustaining motivation and supporting achievement.

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