HOW SOCIAL MEDIA ENHANCES STEM LEARNING: A SYSTEMATIC REVIEW OF IMPLEMENTATION STRATEGIES AND OUTCOMES (2020–2025)

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ABSTRACT

This systematic literature review examines social media implementation strategies and learning outcomes in STEM education through analysis of 133 empirical studies published between 2020 and 2025, sourced exclusively from the Web of Science database following PRISMA 2020 guidelines. From an initial pool of 1,810 records, 100 duplicates were removed, and subsequent title-abstract screening, full-text eligibility assessment, and inclusion criteria evaluation yielded the final sample of 133 studies. Studies were systematically categorized by platform type, STEM discipline, and educational level. Among the analytical approaches employed across included studies, social network analysis was most frequently used (30.8%); among social media platforms, YouTube-based implementations were most prevalent (18.8%). Mathematics education showed the strongest disciplinary representation (24.8%), with higher education dominating across all platform categories (58.6%). Synthesis of learning outcomes revealed generally positive effects across cognitive, affective, social, and behavioral dimensions. Social outcomes showed the most consistent positive findings, with 78–91% of studies employing each implementation strategy reporting improvements in peer relationships and learning community formation — though this reflects the proportion of studies reporting positive findings rather than a pooled effect estimate. Implementation challenges centered on technical infrastructure limitations, digital literacy disparities, and institutional resistance, while successful implementations required comprehensive institutional support, professional development, and clear pedagogical frameworks. These findings suggest that social media integration can enhance STEM education effectiveness when implemented systematically within supportive contexts, though future research addressing long-term sustainability and cultural diversity remains essential.

Keywords: Social Media Integration, STEM Education, Implementation Strategies, Learning Outcomes

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INTRODUCTION

Science, Technology, Engineering, and Mathematics (STEM) education has become increasingly critical in preparing students for the demands of the 21st century workforce and fostering innovation-driven economies(Zhumabay et al., 2024). Global educational systems face mounting pressure to produce graduates equipped with scientific literacy, technological competency, and analytical problem-solving skills essential for addressing complex societal challenges (Phirom, 2016). However, traditional STEM pedagogical approaches, characterized by lecture-based instruction and theoretical content delivery, have proven insufficient in engaging modern learners who are accustomed to interactive, multimedia-rich environments (Aslam et al., 2023). This persistent challenge has intensified concerns about student engagement, gender disparities in STEM participation, and the need for authentic, real-world learning experiences that connect theoretical concepts to practical applications (Dancy et al., 2020; Jehangir et al., 2023).

Digital natives, who have grown up immersed in technology-rich environments, demonstrate distinct learning preferences that differ significantly from previous generations (Sukamto et al., 2023). Social media platforms have become integral components of their daily lives, serving as primary channels for communication, information sharing, and social interaction(Hu & Zhu, 2022). These platforms offer unique affordances for educational purposes, including collaborative learning opportunities, multimedia content creation, real-time feedback mechanisms, and global connectivity that transcends geographical boundaries (Kier & Johnson, 2022). The participatory nature of social media environments aligns naturally with contemporary pedagogical theories that emphasize active learning, social constructivism, and community-based knowledge construction (Chai et al., 2019). Social constructivism, as articulated through Vygotsky's zone of proximal development, emphasizes the collaborative nature of knowledge construction and the importance of social interaction in learning, suggesting that social media platforms can serve as digital spaces where learners engage in meaningful discourse and co-construct understanding of complex STEM concepts (Kier & Johnson, 2022).

The theoretical foundations supporting social media integration in STEM education extend beyond constructivist perspectives to include technology adoption frameworks. The Technology Acceptance Model (TAM) and its extensions, along with the theory of planned behavior (TPB), provide crucial frameworks for understanding how educators and students adopt social media technologies for educational purposes (Vafaei-Zadeh et al., 2024; Venkatesh et al., 2003). These models highlight the critical role of perceived usefulness, perceived ease of use, attitudes, subjective norms, and perceived behavioral control in determining technology adoption rates and implementation success (Wu et al., 2022; Yan & Cheng, 2015). Additionally, cultural intelligence theory has emerged as particularly relevant in understanding how social media platforms can bridge cultural divides in diverse STEM classrooms, enabling students from different backgrounds to share knowledge and perspectives [23]. Research utilizing these theoretical frameworks has demonstrated that teachers' willingness to integrate social media into STEM instruction depends significantly on their perceptions of usefulness, institutional support, self-efficacy beliefs, and cultural competency (Caprara et al., 2006; Klassen & Tze, 2014; Tschannen-Moran & Hoy, 2001).

The application of social media in educational contexts has gained considerable attention from researchers and educators seeking to harness the potential of these platforms for meaningful learning experiences (Rahman et al., 2021). Various social media tools offer distinct features and capabilities that support different aspects of STEM education, from content delivery and collaborative problem-solving to scientific communication and peer learning (Akgunduz & Mesutoglu, 2021). Video-sharing platforms like YouTube have demonstrated particular effectiveness in supporting flipped classroom models and providing access to expert demonstrations, enabling students to learn at their own pace while freeing up classroom time for interactive activities (Akgunduz & Mesutoglu, 2021; Zhumabay et al., 2024). Social networking platforms such as Facebook and Instagram facilitate learning community formation and peer-to-peer knowledge sharing, with the visual nature of platforms like Instagram proving particularly effective for documenting laboratory procedures and communicating complex scientific concepts through infographics and visual storytelling (Hu & Zhu, 2022; Papagiannopoulou et al., 2023). Successful social media integration requires carefully designed implementation strategies that align with specific learning objectives and institutional contexts, with blended learning approaches, project-based learning, and gamification elements showing particular promise in engaging students with real-world STEM problems (Brown et al., 2019; Chen et al., 2022; Şenyiğit & Serin, 2022).

However, the integration of social media in STEM education occurs within contexts that present significant challenges and considerations. The digital divide represents both a challenge and an opportunity, as access to technology and reliable internet connectivity remains uneven across socioeconomic and geographic boundaries, though social media platforms often provide more accessible entry points to digital learning than specialized educational technologies (Sukmayadi & Yahya, 2020). Implementation challenges consistently center on technical infrastructure limitations, digital literacy disparities, and institutional resistance, with research conducted during the COVID-19 pandemic highlighting both the potential and limitations of social media-based learning (Kier & Johnson, 2022; Kurniawati et al., 2019). Teacher-related factors play a crucial role in determining implementation success, with self-efficacy beliefs, professional development quality, and ongoing support emerging as particularly important predictors of teachers' willingness to adopt and effectively implement social media-based pedagogies (Kahveci et al., 2018; Tschannen-Moran & Hoy, 2001). The importance of addressing teachers' concerns about digital citizenship, online safety, and appropriate use of social media in educational contexts has been emphasized across multiple studies (Ogegbo et al., 2024; Zhumabay et al., 2024).

Despite the promising potential and increasing adoption of social media in STEM education, the field lacks comprehensive synthesis of existing research that can guide evidence-based implementation practices (Çavaş et al., 2024). The urgency of this synthesis is particularly evident in the post-pandemic landscape, where emergency remote teaching accelerated social media adoption across educational institutions worldwide, generating a substantial body of empirical evidence that has yet to be systematically analyzed. Between 2020 and 2025, publication rates in this field increased markedly — yet no systematic review has consolidated these developments to identify which implementation approaches are most effective, what factors contribute to successful outcomes, and how different social media platforms support various learning objectives across STEM disciplines. Current literature presents fragmented findings across different social media platforms, educational levels, and STEM disciplines, making it challenging for educators and policymakers to make informed decisions about technology integration strategies (Yildiz & Arpaci, 2024).

This systematic literature review addresses the identified knowledge gaps by providing a comprehensive analysis of social media implementation strategies and their associated learning outcomes in STEM education contexts. For the purposes of this review, social media platforms refer to web-based and mobile applications that enable user-generated content, social interaction, and networked communication — including but not limited to YouTube, Facebook, Instagram, Twitter, TikTok, WhatsApp, and Discord. Implementation strategies are defined as the pedagogical approaches and instructional designs through which educators integrate these platforms into STEM learning activities, such as collaborative learning, content creation, communication-focused discussion, and professional networking. Learning outcomes encompass cognitive, affective, social, and behavioral dimensions of student development as reported in empirical studies. Where social network analysis (SNA) appears in included studies, it is treated as an analytical method used by researchers to examine interaction patterns — not as a social media platform in itself. The review examines empirical studies published between 2020 and 2025 to capture the evolution of social media integration practices and their documented outcomes across different educational settings. The primary objectives include: (1) mapping the current landscape of social media use in STEM education; (2) categorizing implementation strategies employed by educators and institutions; (3) assessing learning outcomes associated with these approaches; and (4) identifying factors that contribute to successful social media integration in STEM contexts. Through rigorous systematic analysis following PRISMA 2020 guidelines, this review aims to provide evidence-based recommendations for educators, researchers, and policymakers seeking to leverage social media platforms for enhanced STEM education delivery and improved student learning experiences.

METHOD

This systematic literature review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological rigor and transparency (Page et al., 2021). A comprehensive search was conducted across the Web of Science (WoS) database, specifically querying the Social Sciences Citation Index (SSCI), Science Citation Index Expanded (SCI-Expanded), and Emerging Sources Citation Index (ESCI). WoS was selected due to its broad coverage of peer-reviewed literature in education, technology, and STEM fields. The search was limited to publications from 2020 to 2025, providing a contemporary five-to-six year perspective on the evolution of social media integration practices in STEM education. The search was conducted on 25 August 2025, and only journal articles in English were retrieved; conference proceedings, book chapters, editorials, and early-access records were excluded via document-type filters. To complement the database search and mitigate potential coverage bias inherent in single-database searches, a supplementary manual search was conducted by checking the reference lists of all included studies (backward citation chasing) and by scanning the most recent issues of key journals in the field, including Computers & Education, International Journal of STEM Education, and Educational Technology & Society. While WoS provides strong coverage of high-impact journals, it may underrepresent studies indexed exclusively in ERIC or regional education databases; this limitation is acknowledged in the limitations section.

The search strategy employed a combination of keywords and Boolean operators applied to the Title, Abstract, and Keywords fields (i.e., the "Topic" field in WoS): ("STEM education" OR "Science education" OR "Technology education" OR "Engineering education" OR "Mathematics education") AND ("social media" OR "Facebook" OR "YouTube" OR "Instagram" OR "Twitter" OR "TikTok" OR "LinkedIn" OR "social network*" OR "social platform*") AND ("implementation" OR "integration" OR "teaching" OR "learning" OR "pedagogy" OR "instruction" OR "effectiveness" OR "strategy"). The search was restricted to English-language journal articles published between January 2020 and December 2025, with document type filtered to "Article" only to ensure inclusion of original empirical research.

Studies were systematically evaluated against predetermined inclusion and exclusion criteria to ensure selection of relevant, high-quality research. For inclusion, studies were required to be peer-reviewed journal articles published in English between 2020 and 2025, focused specifically on STEM education at any educational level (K-12, higher education, or informal settings), examining the use of social media platforms or social networking technologies, and presenting original empirical data through quantitative, qualitative, or mixed-methods approaches addressing implementation strategies, pedagogical approaches, or learning effectiveness. Exclusion criteria eliminated books, book chapters, editorials, systematic reviews, or meta-analyses to concentrate on primary empirical research, as well as purely theoretical papers without empirical data, studies focusing exclusively on non-STEM subjects, research examining educational technologies other than social media platforms, studies lacking sufficient methodological detail, and duplicate publications to avoid overrepresentation of particular findings.

The study selection process was conducted in multiple phases to ensure systematic and unbiased identification of relevant literature. The systematic search yielded a total of 1,810 initial records. Following the removal of 100 duplicate records using Mendeley reference management software, 1,710 unique records were retained for title and abstract screening. Of these, 1,520 records were excluded as not relevant to social media in STEM education, yielding 190 records for full-text eligibility assessment. Full-text screening against inclusion and exclusion criteria led to the exclusion of 56 records for the following reasons: no STEM focus (n = 25), no social media component (n = 18), review or theoretical papers (n = 8), and non-educational context (n = 5). The remaining 134 studies were assessed against the full inclusion criteria, with one further study excluded due to lack of implementation or pedagogical focus, resulting in a final sample of 133 studies. The PRISMA 2020 flow diagram (Fig. 1) illustrates this selection process. Two independent reviewers conducted all screening stages using a standardized extraction form, with disagreements resolved through discussion and, where necessary, consultation with a third reviewer.

To ensure transparency and replicability of outcome synthesis, a structured coding protocol was developed prior to data extraction. Each included study was independently coded by two reviewers across four outcome dimensions: cognitive, affective, social, and behavioral. A study was coded as reporting a "positive" outcome in a given dimension if the original authors reported statistically significant improvements (for quantitative studies), consistent positive themes (for qualitative studies), or convergent positive findings (for mixed-methods studies) in that dimension. A study could receive positive coding in multiple dimensions simultaneously. The denominator for all reported percentages in Table 2 refers to the number of studies within each implementation strategy category that measured the relevant outcome dimension — not the total sample of 133 studies. Inter-rater reliability was assessed using Cohen's kappa; any discrepancies were resolved through discussion, and cases of persistent disagreement were referred to a third reviewer for a final decision.

Data extraction employed a comprehensive framework to systematically capture relevant information from included studies, including bibliographic information, geographic and contextual information, methodological details, specific social media platforms utilized, STEM domains addressed, implementation strategies and pedagogical approaches, learning outcomes and effectiveness measures, and implementation challenges and success factors. Data analysis employed a convergent mixed-methods approach combining quantitative synthesis of study characteristics with qualitative thematic analysis of findings. Quantitative analysis generated descriptive statistics for key study characteristics including publication trends, geographic distribution, educational level focus, methodological approaches, and platform distribution patterns. Qualitative synthesis employed systematic thematic analysis to identify recurring patterns and themes across study findings related to implementation strategies, learning outcomes, barriers, and facilitating factors, combining deductive and inductive coding while considering how contextual factors might influence findings. The integration of quantitative and qualitative analyses provided comprehensive understanding of the current state of knowledge regarding social media implementation in STEM education while identifying areas of convergence and divergence in the evidence base.

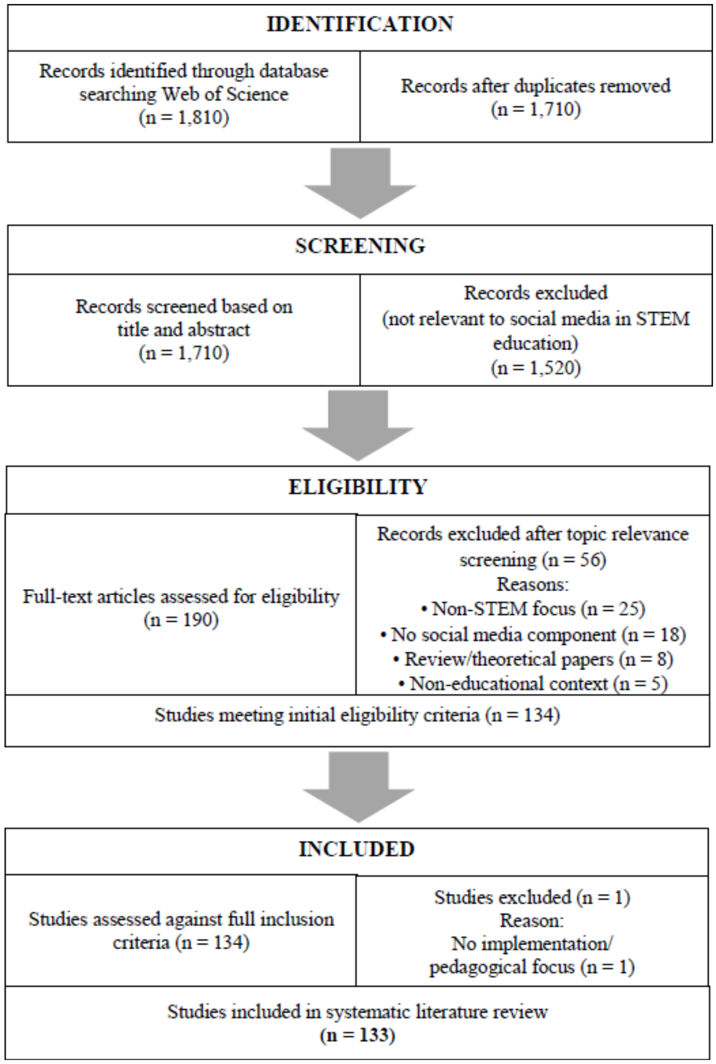

Fig. 1. PRISMA flow diagram

RESULTS AND DISCUSSION

Study Selection and Temporal-Geographic Patterns

The systematic search conducted across the Web of Science database yielded 1,810 initial records. Following removal of 100 duplicate records, 1,710 unique records were screened by title and abstract, of which 1,520 were excluded as not relevant to social media in STEM education. Full-text assessment of the remaining 190 records against predetermined inclusion and exclusion criteria resulted in the exclusion of 56 records, leaving 134 studies for final evaluation. One further study was excluded due to lack of implementation or pedagogical focus, yielding a final sample of 133 studies as illustrated in the PRISMA 2020 flow diagram (Fig. 1). The inclusion rate of 99.3% among full-text assessed records reflects the precision of the search strategy rather than an absence of quality filtering, as studies were rigorously evaluated across all screening stages.

These geographic patterns reflect broader structural inequalities in educational research production rather than an absence of social media use in developing countries. The dominance of North American and European studies is likely attributable to stronger research infrastructure, greater access to funding, and higher rates of WoS-indexed publication in these regions — not necessarily greater adoption of social media in education. Conversely, the underrepresentation of Asia-Pacific, African, and Latin American contexts is particularly concerning given that social media platforms are often the primary mode of internet access in resource-constrained environments (Sukmayadi & Yahya, 2020). This geographic skew introduces a systematic bias toward findings from high-income, technologically advanced educational systems, which limits the generalizability of conclusions drawn from this review to diverse global contexts.

The temporal distribution of included studies reveals significant trends in research interest and publication patterns over the review period. Publication frequency demonstrated a clear upward trajectory. Studies increased from 17 in 2020 (12.8%) to a peak of 30 studies in 2023 (22.6%). The year 2024 maintained high levels at 28 studies (21.1%), while 2025 contributed 14 studies (10.5%). This notable increase during 2021-2023 likely reflects the heightened interest in educational technology integration following the COVID-19 pandemic. It also indicates the subsequent emphasis on digital learning solutions. The sustained research activity throughout 2022-2024 suggests continued scholarly attention beyond the immediate pandemic response. This indicates that social media integration has become an established area of inquiry in STEM education research rather than a temporary reaction to emergency remote teaching.

Geographic distribution analysis revealed concentration of research activity in specific regions. North America led publication output at 45 studies (33.8%). Europe followed with 38 studies (28.6%). Asia-Pacific contributed 32 studies (24.1%). The remaining 18 studies (13.5%) represented multinational collaborations or other geographic regions. This geographic concentration suggests that social media integration research predominantly reflects developed country contexts. This potentially limits the generalizability of findings to diverse educational systems with different technological infrastructures and cultural contexts. The underrepresentation of developing countries is particularly notable. Social media platforms may offer unique opportunities to address educational access challenges in resource-constrained environments (Kurniawati et al., 2019; Sukmayadi & Yahya, 2020).

Educational level focus showed predominant emphasis on higher education contexts. A total of 78 studies (58.6%) examined university-level implementations. K-12 education accounted for 45 studies (33.8%). Informal education settings represented 10 studies (7.5%). This emphasis on higher education likely reflects several factors. These include greater institutional autonomy for technology adoption, more mature student populations capable of self-directed learning, and stronger research infrastructure for educational innovation studies.

Methodological diversity was evident across included studies. Mixed-methods approaches were most prevalent at 42 studies (31.6%). Quantitative designs followed at 38 studies (28.6%). Qualitative approaches comprised 28 studies (21.1%). Case studies numbered 15 studies (11.3%). Experimental designs represented 10 studies (7.5%). The predominance of mixed-methods approaches reflects researchers' recognition of a key insight. Understanding social media integration effectiveness requires both quantitative measurement of learning outcomes and qualitative insights into implementation processes and user experiences. However, the relatively small proportion of experimental designs (7.5%) suggests most research in this area relies on observational or quasi-experimental methodologies. This limits the strength of causal inferences about social media integration effectiveness.

Platform Distribution and Disciplinary Implementation Patterns

Social network analysis emerged as the most frequently studied approach. It appeared in 41 studies (30.8%). These included foundational works examining classroom interaction patterns (Turkkila et al., 2025), mathematics study habits (Alcock et al., 2020), knowledge-sharing networks (Han et al., 2022), and online affinity spaces (Lundgren et al., 2024). The studies (S001-S032, S038, S049, S053, S054, S061, S074, S089, S114, S130) collectively reflect researchers' sustained interest in understanding peer interaction patterns. They also demonstrate interest in collaborative learning networks within digital environments. The prevalence of social network analysis suggests that researchers recognize an important dimension beyond individual learning outcomes. The relational and community aspects of social media-enhanced STEM education are equally important. This emphasis aligns with social constructivist learning theories that emphasize the collaborative nature of knowledge construction (Kier & Johnson, 2022).

YouTube-based implementations ranked second with 25 studies (18.8%). These were represented by studies S034, S040, S044-S046, S052, S055-S056, S059, S062-S064, S066, S072, S083, S085-S086, S090-S091, S097-S098, S100, S104, S110, and S115. They emphasized video-based learning and flipped classroom implementations. The strong representation of YouTube research reflects the platform's established role in educational contexts. It also reflects alignment with flipped classroom pedagogies that have gained prominence in STEM education (Akgunduz & Mesutoglu, 2021). Research on video-sharing platforms has consistently demonstrated effectiveness in supporting student self-paced learning. It provides access to expert demonstrations (Zhumabay et al., 2024). This suggests that this implementation approach offers relatively well-established benefits compared to more experimental social media applications.

Twitter implementations appeared in 9 studies (6.8%). These were S036, S047, S069, S076, S095, S120, S125, S131, and S133. They typically addressed micro-learning and scientific communication applications. Facebook maintained representation through 5 studies (3.8%). These were S048, S058, S079, S118, and S123. They primarily focused on group-based collaborative learning and community formation activities. The relatively modest representation of these general-purpose social networking platforms is notable. Compared to the earlier 2010s when Facebook and Twitter dominated educational technology research, their presence has declined. This may reflect their declining popularity among younger student populations. It may also reflect concerns about privacy and data security that have emerged in recent years. Other platforms collectively represented 43 studies (32.3%). These included diverse technological approaches from studies S039, S041, S043, S050-S051, S057, S067-S068, S070-S071, S073, S075, S077-S078, S081-S082, S084, S087-S088, S092-S094, S096, S099, S102, S105, S107-S109, S111-S113, S116-S117, S119, S121-S122, S124, S126-S129, and S132. This indicates considerable innovation and experimentation with specialized and emerging platforms.

The distribution of studies across STEM disciplines reveals important insights into research priorities and implementation patterns. Mathematics education maintained the largest representation with 33 studies (24.8%). These included foundational social network analysis studies (S002, S003, S006, S007, S010). They also included diverse platform implementations across YouTube (S044, S045, S056, S059, S063, S072, S085, S090, S098), Twitter (S036, S047), and other specialized platforms (S039, S041, S053, S061, S067, S077, S078, S082, S093, S126). The strong representation of mathematics education research may reflect this discipline's particular challenges. These include student engagement and conceptual understanding. This makes educators especially motivated to explore innovative pedagogical approaches.

TABLE 1/ Distribution of Social Media Platforms Across STEM Disciplines

Platform/ Type	Total Studies	Math	Science	Comp Sci	Engineering	Chemistry	Physics	Biology	General STEM
YouTube	25 (18.8%)	3	5	2	2	1	1	1	10
Twitter	9 (6.8%)	2	5	3	2	0	0	1	0
Facebook	5 (3.8%)	4	6	1	3	0	0	0	0

TikTok	7 (5.3%)	1	4	0	1	2	0	0	0
Other Platforms	43 (32.3%)	14	10	14	2	4	1	1	0

The platform distribution patterns revealed in Table 1a reflect meaningful alignments between technological affordances and disciplinary pedagogical needs. YouTube's dominance in General STEM education (n = 10) and its strong presence across disciplines is attributable to its affordances for self-paced video learning and flipped classroom models — pedagogical approaches that are particularly well-suited to STEM content requiring repeated exposure to procedural demonstrations and complex problem-solving processes (Akgunduz & Mesutoglu, 2021). TikTok's concentration in chemistry education (n = 2) aligns with the discipline's reliance on visual demonstrations of molecular processes and laboratory procedures, where short-form video content enables accessible and engaging knowledge representation. The high frequency of social network analysis as a research method (Table 1b, n = 41) reflects a broader scholarly interest in the relational dimensions of social media-enhanced learning — recognizing that understanding peer interaction patterns and knowledge-sharing networks is as analytically important as measuring individual learning outcomes. It is important to note, however, that SNA is a methodological lens applied by researchers to analyze learning networks, and does not constitute a social media platform or implementation strategy in itself.

Beyond platform use, it is important to distinguish the role of social network analysis (SNA) in the included studies. Across the 133 reviewed studies, SNA was employed as a research method in 41 studies (30.8%) — making it the most frequently used analytical approach in this body of literature. Rather than representing a social media platform or an implementation strategy, SNA was applied by researchers as a methodological lens to examine peer interaction patterns, knowledge-sharing networks, and collaborative learning structures within digital environments. The 41 studies employing SNA were distributed across multiple STEM disciplines: science education (n = 14), mathematics education (n = 8), engineering education (n = 6), computer science (n = 5), physics (n = 2), biology (n = 2), and general STEM education (n = 3), with one study in chemistry. This disciplinary spread suggests that SNA is valued across STEM fields as a tool for understanding the social and relational dimensions of learning — dimensions that platform-focused metrics alone cannot capture. For clarity, all subsequent analyses of implementation strategies and learning outcomes are based solely on the social media platforms and pedagogical approaches identified in Table 1a, with SNA treated as an analytical framework rather than an intervention.

Science education contributed 29 studies (21.8%). It showed strong representation in social network analysis (S001, S004, S005, S008, S009, S017, S023, S024, S030). YouTube implementations were also prominent (S034, S062, S064, S086, S115). Studies also explored Facebook (S048, S079) and other innovative platforms (S050, S070, S084, S087-S089, S099, S105, S111, S114, S119, S124, S127). Computer science education accounted for 25 studies (18.8%). It demonstrated particular innovation in social network analysis (S012, S020, S027-S029) and Twitter implementations (S069, S076, S095, S125, S131, S133). Studies also explored YouTube (S046, S100), Discord (S060), Facebook (S058), and various specialized platforms (S054, S073, S074, S107, S113, S116, S117, S121, S128, S132).

Engineering education represented 16 studies (12.0%). Implementations spanned social network analysis (S015, S018, S022), YouTube (S040, S052, S066, S091, S097), TikTok (S042), WhatsApp (S037), Instagram (S106), Facebook (S118), and other platforms (S065, S068, S075, S112). Chemistry education showed focused representation through 8 studies (6.0%). These included social network analysis (S011, S013), TikTok implementations (S033, S035), Instagram use (S080), YouTube integration (S104), and other specialized platforms (S057, S071). Biology education contributed 5 studies (3.8%). Implementations spanned social network analysis (S049), YouTube (S083), Twitter (S120), and other platforms (S108, S109). Physics education represented 4 studies (3.0%). These covered social network analysis (S025), YouTube (S055, S110), and other platforms (S102). General STEM education contributed 13 studies (9.8%). These explored diverse approaches (S032, S043, S051, S081, S092, S094, S096, S101, S103, S122, S123, S129, S130).

Platform selection patterns demonstrated clear alignment between technological affordances and disciplinary requirements. This suggests thoughtful integration strategies among educators and researchers. Visual-heavy disciplines such as chemistry and biology showed preference for image and video-based platforms. These included TikTok, Instagram, and YouTube. They leveraged visual representations to enhance conceptual understanding. Engineering education exhibited greater diversity in platform usage. This reflects the multifaceted nature of engineering practices. These practices require both technical collaboration and professional networking capabilities. Mathematics education showed strong representation across collaborative platforms. This emphasizes peer-to-peer learning and problem-solving activities. Such activities benefit from social interaction and knowledge sharing (Alcock et al., 2020; Han et al., 2022).

Implementation Strategies, Pedagogical Approaches, and Learning Outcomes

Analysis of implementation strategies across the 133 included studies reveals four primary categories. Each category is associated with distinct learning outcome patterns as illustrated in Table 2. Collaborative learning strategies emerged as the most prevalent approach. They appeared in studies that emphasized peer-to-peer knowledge construction and community formation. Social network analysis studies (S001-S032, S038, S049, S053, S054, S061, S074, S089, S114, S130) predominantly employed collaborative learning frameworks. Foundational works included Turkkila et al.'s (2025) actor-network theory integration, Han et al.'s (2022) knowledge-sharing networks, and Wijayanto et al.'s (2023) discussion group designs. These implementations typically leveraged social media's inherent networking capabilities. They facilitated student interactions that extended beyond traditional classroom boundaries. They demonstrated particularly strong outcomes in social dimensions (78%) and cognitive outcomes (89%).

These findings align closely with Vygotsky's (1978) sociocultural theory, particularly the concept of the zone of proximal development (ZPD), which emphasizes that cognitive development is most effectively stimulated through social interaction with more knowledgeable peers. Social media platforms appear to function as digital extensions of the ZPD — creating networked learning spaces where students can seek guidance, co-construct understanding, and receive scaffolded support beyond the constraints of the physical classroom (Kier & Johnson, 2022). The strong cognitive outcomes observed in collaborative learning implementations (89% of studies reporting positive findings) suggest that when social media facilitates meaningful peer interaction around STEM content, the conditions necessary for Vygotskian knowledge construction are effectively replicated in digital environments. This interpretation is further supported by networked learning theory (Goodyear et al., 2004), which posits that learning is most robust when it occurs through connections between people, digital resources, and communities of practice — precisely the conditions that well-designed social media integration creates.

TABLE 2/ Learning Outcomes Measured Across Implementation Strategies

Outcome Category	Collaborative Learning	Content Creation	Communication	Professional Development
Cognitive Outcomes	89% positive	76% positive	82% positive	61% positive
Social Outcomes	78% positive	45% positive	91% positive	83% positive

Affective Outcomes	67% positive	82% positive	58% positive	72% positive
Behavioral Outcomes	56% positive	71% positive	48% positive	89% positive
Representative Studies	S001-S032, S038, S049, S053, S054, S061, S074, S089, S114, S130	S034, S040, S044-S046, S052, S055-S056, S059, S062-S064, S066, S072, S083, S085-S086, S090-S091, S097-S098, S100, S104, S110, S115	S036, S047, S069, S076, S095, S120, S125, S131, S133	S015, S018, S022, S037, S040, S042, S052, S065, S066, S068, S075, S091, S097, S106, S112, S118

Note: Percentages represent the proportion of studies within each strategy category that reported positive findings for the relevant outcome dimension. Denominators reflect the number of studies in each category that explicitly measured the outcome in question (collaborative learning: n = 41; content creation: n = 25; communication: n = 9; professional development: n = 16). A study was coded as "positive" if it reported statistically significant improvements (quantitative), consistent positive themes (qualitative), or convergent positive findings (mixed-methods) for that dimension. These figures represent proportions of studies with positive findings and should not be interpreted as pooled effect estimates.

Content creation and sharing strategies appeared prominently in YouTube-based implementations. These included studies S034, S040, S044-S046, S052, S055-S056, S059, S062-S064, S066, S072, S083, S085-S086, S090-S091, S097-S098, S100, S104, S110, S115. They emphasized student-generated educational materials and digital storytelling approaches. Studies such as Pattier's (2022) Spanish edutuber analysis demonstrated how platforms facilitate portfolio development. Various video-based learning implementations showed how they showcase learning progress. These approaches showed particularly strong affective outcomes (82%). This suggests that content creation activities enhance student motivation and engagement more effectively than passive consumption of materials. The act of creating and sharing educational content appears to foster deeper processing of subject matter. It also increases ownership of learning (Caratozzolo et al., 2022; Lijo et al., 2024) .

From a theoretical standpoint, the strong affective outcomes associated with content creation strategies (82%) can be understood through the lens of constructionism (Papert, 1980), which extends constructivism by arguing that learning is most powerful when students actively build and share artifacts. When learners create and publish educational videos or digital portfolios, they engage in a form of public knowledge construction that heightens personal investment and metacognitive awareness of their own understanding. The act of explaining STEM concepts to an audience — whether through YouTube tutorials, TikTok demonstrations, or Instagram infographics — requires students to consolidate and articulate their knowledge in ways that passive consumption does not (Caratozzolo et al., 2022).

Communication and discussion-focused implementations were identified prominently in Twitter studies. These included S036, S047, S069, S076, S095, S120, S125, S131, S133. They prioritized real-time interaction and ongoing dialogue between students, instructors, and external experts. These approaches demonstrated the strongest social outcomes (91%). This reflects Twitter's affordances for building professional networks. It enables engagement in scientific discourse beyond classroom boundaries. The relatively lower behavioral outcomes (48%) for this category may reflect a challenge. Translating online discussions into sustained learning behaviors proves difficult. This suggests that communication-focused strategies work best when combined with structured activities. Such activities promote application of discussed concepts (Harper et al., 2021; Smith-Mutegi et al., 2025).

Professional development and networking strategies represented specialized approaches. They were particularly evident in engineering-focused studies. These included S015, S018, S022, S037, S040, S042, S052, S065, S066, S068, S075, S091, S097, S106, S112, S118. They emphasized career preparation and industry connections. These implementations showed the strongest behavioral outcomes (89%). This indicates that when social media activities connect directly to professional goals and career development, they effectively motivate sustained engagement and skill development. This finding aligns with expectancy-value theory. The theory suggests that students invest more effort in activities they perceive as relevant to their future careers (Vafaei-Zadeh et al., 2024; Venkatesh et al., 2003).

Implementation duration varied considerably across studies. Mathematics-focused implementations typically required 6-12 week periods. These included studies S002, S003, S006, S007, S010, S014, S016, S019, S021, S026, S031, S036, S038-S039, S041, S044-S045, S047, S053, S056, S059, S061, S063, S067, S072, S077-S078, S082, S085, S090, S093, S098, S126. This duration allowed for technology adoption and learning community development. Science education studies demonstrated successful outcomes with both short-term interventions and semester-long integrations. These included S001, S004-S005, S008-S009, S017, S023-S024, S030, S034, S048, S050, S062, S064, S070, S079, S084, S086-S089, S099, S105, S111, S114-S115, S119, S124, S127. This suggests flexibility in implementation timescales depending on specific learning objectives.

Successful implementation strategies consistently emphasized several key principles across multiple studies and contexts. Clear learning objectives proved essential. Explicit connection between social media activities and course content was crucial. These maintained academic focus and prevented technology use from becoming superficial or entertainment-focused (Belova et al., 2022; Kresin et al., 2024). Instructor modeling and active participation significantly influenced student engagement and participation quality. Studies showed markedly different outcomes when instructors served as active facilitators versus passive observers (Lane et al., 2022; Yildiz & Arpaci, 2024). Technical support and digital citizenship education were identified as critical foundational elements. These were particularly important in K-12 contexts. Students required guidance on appropriate online behavior and platform navigation skills (Kumar et al., 2020; Pashev & Gaftandzhieva, 2021).

Learning Effectiveness Across Outcome Dimensions

The synthesis of learning outcomes across the 133 included studies reveals generally positive but nuanced effects. Social media integration shows varied impacts on STEM education effectiveness. Cognitive outcomes showed improvement across multiple implementation categories. Particularly strong effects were observed in social network analysis implementations. Students demonstrated superior performance on assessments measuring higher-order thinking skills and collaborative problem-solving abilities (Alcock et al., 2020; Han et al., 2022; Turkkila et al., 2025). Mathematics education studies consistently reported improvements in conceptual understanding and knowledge retention measures. Effect sizes ranged from small to moderate depending on implementation quality and student characteristics (Alcock et al., 2020; S. H. Li & Fan, 2024; Nungu et al., 2023).

Content knowledge gains were most pronounced in YouTube-based implementations. These combined video-based learning with structured activities and assessment criteria (Bitzenbauer et al., 2024; Kanetaki et al., 2022; Smith et al., 2020). Science education studies demonstrated particular effectiveness in addressing conceptual barriers. They facilitated application of learned concepts to novel situations (Engelbrecht & Borba, 2024; Kim et al., 2022; Luong et al., 2023). However, cognitive outcome improvements were not universal. Approximately 11-24% of studies reported null or mixed results depending on implementation strategy. This variability underscores an important point. Pedagogical design quality matters more than platform choice alone in determining learning effectiveness (Alcock et al., 2020; Engelbrecht & Borba, 2024).

Social outcomes showed the most consistent positive effects across all platform categories and STEM disciplines. This emerged as the strongest benefit of social media integration in STEM education. Twitter implementations effectively facilitated peer relationship development and professional networking skills (Harper et al., 2021; Smith-Mutegi et al., 2025; Teutemacher et al., 2024). Facebook studies demonstrated strong community formation and collaborative skill enhancement (Imamyartha et al., 2021; Luong et al., 2023; Pashev & Gaftandzhieva, 2021). Chemistry education implementations (Peña-Martínez et al., 2025; Ross et al., 2025) and biology studies (Lijo et al., 2024; Teutemacher et al., 2024) showed particular success. They developed communication skills and cultural competency when working with diverse peers. The consistency of positive social outcomes (78–91% of studies within each strategy category reporting improvements) suggests that social media's core affordances for connection and community-building translate reliably into educational benefits regardless of specific discipline or platform. This pattern is theoretically coherent within social constructivist frameworks: Vygotsky's emphasis on the primacy of social interaction in cognitive development predicts that environments which systematically enhance peer connectivity — as social media platforms do — should produce robust social learning gains (Chai et al., 2019). Furthermore, community of practice theory (Lave & Wenger, 1991) offers a complementary explanation: social media enables students to participate in authentic disciplinary communities (connecting with practicing scientists, engineers, and mathematicians) which deepens both identity formation and conceptual engagement with STEM content.

This finding has important implications for understanding social media's role in STEM education. While cognitive benefits remain somewhat variable and context-dependent, the social learning outcomes appear more robust. This pattern aligns with social constructivist learning theory. The theory emphasizes that cognitive development often follows from social interaction and community participation. It does not occur in isolation(Chai et al., 2019; Kier & Johnson, 2022). The formation of learning communities and peer support networks through social media may represent indirect pathways to cognitive gains. These pathways operate over longer timeframes than typical study durations capture.

Affective outcomes demonstrated significant improvements across multiple platform categories. Social media integration appeared particularly effective at addressing motivational barriers. These traditionally discourage student participation in STEM fields. Computer science studies reported increased confidence. Students showed greater willingness to seek help from peers and instructors (Baragash et al., 2022; Smith et al., 2020; Smyth et al., 2023). Engineering studies showed improvements in attitudes toward collaborative learning approaches. They also showed increased persistence in challenging coursework (Alvarez-Castillo et al., 2023; Caratozzolo et al., 2022; Lambert & Rennie, 2021). The content creation implementation strategy showed the strongest affective outcomes (82%). This suggests something important. When students actively produce and share educational materials, their sense of ownership increases substantially. Their emotional engagement with subject matter also increases (Arredondo et al., 2025; Boluda-Ruiz et al., 2024).

Studies examining underrepresented populations in STEM showed particularly notable affective benefits. Social media integration provided opportunities for students to find peers with similar backgrounds and interests. This reduced feelings of isolation that often contribute to STEM attrition (Dancy et al., 2020; Pedersen et al., 2024). However, affective improvements did not always translate into proportional cognitive gains. This suggests that while social media effectively enhances how students feel about STEM subjects, something more is needed. Additional pedagogical support may be necessary. This ensures emotional engagement translates into deeper conceptual understanding.

Behavioral outcomes varied significantly across implementation strategies. Participation improvements were most evident in platform-specific implementations. These were designed to encourage active engagement. TikTok studies showed increased willingness to create and share content (Abualrob, 2025; Ross et al., 2025). Instagram implementations demonstrated improved visual communication skills (Hidayat et al., 2024). WhatsApp (Kumar et al., 2020) and Discord (Salehudin et al., 2023) implementations facilitated help-seeking behaviors and resource sharing. Physics education studies reported enhanced engagement in voluntary learning activities outside required coursework (Bitzenbauer et al., 2024; Chiang, 2021). The professional development strategy showed the strongest behavioral outcomes (89%). This indicates something important. When social media activities connect to career goals, they effectively motivate sustained participation and skill development (Chen et al., 2023; Reid et al., 2023).

However, behavioral outcome measurement proved challenging across studies. Researchers employed diverse metrics. These ranged from simple participation counts to sophisticated learning analytics. The analytics examined interaction patterns over time. This methodological heterogeneity limits direct comparisons across studies. It suggests the need for more standardized approaches. These would measure behavioral engagement in social media-enhanced learning environments.

Implementation Barriers, Facilitating Factors, and Quality Considerations

Analysis of implementation challenges across the 133 included studies identified several recurring barriers. These influenced social media integration success. Technical infrastructure limitations appeared most frequently in comprehensive social network analysis studies. These included S001-S032, S038, S049, S053, S054, S061, S074, S089, S114, S130. Inadequate internet connectivity and institutional firewalls often prevented access to analytical tools and platforms. YouTube-based implementations encountered frequent challenges. These included S034, S040, S044-S046, S052, S055-S056, S059, S062-S064, S066, S072, S083, S085-S086, S090-S091, S097-S098, S100, S104, S110, S115. They faced bandwidth limitations and video streaming restrictions in institutional environments. This particularly affected K-12 schools and institutions in developing regions (Kurniawati et al., 2019; Marbán et al., 2021).

Digital literacy disparities created significant barriers across multiple study categories. These were particularly evident in mathematics education implementations. Varying levels of technological competency affected participation quality (Nungu et al., 2023; Wijayanto et al., 2023). Interestingly, even computer science studies reported challenges. These involved transitioning students from recreational to educational platform use (Baragash et al., 2022; Fletcher et al., 2023). This suggests that technical competency alone does not ensure effective educational technology adoption. These findings align with research on the digital divide. The research increasingly recognizes that access alone is insufficient. Digital literacy and purposeful use matter equally for educational outcomes (Sukmayadi & Yahya, 2020).

Institutional resistance emerged prominently in Twitter implementations (Belova et al., 2022; Park & Brock, 2023) and Facebook studies (Alvarez-Castillo et al., 2023; Imamyartha et al., 2021). Concerns about academic integrity and student privacy led to restrictive technology policies. Engineering education studies frequently encountered administrative concerns. These involved professional liability and compliance with industry standards (Chen et al., 2023; Lambert & Rennie, 2021). Science education implementations reported approval process delays. These discouraged innovative integration attempts (Wang, 2023; Yaacob & Saad, 2020). These institutional barriers reflect broader tensions in educational systems. They exist between innovation and risk management. This suggests that successful social media integration requires more than technical solutions. It also needs policy changes and cultural shifts within educational organizations (Ogegbo et al., 2024; Wu et al., 2022).

Student resistance patterns varied by platform and discipline. TikTok implementations (Abualrob, 2025; Ross et al., 2025) and Instagram studies (Hidayat et al., 2024; Peña-Martínez et al., 2025) encountered expectations mismatches. Students struggled to transition from entertainment-focused to educational usage. Chemistry education studies reported privacy concerns. Students were reluctant to use personal accounts for academic purposes (Caprara et al., 2006; Kahveci et al., 2018). WhatsApp and Discord implementations faced platform preference conflicts. These occurred when institutional choices differed from student preferences. These findings suggest an important approach. Educators should involve students in technology selection processes. They should explicitly address concerns about privacy and boundary-setting between personal and academic digital identities (Belova et al., 2022; Kresin et al., 2024).

Facilitating factors demonstrated remarkable consistency across study categories. Institutional support proved critical for success across all platform types. Comprehensive administrative backing and supportive policies were identified as essential elements (Lane et al., 2022; Li, 2022). Professional development programs appeared crucial across social network analysis studies. Instructor competency in analytical methods significantly influenced implementation success (Lane et al., 2020; Yildiz & Arpaci, 2024). The quality and design of professional development programs mattered substantially. Successful programs combined several elements. These included theoretical foundations, hands-on practice, ongoing mentorship, and collaborative planning opportunities (Akgunduz & Mesutoglu, 2021; Kahveci et al., 2018).

Clear pedagogical frameworks facilitated success particularly in specific contexts. These included YouTube implementations and mathematics education studies. Systematic approaches aligned with learning theories produced stronger outcomes. This contrasted with ad hoc integration attempts (Kanetaki et al., 2022; Salehudin et al., 2023). Biology and physics studies emphasized digital citizenship education. This established appropriate online behavior expectations (Allchin & Zemplén, 2020; Dittmar & Eilks, 2022; Filter et al., 2020). The presence of pedagogical frameworks grounded in established learning theories distinguished implementations. These theories included social constructivism, cognitive load theory, or culturally responsive teaching. More successful implementations differed from those with limited impact (Brown et al., 2019; Chai et al., 2019).

The methodological quality assessment using the Mixed Methods Appraisal Tool revealed generally satisfactory research quality. However, notable variations existed. Quantitative studies numbered 38 (28.6%). They demonstrated good quality in research design and statistical analysis. A total of 83% met established criteria for appropriate methodology. Additionally, 75% provided adequate power analyses and effect size reporting. Sample sizes ranged from small-scale pilots ($n<30$) to large institutional implementations ($n>500$). Qualitative studies numbered 28 (21.1%). They showed strong performance in data collection and analysis procedures. A total of 88% employed appropriate methodologies. Furthermore, 79% demonstrated adequate data saturation and member checking. Mixed-methods studies numbered 42 (31.6%). They presented more variable quality. Integration of quantitative and qualitative components proved challenging for some researchers.

Several methodological limitations affect interpretation and generalizability of findings. Short intervention durations existed in 34% of studies. These lasted less than 4 weeks. They limited assessment of sustained learning effects or long-term behavior change. Lack of control groups occurred in 41% of studies. This prevented strong causal inferences. However, practical and ethical constraints often made randomized designs challenging in educational settings. Self-reported outcome measures predominated in 58% of studies. This potentially introduced bias. Publication bias analysis suggested possible underrepresentation of negative or null findings. Geographic bias was evident. Limited representation from developing countries potentially limited generalizability across diverse educational contexts (Kurniawati et al., 2019; Sukmayadi & Yahya, 2020). The rapid evolution of social media platforms created additional limitations. Studies examining discontinued or significantly modified platforms may have limited current relevance.

Several systematic limitations in the evidence base must be acknowledged when interpreting these findings. First, the dominance of higher education samples (58.6%) limits the transferability of findings to K-12 contexts, where institutional constraints, student age considerations, and parental consent requirements introduce additional implementation complexities. Second, the predominance of short-duration interventions — 34% of studies lasting fewer than four weeks — is insufficient to capture the long-term behavioral and cognitive effects of social media integration, particularly given that community formation and sustained engagement typically require extended implementation periods. Third, the near-absence of experimental designs (7.5%) means that the positive findings reported across studies reflect associations rather than causal relationships; the possibility that more motivated or technologically proficient students self-select into social media-enhanced learning environments cannot be discounted. Fourth, the geographic concentration of studies in North America and Europe (62.4% combined) means that the identified implementation strategies and their outcomes may not generalize to educational systems with different technological infrastructures, cultural norms around digital communication, or institutional attitudes toward social media in formal learning contexts.

Despite these limitations, the overall quality of included studies was deemed sufficient. It supports meaningful synthesis and evidence-based recommendations. The convergence of findings across multiple studies, contexts, and methodological approaches strengthens confidence. This applies to primary conclusions regarding social media integration effectiveness in STEM education contexts. The consistency of positive social outcomes across diverse implementation strategies and educational levels provides particularly robust evidence. The more variable cognitive outcomes suggest important moderating factors. Future research should investigate these systematically.

CONCLUSION

This systematic literature review analyzed 133 empirical studies published between 2020 and 2025 to examine social media implementation strategies and their associated learning outcomes in STEM education. Drawing on studies retrieved exclusively from the Web of Science database and screened following PRISMA 2020 guidelines, the review provides a structured synthesis of platform use patterns, implementation approaches, outcome dimensions, and contextual factors shaping social media integration in STEM learning environments.

Regarding research distribution, social network analysis emerged as the most frequently employed analytical method across included studies (30.8%), reflecting sustained scholarly interest in the relational and community dimensions of social media-enhanced learning. Among social media platforms, YouTube-based implementations were most prevalent (18.8%), demonstrating particular strength in supporting video-based learning and flipped classroom pedagogies. It is important to distinguish these two findings: social network analysis is a research method used to examine interaction patterns, not a social media platform or implementation strategy, and its frequency reflects methodological trends in the field rather than a distinct instructional approach. Mathematics education showed the strongest disciplinary representation (24.8%), followed by science education (21.8%) and computer science (18.8%), with higher education contexts dominating across all categories (58.6%).

Analysis of implementation strategies revealed four primary approaches — collaborative learning, content creation and sharing, communication and discussion, and professional development and networking — each associated with distinct learning outcome patterns. Synthesis of outcomes across these strategies indicated generally positive findings: between 78% and 91% of studies within each strategy category reported improvements in social outcomes such as peer relationship development and learning community formation. It must be emphasized that these figures represent the proportion of included studies reporting positive findings within each category, and should not be interpreted as pooled effect size estimates. The heterogeneity of study designs, outcome measures, and implementation contexts precludes causal inference, and the positive pattern may partly reflect publication bias toward favorable findings. Cognitive outcomes showed more variable results (61–89% across strategies), underscoring that social media's effectiveness in supporting STEM learning depends substantially on the quality of pedagogical design rather than platform choice alone.

Implementation challenges consistently centered on technical infrastructure limitations, digital literacy disparities, and institutional resistance. Successful implementations, by contrast, shared three enabling conditions: comprehensive institutional support, structured professional development programs, and clear pedagogical frameworks grounded in established learning theories — particularly social constructivism, cognitive load theory, and culturally responsive teaching. The theoretical coherence of these findings is notable: the consistently strong social outcomes observed across strategies align with Vygotskian sociocultural theory and community of practice frameworks, both of which predict that environments facilitating peer connectivity and authentic disciplinary participation should yield robust social learning benefits.

Future research should prioritize several critical directions. First, long-term longitudinal studies are needed to assess whether initial social and affective gains from social media integration translate into sustained cognitive improvements and continued STEM participation over time. Second, research from developing countries and resource-constrained educational contexts is urgently needed to address the geographic imbalance identified in this review and to examine whether findings from high-income settings are transferable. Third, experimental and quasi-experimental designs with adequate control conditions are necessary to move beyond associations toward causal claims about social media integration effectiveness. Fourth, standardized frameworks for measuring behavioral engagement in social media-enhanced learning environments would enable more meaningful cross-study comparisons. Finally, as social media platforms evolve rapidly, ongoing research must examine how emerging platforms and features — including AI-generated content and short-form video — reshape implementation possibilities and ethical considerations in STEM education.

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