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Academic-Related Social Media Use and Academic Achievement Among STEM Pre-Service Teachers at a Ghanaian Public University: The Mediating Roles of Collaborative Learning Engagement and Cognitive Load

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Abstract: The increasing integration of social media into higher education has generated interest in its educational potential. However, the mechanisms through which academic-related social media use influences students' academic achievement remain insufficiently understood, particularly in STEM teacher education in developing countries. This study examined the direct and indirect effects of academic-related social media use on the academic achievement of STEM pre-service teachers at a Ghanaian public university, with collaborative learning engagement and cognitive load as mediators. Guided by social constructivist and cognitive load theories, this study employed a quantitative cross-sectional survey design involving 414 STEM pre-service teachers selected through purposive sampling method. Data were analyzed using descriptive statistics and Hayes' PROCESS macro (Model 4) with 5,000 bootstrap samples to test the direct and indirect relationships between the variables. The findings revealed that academic-related social media use had a significant positive direct effect on academic achievement (B = 0.151, p < .001) and significantly predicted collaborative learning engagement (B = 0.627, p < .001) and cognitive load (B = 0.314, p < .001). Collaborative learning engagement (B = 0.233, p < .001) and cognitive load (B = 0.334, p < .001) also significantly predicted students' academic achievement. Furthermore, collaborative learning engagement (indirect effect = 0.146, 95% CI [0.074, 0.223]) and cognitive load (indirect effect = 0.105, 95% CI [0.070, 0.141]) partially mediated the relationship between the use of social media for academic purposes and academic achievement. The mediation models explained 32.2% and 42.6% of the variance in academic achievement, respectively. The study concludes that the educational benefits of academic-related social media arise through complementary social and cognitive learning processes rather than through technology use alone. By integrating Social Constructivist Theory and Cognitive Load Theory within a single explanatory framework, this study extends the current understanding of technology-enhanced learning and provides empirical evidence to support the pedagogically purposeful integration of academic-related social media into STEM teacher education in Ghana and comparable higher education contexts.

Keywords: *Academic-Related Social Media Usage, Academic Achievement, Collaborative Learning Engagement, Cognitive Load, STEM Pre-Service Teachers, Public University.*

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I. INTRODUCTION

➢ *Background of the Study*

Since early 2020, the COVID-19 pandemic has radically changed the functioning of all components of the global education system. This has changed the way learners access, process, and interact with information. In this context, the influence of social media has been the focus of much research in higher education. This is due to the unique ways in which social media technologies can stretch communication, aid the sharing and construction of information, and enhance the learning process (Lemoine et al., 2021; Shareef, 2025). Social media applications such as WhatsApp, Facebook, Telegram, YouTube, and X (formerly Twitter) have transcended their social and entertainment origins. These platforms are increasingly being adopted by educators to support student learning beyond the classroom. Consequently, social media has become an integral part of the academic and social lives of students in higher learning (Piven et al., 2018; Singh, 2018).

In Ghana, the COVID-19 pandemic accelerated the adoption of digital learning in public universities (Aboagye et al., 2021). While studies have examined the direct effects of social media on achievement (Liu et al., 2022), few have investigated dual mediation pathways integrating social and cognitive mechanisms (Hameed et al., 2022), and none have focused specifically on STEM pre-service teachers in sub-Saharan African contexts. Academic-related social media use describes the use of social media for learning purposes, such as accessing learning materials, participating in learning-related discussions, resource sharing, peer collaboration, and course-related assistance (Foster et al., 2016; Gupta, 2018). Evidence suggests that the use of social media for academic-related purposes, when incorporated appropriately, can enhance the learning process and construct and express a greater level of understanding within the social media platform, thus improving the overall learning experience (Roy, 2020).

It is crucial to train future teachers to include technology in teaching and learning frameworks. Given the changing dynamics of the teaching and learning environment, teachers are required to possess the knowledge and skills to use digital technologies in various teaching and learning situations. This is especially true for teaching STEM subjects, where the use of technology is often required for tools that mediate the processes of inquiry, experimentation, problem-solving, and understanding concepts (Milner-Bolotin, 2020; Triplett, 2023). Thus, it is important to use social media as a learning tool to understand how STEM education pre-service teachers engage in self-learning to inform the digital pedagogy framework in teacher-training programmes.

One of the main teaching and learning processes mediated by the use of academic-related social media is collaborative learning. Vygotsky (1978) argues that knowledge is collectively constructed. Through social media, learners can engage in asking and answering questions, exchanging ideas, discussing, and providing constructive feedback to each other. Such processes and interactions are important in STEM education, where problem-solving, explanation, and discussion are part of the processes that culminate in understanding and conceptualizing knowledge. Social media use for academic purposes may affect learning through the processing challenges that accompany digital-learning environments. According to the Cognitive Load Theory, the effectiveness of learning is driven by the psychological trade-offs made by learners when information is taught (Sweller et al., 2019).

Digital learning environments often require learners to interact with multiple information sources, modes of social interaction, and academic resources, culminating in increased psychological demands. While excessive and irrelevant information may create unnecessary cognitive demands, engaged academic information may create conditions for knowledge construction and deeper learning processing. Therefore, the educational consequences of academic-related social media may not be a function of technology availability but rather of how learners interact with digital technology and the challenges of cognitive trade-offs in learn

ing.

Although there is a growing body of literature on the use of social media for educational purposes, the relationship between academic social media use and academic performance remains poorly defined. Some studies have noted the positive implications of academic-related social media use; however, others have found mixed results that are dependent on the context (Bedua et al., 2021; Riaz et al., 2023). These contradictory findings imply that the use of social media and academic performance may be indirectly connected through cognitive engagement and collaboration in construction efforts. For this reason, it is important that further stages of research concentrate on collaborative engagement and cognitive mechanisms of social media use when considering their implications for learning.

The availability of Internet services, combined with the increasing use of smartphones and digitalization in Ghana, has enabled students to use social media for academic purposes. Public universities have opted to use technology-based learning to equip their students to teach in digital environments (Adu-Marfo and Oheneba-Sakyi 2017; Kwaah 2024). However, the effects of using social media for academic purposes by STEM pre-service teachers have not been studied thoroughly. Most studies in Ghana have focused on the general population of university students and have focused very little on public universities, which are vital in preparing the future teaching workforce (Issah et al., 2025; Kwaah, 2024). In addition, few studies have combined the roles of collaborative learning engagement and cognitive processes in the context of academic social media use and academicachievement.

This research gap is critical because current STEM pre-service teachers are Ghana's first potential science and mathematics educators. Effectively using technology in teaching and learning transforms and enhances the quality of

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education and strengthens STEM education initiatives. Therefore, studying the use of social media in an educational context is important for teachers and educators in Ghana. Therefore, this study investigates the use of social media for educational and academic purposes, focusing on STEM pre-service teachers, and examines how collaborative learning and cognitive load, as learning factors, act as intermediaries within this context. This study is important because it attempts to understand the use of social media and the learning factors and cues it evokes within the scope of Ghanaian teacher education.

➢ *Problem Statement*

As social media becomes more integrated into the landscape of Higher Education, its impact on students' academic performance is coming into sharper focus. Higher Education students often use social media to source study materials and engage in collaborative study and discourse. Social media also provides an avenue for users to curate and disseminate study materials. However, learning in digital contexts means that students must learn to manage and make sense of multiple competing channels of academic engagement. As learning becomes increasingly cognitively demanding, the relationship between social media consumption and academic performance is likely to become more complex (Parveen et al., 2025). This complexity suggests that the impact of social media on academic performance is better understood by exploring social media consumption that takes place outside of social media. For instance, social media designed to support academic collaboration encourages the sharing of knowledge and social interaction and may affect the learning and information processing demands of the social media consumer in the context of collaboration. Research examining mediation pathways in STEM teacher education contexts remains limited, particularly in developing countries. Increased access to the Internet and the rise of digital learning have led to the proliferation of academic-related social media use among students in Ghana's public universities. Nevertheless, a gap remains in the educational literature regarding the use of social media for educational purposes among STEM pre-service teachers (Gupta, 2018; Asante, 2020). Additionally, many studies in public universities in Ghana focus on the relationship between academic-related social media use and academic achievement without considering the roles of collaborative learning engagement and cognitive load. This study attempts to fill this gap by examining the direct and indirect impacts of academic-related social media use on the academic achievement of STEM pre-service teachers at a public university in Ghana, considering the roles of collaborative learning engagement and cognitive load in the process.

➢ *Purpose of the Study*

This study examined the influence of academic-related social media use on academic achievement among STEM pre-service teachers in Ghanaian public universities. Specifically, this study sought to investigate the extent to which academic-related social media use predicts academic achievement and to determine whether collaborative learning engagement and cognitive load mediate this relationship.

➢ *Specific Objectives*

- To determine the direct effect of academic-related social media use on academic achievement among STEM pre-service teachers in Ghanaian public universities.
- To determine the effect of academic-related social media use on collaborative learning engagement among STEM pre-service teachers in Ghanaian public universities.
- To assess the effect of academic-related social media use on cognitive load among STEM pre-service teachers in Ghanaian publics universities.
- To investigate the mediating roles of collaborative learning engagement and cognitive load in the relationship between academic-related social media use and academic achievement among STEM pre-service teachers in Ghanaian public universities.

➢ *Research Hypotheses*

- H1: Academic-related social media use has a significant positive effect on the academic achievement of STEM pre-service teachers.
- H2: Academic-related social media use has a significant positive effect on collaborative learning engagement.
- H3: Academic-related social media use has a significant positive effect on cognitive load among STEM pre-service teachers.
- H4: Collaborative learning engagement significantly mediates the relationship between academic-related social media use and academic achievement.
- H5: Cognitive load significantly mediates the relationship between academic-related social media use and academic achievement.
- H6: Cognitive load has a direct significant positive effect on academic achievement.
- H7: Collaborative learning engagement has a direct significant effect on academic achievement.

II. LITERATURE REVIEW

The literature review provides the conceptual, theoretical, and empirical foundations for this study. The study begins with a conceptual framework illustrating the relationships among academic-related social media usage, collaborative learning engagement, cognitive load, and academic achievement. The review then discusses the theoretical foundations underpinning these relationships and concludes by synthesizing empirical evidence to justify the study and address the research objectives in the context of Ghanaian public universities.

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➢ *Conceptual Framework*

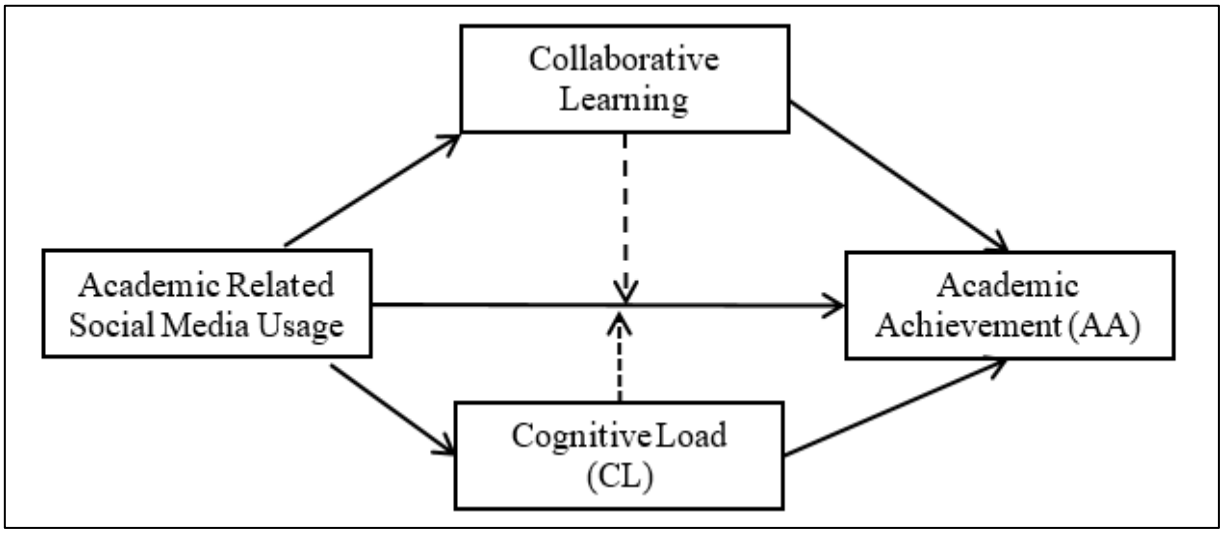


Fig 1 Conceptual Framework of the Study
Source: Author (2026)

This study examined how two pathways of learning impacted the achievement of STEM pre-service teachers and their use of educational social media. Two complementary pathways are proposed: a social pathway (via collaborative engagement) grounded in Social Constructivist Theory and a cognitive pathway (via cognitive load) grounded in Cognitive Load Theory. These pathways may operate independently of each other. The other perspective is that academic-related social media use (ARSMU) can promote achievement because of the mental 'pressure' of processing, organizing, and integrating information. This perspective considers the use of many academic-related social media platforms. To understand the mechanisms of social media-related learning outcomes in higher education, it is imperative to consider this perspective. The same is true for higher-education media applications. The burden is on the students; they must determine how social media can aid them in content cognition and cognitive load learning within a social media context.

The use of digital learning platforms in Ghanaian higher education has grown rapidly owing to the increased use of online and blended learning methods in recent years. Research conducted in Ghana indicates that tertiary-level students use digital platforms for communicating, gaining access to learning resources, interacting with colleagues, and maintaining academic engagement beyond the traditional classroom (Boateng, 2023; Amponsah *et al*., 2024). This is relevant for public universities, where pre-service teachers are expected to acquire the digital skills necessary for modern classrooms. Given that STEM education is based on the engagement and collaboration of numerous concepts, academic-related social media use may provide STEM pre-service teachers with a means to discuss challenging concepts and provide support (Onanuga & Saka, 2025).

The collaborative learning engagement (CLE) pathway illustrates the social and interactive components of learning. According to Lev Vygotsky (1978), learning is social and comes from interaction and dialogue, which leads to the co-construction of knowledge. Informal learning spaces may be provided by different platforms (e.g., WhatsApp, Telegram, Facebook, YouTube) where learners may initiate and participate in learning-related discussions, provide and/or answer requests for information, and assist each other in completing learning tasks. This is evident in the case of Ghana. Studies on Ghanaian higher education have shown that digital platforms cater to peer interactions, provide learning resources, and enable collaborative learning for students (Aboagye et al., 2021; Amponsah et al., 2022, 2024). However, the same studies reported that participants' digital skills and their ability to interact constructively with digital content were imperative for the achievement of enhanced learning, which has been largely unexamined in STEM teacher education (Adarkwah, 2021). Recent critiques suggest that Social Constructivist Theory may overestimate the automatic benefits of interaction in digital environments, where participation does not guarantee cognitive processing (Kirschner & De Bruyckere, 2017). Therefore, we hypothesize that collaborative engagement alone may be insufficient without accompanying cognitive effort and aim to fill this gap by examining academic-related social media and collaborative learning, as well as the collaborative learning frameworks used to understand the different social media platforms and their effects on learning. It may be argued that when employed intentionally and purposefully, academic social media use by STEM pre-service teachers may not only support collaborative learning, but may also yield beneficial academic results.

African studies also encourage the development of participatory learning pathways. Mtebe and Raisamo (2014), along with other South African studies, suggest that technology-enabled learning environments in East African countries enhance participants' involvement in the learning process. Upon reviewing South African Higher Education literature, Bon (2017), Jowi (2024), and Venter (2025) highlighted the importance of digital platforms in peer

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learning and structured learning activities. Existing studies from Africa mirror the international landscape that social media and technology-supported collaboration improve communication, participant engagement, knowledge articulation, and academic achievement (Sahoo & Khuntia, 2026). In the case of STEM, pre-service teachers developed their ideas best through collaborative social interactions. Scientific and mathematical ideas often emerge through the explanation of concepts, questioning, and discussion of ideas, as well as through interactions in collaborative processes of practice and problem solving.

Cognitive Load Theory relates learning to the limits of human working memory and the demands of learning on the learner (Sweller et al., 2019). It posits that the learning process involves the allocation of cognitive resources for the processing, organization, and integration of new information, where the effectiveness of learning is measured by the extent of cognitive resources devoted to these activities. Academic-related social media present learners with large amounts of information and multiple social interaction stimuli that, in terms of forum messages and academic-related interactions, are continuous and require a significant amount of cognitive effort to process and manage. Learning can be hindered by excessive and irrelevant information. Nevertheless, engaging with purposeful academic information can create cognitive demands and facilitate knowledge construction. Cognitive load (CL) are most apparent in online learning environments. Evidence also suggests that online learning environments can create cognitive load through the management of attention and interaction stimuli that are characteristic of online learning (Aboagye et al., 2021; Paulsen & McCormick, 2020). Adarkwah (2021) noted that while Ghanaian tertiary students had difficulty managing online learning, they appreciated its value of online learning. These cognitive demands are most relevant in STEM education, as learners are required to perform activities that demand the integration of concepts, abstract reasoning, and complex problem solving (Acheampong et al., 2025; Kammer et al., 2025). Therefore, the current study seeks to understand how academic-related social media can positively impact STEM pre-service teachers through the lens of cognitive load and the social constructivist theory.

This argument is pertinent in Africa, where various difficulties, such as inconsistent Internet, lack of digital devices, high costs for data, and disparities in digital skills, create unique problems for students engaging in learning with technology. Due to these conditions, students face additional demands to access, process, and engage with instructional content delivered through technology. This situation forces students to expend effort in dealing with technology and information problems in addition to the demands of academic tasks. In this context, the effect of academic-related social media on learning is not strictly positive or negative. It is more about how students use social media and how they think about the learning challenges posed technology. The impact of academic-related social media on academic performance is best explained by the challenges of thinking and the social media context within the collaborative learning framework, rather than traditional views of positive or negative impact.

This framework identifies the use of social media for academic purposes as an independent variable, academic achievement as a dependent variable, and collaborative learning engagement and cognitive load as mediating variables. This further suggests that the use of academic-related social media has the potential to indirectly impact academic achievement by promoting engagement in collaborative learning and creating cognitive stress in processing and assimilating academic content in digital learning environment. The framework offers a more sophisticated and complex understanding of the role that social media plays in learning when integrated into STEM disciplines for pre-service teachers in Ghanaian public universities. This framework adds to the existing body of work in educational technologies by arguing that the existing debate on the role of social media in educational contexts, whether positive or negative, should be transcended, and instead focus on how social media and related technologies impact the academic work of teacher-education.

➢ *Theoretical Review*

- *Social Constructivist Theory*

Vygotsky's (1978) Social Constructivist Theory posits that learning is a consequence of social participation and partnership. In contrast to the belief that learners passively absorb knowledge, Vygotsky's theory implies that learners construct knowledge through social engagement. Vygotsky believed that cognitive development is fostered through the interactions of learners and guides, which can be a teacher, peer, or any other individual with sufficient knowledge of the subject. These social partnerships stimulate learners and enable individuals to think, understand, and acquire new knowledge to a greater extent. One of the theory's fundamental aspects is the Zone of Proximal Development, which defines the gap between what the learner is able to do and what the learner is able to do with support. Guided participation in joint endeavors enables learners to perform tasks at a higher level. Based on this, Social Constructivist Theory focuses on the significance of active participation through communication and joint engagement in problem-solving.

This theory has gained importance in the current age because social media creates opportunities for interaction that go beyond the confines of traditional classroom settings. Applications such as WhatsApp, Telegram, Facebook, and YouTube allow learners to converse on different topics, post questions to receive feedback, exchange discussion materials, and work on assignments together. Social media has the potential to facilitate collaborative learning and learner engagement through its capacity to support interaction, communication, and information sharing among learners (Gupta *et al.*, 2024). Concerning this theory and the current age in Ghana, Agormedah *et al*. (2020) and Aboagye *et al.* (2021) show that digital media foster academic interaction and collaboration among tertiary students. This

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theory is important for STEM education because learning in STEM fields is centered on social inquiry, collaboration, teamwork, and critical problem-solving (Muhtaseb, 2019). Social media use for academic purposes allows STEM pre-service teachers to participate in academic interactions for collaborative learning, thus enhancing their social learning engagement and academic performance. Thus, it enhances social learning engagement. However, the theory suggests that interaction must be coupled with cognitive engagement and scaffolding to translate into achievement gains (Kirschner et al., 2006).

- *Cognitive Load Theory*

Cognitive Load Theory (CLT), developed by Sweller (1988), explains learning in relation to the limited processing capacity of working memory and the cognitive demands imposed by instructional activities. The theory maintains that effective learning depends on the extent to which available cognitive resources are allocated to processing, organising, and integrating information into long-term memory (Sweller et al., 2019). Traditionally, CLT distinguishes among intrinsic cognitive load, arising from the complexity and interactivity of learning materials; extraneous cognitive load, generated by unnecessary processing demands associated with instructional design; and germane cognitive load, historically associated with cognitive effort directed towards knowledge construction. However, contemporary formulations increasingly conceptualise germane processing as resources devoted to managing intrinsic load rather than as an entirely independent source of cognitive load (Sweller et al., 2019). Accordingly, the educational implications of cognitive load depend on the nature of the demands imposed on learners rather than their magnitude alone.

Within digitally mediated learning environments, academic-related social media use may influence cognitive load by exposing learners to multiple information sources, academic discussions, shared learning resources, and competing attentional demands. Although these interactions can facilitate access to instructional information, fragmented content, irrelevant notifications, and simultaneous communication may impose additional processing demands that compete with resources required for meaningful learning. This relationship is particularly relevant to STEM education, where understanding abstract concepts, integrating multiple representations, and solving complex problems require substantial working-memory resources. Consequently, academic-related social media use may be associated with cognitive demands that either support or constrain learning, depending on the relevance, organisation, and complexity of the information encountered.

CLT further suggests that the relationship between cognitive load and academic achievement is contingent on how cognitive resources are utilised. Whereas excessive extraneous load may interfere with comprehension and knowledge acquisition, cognitive resources directed towards relevant learning activities may facilitate conceptual understanding and academic performance. Applied to the present study, the theory provides a framework for examining cognitive load as a potential statistical mediator of the relationship between academic-related social media use and academic achievement among Ghanaian STEM pre-service teachers. Nevertheless, the direction and interpretation of this pathway depend on the dimensions of cognitive load captured by the measurement instrument. Thus, the proposed mediation relationship is theoretically plausible but should not be interpreted as evidence that increasing cognitive load necessarily enhances academic achievement, particularly given the cross-sectional nature of the study.

III. METHODOLOGY

➢ *Research Design*

This study used a quantitative cross-sectional survey model. This model was appropriate because it allowed the researcher to capture STEM pre-service teachers' data at one moment in time to analyze the presence and magnitude of the relationships between social media use for academic purposes, collaborative learning, cognitive load, and academic achievement. As cited in Creswell and Creswell (2018), cross-sectional surveys are useful for locating research in context and assessing the relationships among variables in the absence of total control over the study conditions.

➢ *Participants (Population, Sample, and Sampling Procedure)*

According to Creswell and Creswell (2018), a population includes all individuals from whom a sample can be drawn for a specific study. The total number of participants in the study was 414 pre-service STEM teachers. Participants were selected from a public university in the Greater Accra regions specifically selected for their enrollment of STEM pre-service teachers. A census approach targeted all 450 eligible second- and third-year STEM majors, yielding 414 participants (92% participation rate).

➢ *Instrumentation and Measures*

A structured online questionnaire was developed by adapting validated scales from prior research: academic-related social media use items from Cao and Hong (2011), collaborative learning engagement from So and Brush (2008), cognitive load from Leppink *et al*. (2013), and for example, Klepsch and Seufert (2020). The survey comprised five sections: The first section (demographics) collected information on gender, age, level, GPA and field of education. The second section (academic-related social media, seven items) included items such as '*I access social media for social media-related academic content*.' The third section (engagement in collaborative learning, seven items) included items such as '*Social media allows academic-related peer collaborations*.' The fourth section (cognitive load, seven items) included items such as, '*Social media's overwhelming content loads hinder my study focus*.' Academic achievement was measured using students' reported GPA. The items in the second, third, and fourth sections were measured using a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree).

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➢ *Data Collection Procedure*

The researcher obtained authorization from the selected public university, administered the surveys, briefed participants on the study, and obtained informed consent prior to survey completion. Questionnaires were administered to the STEM pre-service teachers during relevant teaching periods and were collected immediately after to achieve a high response rate and zero data omissions. The submitted questionnaires were checked for completeness and accuracy before data analysis.

➢ *Ethical Considerations*

Ethical considerations were followed in this study. Permission was subsequently secured from the head of the department of the participating university. The participants were briefed on the study, and informed consent was obtained before completing the survey. Participants were free to withdraw from the study with no consequences after participation. The surveys were designed to protect the participants' identities; therefore, no personally identifiable information was included, and the answers provided were used only for the study. This study espoused ethics of, among other things, respect for persons (participants), justice and beneficence (Creswell & Creswell, 2020).

➢ *Validity and Reliability*

Table 1 Reliability of the Measurement Model

	No. of Items	Cronbach's Alpha	Interpretation
Academic-Related Social Media Usage	7	.947	Excellent
Collaborative Learning Engagement	7	.924	Excellent
Cognitive Load	7	.794	Good

Source: Author (2026)

Cronbach's alpha coefficients were computed to assess the internal consistency of the study instrument. The findings revealed that the reliability coefficients ranged from .656-.947. Academic-related social media usage (α = .947) and collaborative learning engagement (α = .924) demonstrated excellent internal consistency, whereas cognitive load (α = .794) exhibited good reliability. These results indicate that the instrument possessed satisfactory internal consistency and was appropriate for subsequent descriptive, correlation, regression, and mediation analyses.

IV. RESULTS AND DISCUSSION

➢ *Results*

Table 2 Mediation Analysis of the Effect of ARSMU on AA Through CLE (PROCESS Model 4.0, N=414)

Path	Relationship	β	SE	T-value	P-value	95% CL	Decision
a (H2)	ARSMU → CLE	.627	.024	26.671	<.001	[.581, .673]	Fail to Reject H2
b (H7)	CLE → AA	.233	.048	4.902	<.001	[.140, .327]	Fail to Reject H7
c	Total Effect: ARSMU → AA	.297	.023	12.716	<.001	[.251, .343]	Supported
c^{l} (H1)	Direct Effect: ARSMU → AA (Controlling for CLE)	.151	.038	4.013	<.001	[.077, .224]	Fail to Reject H1
a×b (H4)	Indirect Effect through CLE (ARSMU → CLE → AA)	.146	.038+	—	—	[.074, .223]#	Fail to Reject H4

Source: Author (2026)

B = unstandardized regression coefficient; SE = standard error; CI = confidence interval; c = total effect; c′ = direct effect; a × b = indirect effect. †BootSE = bootstrap standard error based on 5,000 bootstrap samples. ‡The indirect effect is statistically significant because the 95% bootstrap confidence interval does not include zero.

A mediation analysis using Hayes' PROCESS macro (Model 4) with 5,000 bootstrap samples revealed that academic-related social media use significantly predicted collaborative learning engagement (B = 0.627, SE = 0.024, $t(412) = 26.67$, $p < .001$). Collaborative learning engagement, in turn, significantly predicted academic achievement while controlling for academic-related social media use, B = 0.233, SE = 0.048, $t(411) = 4.90$, $p < .001$ Thus, we fail to reject H2. The direct effect of academic-related social media use on academic achievement remained significant (B = 0.151, SE = 0.038, $t(411) = 4.01$, $p < .001$), indicating partial mediation. Thus, H1 is supported. The indirect effect was significant (B = 0.146, BootSE = 0.038, 95% bootstrap CI [0.074, 0.223]). Because the confidence interval excluded zero, collaborative learning engagement significantly mediated the relationship between academic-related social media use and academic achievement; therefore, we failed to reject H4.

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Table 3 Panel A Model Statistics

Outcome Variables	Predictor (s)	R^2	F	df	p
CLE	ARSMU	.633	711.323	[1, 412]	<.001
AA	ARSMU + CLE	.322	97.385	[2, 411]	<.001
AA (Total Effect)	ARSMU	.282	161.704	[1, 412]	<.001

Source: Author (2026)

The model statistics showed that academic-related social media use significantly predicted collaborative learning engagement ($F(1, 412) = 711.323$, $p < .001$), explaining 63.3% of the variance in collaborative learning engagement ($R = .796$, $R^2 = .633$). The total effect model also showed that academic-related social media use significantly predicted academic achievement, $F(1, 412) = 161.704$, $p < .001$, explaining 28.2% of the variance in academic achievement ($R = .531$, $R^2 = .282$). After collaborative learning engagement was introduced into the model, academic-related social media use and collaborative learning engagement jointly produced a statistically significant model, $F(2, 411) = 97.385$, $p < .001$, explaining 32.2% of the variance in academic achievement ($R = .567$, $R^2 = .322$). The increase in the explained variance from 28.2% to 32.2% indicates that collaborative learning engagement adds explanatory value to the prediction of academic achievement.

Table 4 Mediation Analysis of the Efect of ARSMU on AA through CL (PROCESS Model 4.0, N=414)

Path	Relationship	β	SE	T-value	P-value	95% CL	Decision
a (H3)	ARSMU → CL	.314	.031	10.001	<.001	[.252, .375]	Fail to reject H3
b (H6)	CL → AA	.334	.033	10.166	<.001	[.269, .398]	Fail to Reject H6
c	Total Effect: ARSMU → AA	.297	.023	12.716	<.001	[.251, .343]	Supported
c^{l} (H1)	Direct Effect: ARSMU → AA (Controlling for CL)	.192	.023	8.252	<.001	[.146, .238]	Fail to Reject H1
a×b (H5)	Indirect Effect through CL (ARSMU → CL → AA)	.105	.018[+]	—	—	[.070, .141][#]	Fail to Reject H5

Source: Author (2026)

B = unstandardized regression coefficient; SE = standard error; CI = confidence interval; c = total effect; c′ = direct effect; a × b = indirect effect. †BootSE = bootstrap standard error based on 5,000 bootstrap samples. ‡The indirect effect is statistically significant because the 95% bootstrap confidence interval does not include zero.

A mediation analysis using Hayes' PROCESS macro (Model 4) with 5,000 bootstrap samples revealed that the use of academic-related social media use significantly predicted cognitive load ($B = 0.314$, $SE = 0.031$, $t(412) = 10.00$, $p < .001$). Therefore, we fail to reject H3. Cognitive load, in turn, significantly predicted academic performance while controlling for academic-related social media use ($B = 0.334$, $SE = 0.033$, $t(411) = 10.17$, $p < .001$). The direct effect of academic-related social media use on academic performance remained significant ($B = 0.192$, $SE = 0.023$, $t(411) = 8.25$, $p < .001$), indicating partial mediation. The indirect effect was significant ($B = 0.105$, BootSE = 0.018, 95% bootstrap CI [0.070, 0.141]). Because the confidence interval excluded zero, cognitive load significantly mediated the relationship between academic-related social media use and academic performance. Thus, H5 is supported.

Table 5 Panel B Model Statistics

Outcome Variables	Predictor (s)	R	R^2	F	df	P-value
CL	ARSMU	.442	.195	100.02	[1, 412]	<.001
AA	ARSMU + CL	.653	.426.	152.61	[2, 411]	<.001
AA (Total Effect)	ARSMU	.531	.282	161.70	[1, 412]	<.001

Source: Author (2026)

The regression model predicting cognitive load from academic-related social media use was statistically significant, $F(1, 412) = 100.02$, $p < .001$, explaining 19.5% of the variance in cognitive load ($R^2 = .195$). The model predicting academic performance from academic-related social media use and cognitive load was also statistically significant, $F(2, 411) = 152.61$, $p < .001$, accounting for 42.6% of the variance in academic performance ($R^2 = .426$). The total effect model further revealed that academic-related social media use significantly predicted academic performance ($F(1, 412) = 161.70$, $p < .001$), explaining 28.2% of the variance in academic performance ($R^2 = .282$). The increase in explained variance from 28.2% to 42.6% after including cognitive load indicates that the mediator substantially improved the model's explanatory power, providing additional evidence for the mediating role of cognitive load in the relationship between the use of social mediafor academic-related purposes and academic performance.

➢ *Discussion*

This study examined the influence of academic-related social media use on the academic achievement of STEM pre-service teachers at a Ghanaian public university, with

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particular emphasis on the mediating roles of collaborative learning engagement (CLE) and cognitive load (CL). Drawing on social constructivist and cognitive load theories, this study sought to explain the social and cognitive mechanisms through which academic-related social media use contributes to students' academic outcomes. Overall, the findings indicate that academic-related social media use positively influences academic achievement both directly and indirectly. The results further revealed that academic-related social media use enhances collaborative learning engagement and cognitive load, both of which positively contribute to academic achievement and partially mediate the relationship between academic-related social media use and academic achievement. Collectively, these findings suggest that the educational benefits of social media extend beyond access to academic information, operating through complementary social and cognitive processes that facilitate meaningful learning among STEM pre-service teachers.

This study contributes to the growing discourse on technology-enhanced learning by demonstrating that academic-related social media use constitutes more than a supplementary communication tool in higher education. Rather, it functions as an integrated pedagogical ecosystem through which STEM pre-service teachers access academic resources, engage in collaborative knowledge construction, and develop cognitive processes that ultimately enhance their academic achievements. While concerns persist regarding the potentially distracting nature of social media, the present findings indicate that its educational value largely depends on the context and purpose of its use (Devi et al., 2019; Greenhow et al., 2019). When social media is intentionally employed to support teaching and learning, it creates interconnected social and cognitive learning environments that extend academic engagement beyond formal classrooms.

This interpretation reflects an important shift in contemporary educational research in that earlier studies frequently portrayed social media as a competing influence that diverted students' attention from academic work and consequently undermined learning outcomes (Maheswari et al., 2024; Osatuyi & Passerini, 2016). However, recent evidence suggests that the relationship between social media use and academic achievement is more nuanced. Rather than exerting inherently positive or negative effects, social media appears to influence learning according to the extent to which learners engage with academically meaningful content and educational interactions (Khan, 2024; Maheswari et al., 2024). The present study reinforces this emerging perspective by demonstrating that academically oriented social media engagement is positively associated with academic achievement among STEM pre-service teachers.

One plausible explanation is that academic-related social media substantially expands students' learning opportunities beyond scheduled instructional periods. Unlike traditional classroom instruction, where interactions are constrained by time and physical space, digital platforms enable learners to sustain academic discussions, exchange lecture materials, revisit difficult concepts, and obtain immediate clarification from peers and instructors (Neupane, 2023; Tung, 2024). These continuous interactions transform learning into an ongoing process rather than an activity restricted to formal classroom sessions. Consequently, social media has become an extension of the learning environment in which students continuously negotiate understanding, solve academic problems, and reinforce their newly acquired knowledge (Doherty-Restrepo, 2012; Lawson & Murray, 2018).

The findings strongly resonate with the assumptions of Social Constructivist Theory, which conceptualizes learning as a socially situated process in which knowledge is actively constructed through interaction with others rather than passively transmitted from teacher to learner. Within digitally mediated learning environments, social media provides opportunities for learners to explain concepts, challenge alternative viewpoints, negotiate meaning, and construct a collective understanding collectively (Maher, 2023). Such interactions are particularly valuable in STEM education, where conceptual understanding often develops through discussion, experimentation and collaborative reasoning. The findings suggest that social media extends constructivist classrooms into virtual learning communities where meaningful academic discourse continues beyond face-to-face instruction.

Recent empirical evidence supports this interpretation of the results. Al-Rahmi et al. (2014) demonstrated that the educational use of social media enhances students' academic performance by strengthening collaborative learning, knowledge sharing, and learner engagement. Similarly, Greenhow and Galvin (2020) argued that social media has evolved from an informal communication platform into a legitimate educational technology capable of supporting collaborative inquiry and knowledge construction in higher-education settings. Comparable conclusions were reached by Hamadi et al. (2022), who found that the structured academic integration of social media promoted students' learning experiences through sustained interaction and collaborative participation. Collectively, these studies suggest that educationally purposeful social media environments encourage learners to become active participants in knowledge construction rather than passive information recipients (Islam & Shah, 2024; Thomas, 2024).

The present findings are particularly important within teacher education because the participants are not merely university students but future STEM educators whose professional responsibilities will increasingly require competence in digital pedagogy. Their experiences as learners inevitably shape future instructional practices (Akor et al., 2025). Consequently, positive experiences with academically purposeful social media may influence students' academic achievement and their willingness to integrate similar technologies into future classroom instruction. This extends the significance of the present findings beyond immediate academic performance to the broader development of digitally competent STEM teachers capable of facilitating technology-enhanced learning in

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Ghanaian schools and beyond (Antwi, 2023; Onanuga & Saka, 2025).

Beyond its social dimensions, the findings also demonstrate that academic-related social media stimulate meaningful cognitive engagement in learning. This challenges the dominant assumption that an increased cognitive load necessarily undermines learning outcomes (Gupta, 2018; Hameed et al., 2022). In technology-enhanced learning environments, cognitive demand is not inherently detrimental; rather, its educational consequences depend on the nature of the mental processes involved in it. Academic-related social media expose learners to multiple forms of instructional information, including lecture notes, recorded demonstrations, scientific diagrams, multimedia explanations, scholarly articles, and peer-generated interpretations, which require learners to organize, compare, evaluate, and integrate knowledge (White, 2011). These processes inevitably increase mental effort, but they may simultaneously promote a deeper conceptual understanding.

This interpretation is consistent with the Cognitive Load Theory, which distinguishes productive cognitive processing from unnecessary mental burdens. According to this theory, effective learning occurs when instructional activities minimize extraneous cognitive load while promoting germane cognitive load associated with schema construction and knowledge integration (Klepsch & Seufert, 2020). The present findings suggest that academically purposeful social media use primarily stimulates productive cognitive engagement. Rather than overwhelming learners with irrelevant information, educational interactions on social media appear to encourage students to devote cognitive resources to analyzing scientific concepts, synthesizing multiple explanations and constructing coherent conceptual frameworks (Skulmowski & Xu, 2021; Surbakti et al., 2024).

The positive relationship between academic-related social media use and cognitive engagement illustrates an important distinction that has frequently been overlooked in earlier research. Previous studies examining social media often treated all forms of digital engagement as conceptually equivalent, thereby overlooking the differences between recreational and educational usage. The present findings indicate that these distinctions are important both theoretically and practically. Recreational social media frequently encourages multitasking, fragmented attention, and cognitive distraction, whereas academically purposeful social media appears to encourage sustained cognitive engagement directed towards meaningful learning activities. Consequently, the educational consequences of social media cannot be adequately understood without considering the nature and purpose of students' online engagement (Makkar, 2023).

This interpretation aligns with recent studies demonstrating that educational technologies enhance learning by stimulating productive cognitive processing rather than passive information consumption. For example, Fiorella and Mayer (2016) argued that meaningful learning occurs when learners actively organize, integrate, and elaborate on instructional information rather than simply accessing digital resources. Similarly, Sweller et al. (2020) emphasized that instructional environments should encourage cognitive activities that support schema construction while minimizing unnecessary cognitive processing demands. The present study extends these arguments by demonstrating that social media, when used deliberately for academic purposes, may function as an instructional environment capable of promoting desirable cognitive processes.

Taken together, these findings suggest that the educational effectiveness of academic-related social media cannot be explained solely through social interaction or cognitive processing. Instead, both processes appear to operate simultaneously in digitally mediated learning environments such as online learning. Social media creates opportunities for collaborative engagement through continuous interaction among learners while simultaneously encouraging them to process, evaluate and integrate academic information. Consequently, academic achievement appears to be supported by both social participation (via collaborative engagement) and cognitive engagement (via cognitive load), operating as complementary rather than redundant pathways for academic achievement. Future research should examine whether these pathways interact, for example, whether collaborative engagement moderates the cognitive load-achievement relationship. This observation provides a foundation for a more integrated explanation of technology-enhanced learning that combines the complementary insights of social constructivist and cognitive load theories.

V. CONCLUSION

This study aimed to understand the impact of academic-related social media on STEM pre-service teachers education in Ghana, specifically the impact of social media on the academic performance of STEM students at a public university in Ghana. It also examined the mediating roles of collaborative engagement and cognitive load. Grounded in social constructivist and cognitive load theories, positive academic outcomes from the purposeful use of academic-related social media are a result of collaborative engagement and productive cognitive load. This suggests that social media has a positive impact on education when used to facilitate engagement and collaboration in cognitive processes. The purposeful use of academic-related social media improves educational outcomes for future STEM educators. These findings suggest that the intentional integration of academic-related social media may support STEM teacher education. Policymakers and teacher educators should consider pilot programs that scaffold collaborative social media use while managing cognitive load, with rigorous evaluation of implementation and outcomes before scaling to policy-level frameworks. They should also consider developing educational digital infrastructure and providing low-cost, high-speed Internet, and training to educators on the use of academic-related social media. The study also supports the

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Social Constructivist Theory and Cognitive Load Theory in integration and suggests that future studies use this integration with other theories related to technology, such as self-regulated learning and digital literacy. In STEM instruction, teacher educators must include purposeful social media activities such as discussions, peer engagement, resource sharing, and academically guided interactions. This should also include the design of learning tasks that promote the desired level of cognitive engagement and minimize unnecessary cognitive loads. In addition, teacher education institutions should prepare pre-service teachers by integrating social media skills and pedagogical practices to support STEM integration in teacher education. This prepares pre-service teachers to design collaborative, social media-based, student-centered, and technology-integrated STEM learning experiences. The study concludes that the purposeful integration of academic-related social media within the STEM context of higher education in Ghana has positive implications for educational policy, theory, and practice, and related contexts by integrating social and cognitive learningprocesses.

- *Limitations of the Study and Suggestions for Future Studies*

Although this research advances the existing knowledge on the subject, it has limitations that the reader must be aware of. First, this study used a cross-sectional design, which restricts the ability to identify the direction of the relationship between the use of academic-related social media, collaborative learning, cognitive load, and academic achievement. It will be of benefit to this research field if future studies utilize longitudinal and experimental designs. Second, this study was conducted with STEM pre-service teachers at a select public university in Ghana. While this area of research is important, especially in technology-enhanced learning within teacher education, the findings from this study may be contextually invalid for other STEM and non-STEM pre-service teachers and other educationally and culturally diverse environments. Future research should be conducted in diverse settings and in different fields to improve the external validity of the findings. Finally, this study employed self-reported surveys, which are prone to social desirability and common method biases. Future studies should employ a combination of self-reported measures and social media use metrics, in conjunction with learning analytics and articulated-performance records. Mixed-methods research will provide additional insights into academic-related social media, which is necessary to improve the findings of future studies.

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