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Impact of ePortfolio Implementation on Metacognitive Regulation and Self-Regulated Learning Among Pre-Service Teachers in Ghanaian Colleges of Education

Adjei Amaniampong [1]
Mina Dadzie Ababio [2]
Joseph Nkyi-Asamoah [3]

(1.2.3) Offinso College of Education, Ghana.
Main author's email: amass18@yahoo.com

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Abstract
This longitudinal mixed-methods study investigates the impact of ePortfolio implementation on metacognitive regulation and self-regulated learning (SRL) development among undergraduate pre-service teachers in Ghanaian Colleges of Education over a four-year academic programme. Integrating quantitative measures of self-regulated learning using the Motivated Strategies for Learning Questionnaire (MSLQ) with qualitative analysis of reflective logs, the study tracked 138 first-year students through their entire degree programme, with 40 students selected for in-depth qualitative analysis. A repeated-measures ANOVA indicated significant improvements in metacognitive self-regulation across all measurement points ($F(4,108) = 32.45$, $p < .001$, $\eta^2 = .55$), while growth curve modelling showed a steady upward trend over time ($\beta = 0.52$, $p < .001$). Thematic analysis of reflective logs identified four major themes: development of reflective thinking, improved self-regulated learning, infrastructure and connectivity challenges, and lecturer support as a critical success factor. Qualitative findings demonstrated progressive maturation in students' reflective capacity from descriptive accounts toward theoretically informed, critically reflexive narratives. However, substantial infrastructural barriers, including unstable internet connectivity, limited device access, and high data costs, constrained implementation effectiveness. The study provides empirical evidence that sustained ePortfolio engagement, when supported by structured faculty guidance and adequate infrastructure, significantly enhances students' metacognitive awareness, reflective thinking depth, and autonomous learning capacities. The findings highlight the need for robust teacher professional development, clear and transparent assessment systems, and strong institutional investment in digital infrastructure. This research contributes critical insights to understanding how technology-enabled reflection can facilitate transformative learning in pre-service teacher education and offers practical recommendations for ePortfolio implementation in resource-constrained educational contexts.

Keywords: ePortfolio, metacognitive regulation, reflective practice, self-regulated learning, teacher education.

INTRODUCTION

The increasing adoption of digital technologies in higher education has transformed how learning is documented, assessed, and reflected upon. Among these innovations, ePortfolios have gained prominence as tools that support not only the collection of academic artefacts but also the development of reflective and self-regulated learning practices. As universities seek to prepare graduates with lifelong learning competencies, understanding how such tools influence students' metacognitive development over time has become a critical area of inquiry.

Self-regulated learning (SRL) is widely recognised as a key determinant of academic success and professional competence. SRL conceptualises learning as an active, cyclical process involving three phases: forethought (planning and goal-setting), performance (strategy implementation and self-monitoring), and self-reflection (evaluating outcomes and attributing causes) (Zimmerman, 2002). Learners who effectively regulate their cognition, motivation, and behaviour are better equipped to set goals, monitor progress, and adapt strategies in response to challenges. However, fostering SRL within higher education remains complex, particularly in environments where assessment practices emphasise outcomes over processes.

Parallel to this, reflective practice has been identified as a critical mechanism for professional learning. Reflection enables learners to critically examine their experiences, bridging the gap between theory and practice (Moon, 2004). The distinction between reflection-in-action (thinking while doing) and reflection-on-action (retrospective analysis of practice) highlights the dynamic and iterative nature of learning, particularly in practice-based disciplines such as teacher education. Yet, traditional modes of reflection, often confined to written assignments or isolated journals, may not fully capture the developmental trajectory of reflective thinking over extended periods.

ePortfolios offer a promising intersection between SRL and reflective practice. As digital platforms that integrate artefact collection, reflection, and feedback, ePortfolios create opportunities for learners to document their progress, revisit prior work, and engage in continuous self-assessment. Research suggests that ePortfolios can enhance metacognitive awareness, promote deeper reflection, and support learner autonomy (Nguyen & Ikeda, 2015; Wang, 2009). However, much of the existing literature is cross-sectional or short-term, offering limited insight into how sustained engagement with ePortfolios influences learning processes over time.

Moreover, there remains a gap in understanding the longitudinal impact of ePortfolios on students' metacognitive regulation and SRL development. While studies have demonstrated positive associations between ePortfolio use and reflective thinking, few have systematically tracked these changes across entire academic programmes. This gap is particularly significant given that both SRL and reflective capacity are developmental constructs that evolve gradually through repeated practice and feedback.

To address this limitation, this study adopts a longitudinal mixed-methods approach to examine how iterative engagement with ePortfolios shapes students' metacognitive regulation and self-regulated learning across a four-year undergraduate programme in Ghanaian Colleges of Education. The study, in particular, seeks to respond to the following research questions:

1. How does students' self-regulated learning develop over time in an ePortfolio-supported learning environment?
2. In what ways does engagement with ePortfolio reflection logs influence the depth and quality of students' reflective thinking?
3. What relationships exist between changes in self-regulated learning and the evolution of reflective practice over the duration of the programme?

By examining these questions, the study adds to the expanding literature on digital learning environments and provides empirical evidence on how ePortfolios support the development of lifelong learning skills.

LITERATURE REVIEW

The following review synthesises the theoretical and empirical literature on ePortfolios, self-regulated learning, and reflective practice.

Conceptual Foundations: Self-Regulated Learning and Reflective Practice

Self-regulated learning and reflective practice represent interconnected theoretical constructs that together provide the conceptual foundation for understanding ePortfolio effectiveness. The cyclical model of SRL identifies three recursive phases - forethought, performance, and self-reflection - through which learners actively monitor, evaluate, and adjust their learning strategies (Zimmerman, 2002). This framework

emphasises that effective learning requires metacognitive awareness: the capacity to think about one's own thinking processes and to deploy appropriate cognitive strategies in response to task demands.

Complementing this perspective, the theory of reflective practice provides a framework for understanding how professionals develop expertise through systematic examination of their actions. The distinction between reflection-in-action (real-time adjustment during practice) and reflection-on-action (retrospective analysis) illuminates different modes of professional learning. For pre-service teachers, developing both reflective capacities is essential for navigating the complexities of classroom practice and continuing professional growth throughout their careers (Farrell, 2019).

The intersection of these frameworks suggests that reflective practice serves as a mechanism through which self-regulatory capacities are developed and refined. When learners engage in structured reflection on their learning processes, they cultivate the metacognitive awareness central to SRL. ePortfolios, as platforms that scaffold and document reflection over time, represent potentially powerful tools for developing both reflective practitioners and self-regulated learners.

ePortfolios as Pedagogical Tools for Learning and Assessment

ePortfolios have evolved from simple digital repositories to sophisticated pedagogical tools that integrate assessment with learning processes. Contemporary ePortfolio scholarship emphasises their dual function as both assessment instruments and learning facilitators, promoting the reflective practice essential for developing self-regulated learning capacities (Lam, 2022). This dual purpose distinguishes ePortfolios from traditional assessment approaches that focus primarily on measuring learning outcomes rather than supporting learning processes.

Research consistently demonstrates that ePortfolio effectiveness depends critically on implementation design. Key factors include clear articulation of learning objectives, transparent assessment criteria, meaningful feedback mechanisms, and systematic integration of reflective prompts (Wang, 2009). When these elements are present, ePortfolios successfully visualise student progress, enable interactive feedback, and support the development of self-regulated learning (Nguyen & Ikeda, 2015). However, effectiveness diminishes substantially when reflection tasks lack clarity, when feedback is inconsistent, or when students encounter significant technical difficulties.

The relationship between ePortfolio use and student agency represents an important area of inquiry. Research indicates that ePortfolio systems incorporating co-design principles amplify students' sense of agency across individual, relational, and contextual domains, with particular gains in competence beliefs and opportunities for choice-making (Zhang & Tur, 2024). This finding aligns with broader evidence that student-centred approaches consistently enhance participation and develop critical twenty-first-century abilities, including problem-solving, adaptability, and collaboration (Zhang & Tur, 2023).

Metacognitive Development Through Reflective Writing

Longitudinal examination of reflective writing reveals consistent patterns of metacognitive growth when students receive structured guidance and meaningful feedback (Park et al., 2022). Students' reflective writing progresses from descriptive accounts toward theoretically informed, critically reflexive narratives that demonstrate developmental maturity in reflection quality. This progression parallels theoretical predictions from both SRL theory and reflective practice frameworks, suggesting that metacognitive sophistication develops gradually through sustained engagement with reflective activities.

However, metacognitive development through reflection is not automatic. Educational intervention is needed to help students understand self-reflection approaches and internalise their importance for developing reflective capacity. Training in reflective methodologies has been shown to substantially improve the depth and quality of student reflections (Park et al., 2022). In addition, course designs grounded in reflective practice and metacognitive principles, such as the use of student journals and reflective writing exercises, directly enhance students' metacognitive awareness and foster self-regulated learning behaviours (Zarestky et al., 2022). These findings underscore that effective ePortfolio implementation requires explicit instruction in reflective practices.

The assessment of reflective writing quality presents methodological challenges. The Index for Metacognitive Knowledge (IMK) provides a reliable framework for

assessing reflective writing and for articulating the role of metacognitive knowledge in critical reflection, distinguishing among the declarative, procedural, and conditional knowledge dimensions (Parks, 2023). Comparative analysis of assessment approaches reveals that more structured, criterion-referenced assessment frameworks provide more defensible portfolio evaluation. These methodological considerations inform the present study's approach to analysing qualitative data.

The literature identifies substantial implementation challenges that mediate the effectiveness of ePortfolios. Infrastructure-related constraints, including unreliable internet connectivity and limited access to digital devices, often restrict student engagement, particularly in resource-limited contexts. Students also report difficulties such as confusion with ePortfolio structure, limited digital literacy, time management challenges, and reduced creativity and motivation (Farrell, 2019). In addition, cognitive overload emerges as a significant concern, especially when reflective tasks are poorly structured or unclear, or when students face substantial technical difficulties (Zeitlhofer et al., 2023).

Faculty development emerges as a critical but often underinvested implementation component. The success of portfolio programs depends heavily on the engagement and quality of assigned tutors, and competency-based support for professional identity formation depends not only on structural and didactic curriculum design but also on students' willingness to engage with reflective methods (Gehlhar et al., 2026). Teachers benefit from professional development addressing assessment design, rubric development, and strategies for providing meaningful feedback on reflective writing. Research indicates that effective ePortfolio programmes require the teacher to scaffold students' use of technologies through demonstrating and modelling, providing prompt and timely feedback on ePortfolio work, and designing structured collaborative activities that encourage active learning (Hegarty & Thompson, 2019). Without adequate preparation, faculty may experience unsustainable workloads when assessing reflective portfolios, potentially undermining implementation sustainability.

Contextual factors significantly influence implementation outcomes. Research on technology integration in Ghanaian educational institutions specifically identifies infrastructural barriers as major obstacles affecting beginning teachers' transfer of learning of ICT-enhanced activities (Agyei & Voogt, 2014). The persistent digital divide affecting online learning in Sub-Saharan Africa creates particular challenges for technology-enhanced pedagogical innovations. These contextual considerations are essential for understanding how ePortfolio implementation may unfold differently across educational settings with varying levels of technological infrastructure and institutional support.

Research Gap

Despite growing evidence for ePortfolio effectiveness, significant gaps remain in the literature. Most existing studies employ cross-sectional designs or track implementation over relatively brief periods, limiting understanding of how ePortfolio engagement influences learning development over extended timeframes. The few longitudinal studies available have typically focused on medical education contexts in well-resourced settings, with limited attention to teacher education or resource-constrained environments.

The present study addresses these gaps by adopting a four-year longitudinal mixed-methods design to examine ePortfolio impact on metacognitive regulation and self-regulated learning among pre-service teachers in Ghanaian Colleges of Education. This approach enables examination of developmental trajectories over an entire undergraduate programme while also illuminating implementation dynamics in a context characterised by infrastructural constraints and examination-oriented educational traditions. By integrating quantitative measures with qualitative analysis of reflective logs, the study provides both statistical evidence of change and contextual understanding of the mechanisms through which change occurs.

Theoretical Framework

This study is based on two complementary theoretical perspectives: the cyclical model of self-regulated learning and reflective practice theory. These frameworks guide how the study conceptualises its variables, inform the coding and analysis of qualitative data, and influence the interpretation of results.

The Cyclical Model of Self-Regulated Learning

The cyclical model of self-regulated learning conceptualises SRL as a process involving three interdependent phases. The forethought phase encompasses processes that precede learning efforts, including task analysis (goal-setting and strategic planning) and self-motivational beliefs (self-efficacy,

outcome expectations, intrinsic interest). The performance phase involves processes during learning, including self-control strategies (attention focusing, task strategies, self-instruction) and self-observation (metacognitive monitoring and self-recording). The self-reflection phase occurs after performance and includes self-judgment processes (self-evaluation and causal attribution) and self-reaction (satisfaction/affect and adaptive/defensive responses).

This cyclical model has direct implications for understanding ePortfolio effectiveness. The ePortfolio-based learning model supports the development of student self-regulated learning (Nguyen & Ikeda, 2015). The ePortfolio platform supports forethought processes by providing a structure for goal articulation and strategic planning. Course design based on reflective practice and principles of metacognition, applying elements such as student journals and reflective writing exercises, directly supports students' metacognitive awareness and fosters self-regulated learning behaviours that, in turn, develop critical thinking and problem-solving abilities (Zarestky et al., 2022). Reflective prompts embedded within ePortfolios scaffold performance monitoring by directing students' attention to their learning strategies and progress. Cognitive and metacognitive prompts can activate and support self-regulated learning strategies, and knowing how to use cognitive learning strategies enables using cognitive prompts more effectively (Zeitlhofer et al., 2023). The requirement to revisit and document learning outcomes facilitates self-reflection by creating occasions for self-evaluation and causal reasoning about learning successes and challenges.

In the present study, this framework informs the quantitative measurement of SRL using the Motivated Strategies for Learning Questionnaire (MSLQ), which assesses constructs directly aligned with the cyclical model's phases, including metacognitive self-regulation, management of time and study environments, and regulation of effort. Educational interventions are necessary to support students in understanding self-reflection strategies and their importance in developing their competencies and engaging meaningfully in reflective writing, as these skills do not naturally develop as learners advance through grade levels (Park et al., 2022). The framework further informs qualitative coding by focusing on evidence of forethought (goal-setting and planning), performance control (strategy application and monitoring), and self-reflection (evaluation and attribution) within students' reflective logs. In addition, the Index for Metacognitive Knowledge (IMK) provides a structure for explaining the increasing complexity of students' reflective writing and evaluating the effects of instructional interventions by distinguishing declarative, procedural, and conditional knowledge (Parks, 2023).

The Theory of Reflective Practice

The theory of reflective practice established reflective thinking as central to professional learning. This framework identifies two forms of reflection: reflection-in-action and reflection-on-action. In medical practice, reflective learning enables physicians to pause, evaluate their actions, and understand how their thoughts, emotions, and feelings influence decision-making, clinical reasoning, and professional behaviour. This approach draws on the work of Dewey, Schön, Kolb, Boud et al., and Mezirow regarding critical self-examination (Lim et al., 2023). Reflection-in-action refers to the thinking that occurs during professional activity, where practitioners draw on tacit knowledge to make real-time adjustments in response to unique situational demands. Schon's Reflection-in-Action and Reflection-on-Action model distinguishes between knowing in action, reflection-in-action, and reflection-on-action (Lim et al., 2023).

For pre-service teacher education, this framework highlights the importance of developing both reflective capacities. In an undergraduate medical programme (Selectives), students indicated that reflective learning from academic activities helped them better understand their strengths and weaknesses, implying that structured educational programmes can support the development of reflective learning in certain contexts (Knight et al., 2016). Beginning teachers must learn to think on their feet in dynamic classroom situations (reflection-in-action) while also developing habits of systematic analysis of teaching experiences (reflection-on-action). ePortfolios primarily scaffold reflection-on-action by creating structured opportunities for retrospective analysis. Current methods of structuring reflective writing programs include orientation of users to the benefits of reflection and key aspects of reflection, with novices requiring explicit instructions and practice sessions for reflective journaling at the beginning of programs (Lim et al., 2023).

In this study, the reflective practice framework informs the qualitative analysis of reflective logs by providing criteria for distinguishing different depths of reflection. Reflective writing is coded across a hierarchy from non-

reflectors (e.g., habitual reflection, thoughtful action, introspection), through reflectors (e.g., content reflection, process reflection), to critical reflectors (e.g., premise reflection). Kember et al.'s Reflective Thinking Scale, Hatton and Smith's 4 Levels of Reflective Writing, and Moon's Map of Learning all provide frameworks for categorising reflective depth from description through to transformative learning (Lim et al., 2023). Professional identity construction is observable through students' reflective essays, where student interactions with patients provide rich material for professional identity construction (Adams, 2019). This hierarchical coding enables assessment of how reflective depth evolves over the four-year programme.

Integration of Theoretical Frameworks

The SRL model and reflective practice theory are complementary rather than competing frameworks. Both emphasise the active, constructive nature of learning and the importance of metacognitive processes. The SRL model provides a detailed account of the cognitive and motivational processes involved in self-regulation, while the reflective practice framework illuminates how reflection functions as a mechanism for professional learning and identity development. Together, they suggest that ePortfolios may enhance learning by (a) scaffolding the cyclical processes of planning, monitoring, and reflection central to SRL, and (b) creating structured occasions for the retrospective reflection central to professional practice development.

This integrated framework generates specific predictions tested in the present study: that sustained ePortfolio engagement will be associated with quantitative improvements in self-regulated learning, and that reflective log quality will demonstrate progressive development from descriptive to critically reflexive modes. The mixed-methods design enables examination of both predictions while also exploring the mechanisms linking ePortfolio engagement to learning outcomes.

METHODOLOGY

This study employed a longitudinal mixed-methods design to investigate how iterative engagement with ePortfolios influenced students' metacognitive regulation and self-regulated learning over a four-year undergraduate programme. The design combined quantitative and qualitative data to capture both observable changes in SRL and the development of reflective thinking over time.

The study involved undergraduate students enrolled in a four-year programme at Offinso College of Education, in which ePortfolios form part of the Supported Teaching Services (STS) within the B.Ed curriculum. A cohort sampling strategy was used, recruiting 138 first-year students at baseline and tracking them longitudinally until graduation. Inclusion criteria were enrolment in the full degree programme, active use of the institutional ePortfolio platform, and provision of informed consent. Attrition was addressed through periodic follow-ups and engagement incentives, with the final sample at Year 4 comprising 112 students (81.2% retention rate).

Self-regulated learning was measured using the Motivated Strategies for Learning Questionnaire (MSLQ), a widely validated instrument assessing cognitive, metacognitive, and resource management strategies in higher education contexts. The metacognitive self-regulation subscale was the primary outcome measure. Data were collected at five intervals: beginning of Year 1 (baseline), end of Year 1, end of Year 2, end of Year 3, and end of Year 4, enabling analysis of developmental trajectories in SRL over time.

Qualitative data were derived from students' ePortfolio reflection logs, which were produced regularly as part of coursework. Reflection prompts guided students to articulate learning strategies employed, challenges encountered, adjustments made, and connections between prior and current learning. A purposive subsample of 40 students (29.0% of the baseline sample) was selected to ensure variation in academic achievement, gender, campus location (urban/rural), and engagement levels.

The quantitative analysis involved descriptive statistics for summarising SRL trends, repeated-measures ANOVA to evaluate temporal changes, and growth curve modelling to examine individual learning trajectories. Effect sizes were estimated to evaluate the extent of change, and missing data were handled using multiple imputation where applicable.

Qualitative data were analysed through thematic analysis. Guided by the self-regulated learning framework, analysis followed the six stages proposed by Braun and Clarke (Braun & Clarke, 2006), including data familiarisation, initial coding, theme generation, theme review, theme definition, and reporting. Reflections were also coded using a hierarchical framework, distinguishing descriptive, analytical, and critical

reflection levels. Inter-rater reliability was established through independent coding by two researchers, with Cohen's kappa coefficient of .84 indicating substantial agreement.

The study used a convergent parallel mixed-methods approach, integrating results by aligning quantitative SRL development patterns with qualitative changes in reflective depth to determine areas of convergence, complementarity, or divergence. This triangulation strengthened interpretive validity and provided a more holistic understanding of learning processes.

Quantitative validity was supported through the established reliability and construct validity of the MSLQ. Internal reliability was determined using Cronbach's alpha, which showed values ranging from 0.78 to 0.89 across the various subscales and time points. Qualitative rigour was ensured through credibility (member checking with a subset of participants), dependability (maintaining an audit trail), and confirmability (reflexive journaling by researchers). Triangulation across data sources further enhanced robustness.

Ethical approval was obtained from the Quality Assurance Unit of Offinso College of Education. Informed consent was secured from participants, who also had the right to withdraw at any stage. The data were anonymised, and all ePortfolio artefacts were securely stored and used only for research purposes.

RESULTS AND DISCUSSION

Quantitative Findings

Table 1 presents descriptive statistics for metacognitive self-regulation scores across the five measurement points. The data reveal a consistent pattern of improvement from baseline (M = 3.21, SD = 0.62) through Year 4 (M = 5.31, SD = 0.49).

Table 1. Descriptive Statistics for SRL Variables Across Time

Variable	N	Mean	SD	Min	Max
Metacognition_Y1_Start	138	3.21	0.62	2.10	4.50
Metacognition_Y1_End	134	3.68	0.59	2.40	4.80
Metacognition_Y2	129	4.12	0.55	2.90	5.10
Metacognition_Y3	121	4.89	0.52	3.60	5.90
Metacognition_Y4	112	5.31	0.49	4.10	6.20

Figure 1 illustrates the developmental trajectory of metacognitive self-regulation, effort regulation, and critical thinking across the four-year programme. All three variables demonstrated parallel upward trends, with metacognitive self-regulation showing the most pronounced growth.

Figure 1. SRL Development over Time

To examine developmental changes in metacognitive self-regulation across the undergraduate experience, we conducted a repeated measures analysis of variance (ANOVA) with time as the within-subjects factor, as presented in Table 2.

Table 2. Repeated Measures ANOVA Results

Source	SS	Df	MS	F	p	eta-sq
Time	42.76	4	10.69	32.45	<.001	.55
Error	35.60	108	0.33			

A repeated measures ANOVA revealed a statistically significant effect of time on metacognitive self-regulation, $F(4,108) = 32.45$, $p < .001$, eta-squared = .55, indicating a large effect size according to conventional benchmarks. Bonferroni-adjusted post hoc comparisons revealed statistically significant gains across all successive time points (all $p < .001$). Growth curve modelling further indicated a consistent upward trajectory (beta = 0.52, $p < .001$), suggesting sustained development in self-regulated learning over the four years without ceiling effects or diminishing returns.

To examine changes in metacognitive regulation over time, a growth curve analysis was conducted using data collected at multiple measurement points throughout the programme. Figure 2 presents the resulting trajectory, highlighting the pattern of development in students' metacognitive regulation across the four years.

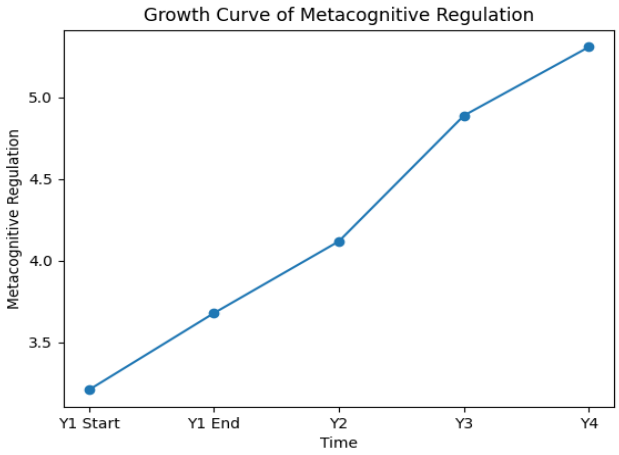

Figure 2. Growth Curve of Metacognitive Regulation

Research in higher education has identified a link between self-regulated learning (SRL) and academic performance; however, it remains underexplored whether SRL improves as students progress through undergraduate science programmes (Higgins et al., 2023). Our study addresses this gap by tracking students across multiple measurement points.

One longitudinal study found that students' SRL increased over the degree, but not over a single first-year semester (Higgins et al., 2023), suggesting that meaningful development in self-regulatory skills requires extended time to manifest. Similarly, research tracking students over 4 years of college found that self-esteem levels dropped substantially during the first semester, rebounded by the end of the first year, and then gradually increased over the next 3 years (Chung et al., 2013), demonstrating that psychological characteristics can show systematic developmental trajectories during the college years.

Within student-centred learning settings, metacognitive self-regulation supports learners in planning, tracking, and regulating their learning activities to produce favourable academic results (ElSayad, 2024). This underscores the importance of understanding how these regulatory capacities evolve over time.

Qualitative Findings

Thematic analysis of reflective logs from the 40-student qualitative subsample identified four major themes: development of reflective thinking, improved self-regulated learning, infrastructure and connectivity challenges, and lecturer support as a critical success

factor. The following sections present findings for each theme with illustrative quotations.

Theme 1: Development of Reflective Thinking

A dominant finding across participant responses was the development of reflective thinking. Students consistently reported that the ePortfolio process encouraged them to think critically about their academic experiences, learning strategies, strengths, and weaknesses. Unlike traditional assignment submission practices, the ePortfolio system required students to revisit their work, evaluate their progress, and document personal reflections. Many students explained that reflective writing enabled them to identify gaps in their understanding and monitor how their competencies evolved:

"The portfolio made me reflect deeply on my learning and identify my weaknesses." (Student 7, Female, Year 3, Urban Campus)

"I began to understand how I learn best after writing reflections every week." (Student 15, Male, Year 4, Rural Campus)

"The ePortfolio helped me think beyond grades and focus on improving myself." (Student 23, Female, Year 4, Urban Campus)

Students further noted that the continuous reflection process improved their confidence and self-awareness as future teachers. Several participants indicated that they became more conscious of how classroom experiences, teaching practice, and peer feedback contributed to their professional growth.

Theme 2: Improved Self-Regulated Learning

Another major theme was improved self-regulated learning. Students described how the ePortfolio activities enhanced their ability to plan academic tasks, organise study schedules, monitor progress, and evaluate learning outcomes. Participants reported becoming more intentional in setting learning goals and tracking their academic development:

"I learned how to plan my assignments and monitor my progress." (Student 3, Male, Year 2, Rural Campus)

"The portfolio made me manage my time better because I had to update it regularly." (Student 11, Female, Year 3, Urban Campus)

"I now evaluate my work before submission and think about what can be improved." (Student 28, Male, Year 4, Rural Campus)

Several students also reported that the ePortfolio system encouraged independent learning and personal responsibility. Rather than relying solely on lecturers for direction, students increasingly took ownership of their learning process.

Theme 3: Infrastructure and Connectivity Challenges

Although students acknowledged the benefits of ePortfolios, they also reported several technological and infrastructural challenges. The most frequently mentioned issues included unstable internet connectivity, limited access to laptops, inadequate ICT laboratories, and the high cost of internet data:

"Poor internet sometimes delays uploading assignments." (Student 5, Female, Year 2, Rural Campus)

"Some of us had to use mobile phones because we did not have laptops." (Student 19, Male, Year 3, Rural Campus)

"The network was sometimes frustrating, especially during submission periods." (Student 32, Female, Year 4, Urban Campus)

Participants from rural and less technologically equipped campuses expressed greater frustration regarding internet reliability and access to digital learning resources. Despite these barriers, many students demonstrated resilience and adaptability by using smartphones, sharing devices with peers, and accessing public internet facilities.

Theme 4: Lecturer Support as a Critical Success Factor

A fourth major theme emerging from the qualitative data was the critical role of lecturer support in mediating ePortfolio effectiveness. Students consistently emphasised that the quality of faculty guidance, feedback, and encouragement significantly influenced their engagement with and benefits from the ePortfolio process. Students described how lecturer feedback shaped their reflective practices:

"When my lecturer gave detailed comments on my reflections, I understood what good reflection looks like." (Student 8, Female, Year 3, Urban Campus)

"Some lecturers just ticked the submission box, but others wrote questions that made me think deeper." (Student 14, Male, Year 4, Rural Campus)

"The encouragement from my supervisor helped me see the portfolio as more than just an assignment." (Student 21, Female, Year 2, Urban Campus)

The variability in lecturer engagement emerged as a significant factor. Students who received consistent, substantive feedback reported greater investment in reflection, while those whose lecturers provided minimal engagement described the ePortfolio as a compliance exercise rather than a learning opportunity:

"When lecturers show they value the portfolio, we also take it seriously." (Student 36, Male, Year 4, Rural Campus)

"I wish all my lecturers gave feedback like my Year 2 supervisor - she helped me grow as a reflective teacher." (Student 27, Female, Year 4, Urban Campus)

Students also highlighted the importance of lecturers modelling reflective practice and explaining the purpose and expectations for portfolio work. Those who received clear guidance on reflective writing frameworks reported greater confidence and depth in their reflections.

DISCUSSION

Theme 1 Discussion: Development of Reflective Thinking

The finding that ePortfolio engagement supported the development of reflective thinking aligns with research arguing that reflective practice is central to teacher professional development. ePortfolios have been conceptualised as platforms for integrated reflection and identity formation. Within the Ghanaian context, this finding is particularly significant because many pre-service teachers originate from examination-oriented educational backgrounds where memorisation and content reproduction are often emphasised over reflective inquiry.

The development of reflective thinking observed in this study demonstrates a fundamental shift in how students engage with their learning. Rather than viewing education as the passive reception of information, students began to adopt a more metacognitive stance, actively monitoring their cognitive processes and evaluating their learning strategies. This transformation occurred gradually over the four years, suggesting that reflective capacity is indeed a developmental construct requiring sustained cultivation. The progression from surface-level reflections about specific assignments to deeper, theoretically informed analyses of learning processes parallels findings documenting similar developmental trajectories in reflective writing quality.

The ePortfolio platform appeared to provide crucial affordances for this development. By creating a persistent digital space where students could revisit prior work, compare earlier reflections with current thinking, and visualise their intellectual growth, the platform transformed reflection from an isolated episodic activity into an ongoing, cumulative process. This longitudinal perspective enabled students to recognise patterns in their learning, identify recurring challenges, and develop more sophisticated responses to familiar problems. The significance of this finding extends beyond individual student development to implications for teacher preparation in Ghana, where the National Teaching Council's competency standards increasingly emphasise reflective practice as a core professional capability.

Theme 2 Discussion: Improved Self-Regulated Learning

The findings strongly support the cyclical model of self-regulated learning, which emphasises planning, monitoring, and self-evaluation as key dimensions of metacognition. The qualitative responses complement the quantitative findings, which demonstrated statistically significant improvements across all metacognitive dimensions. The large effect size (eta-squared = .55) indicates that ePortfolio engagement explained a substantial proportion of variance in metacognitive self-regulation development.

These findings are consistent with research demonstrating that ePortfolio-based learning environments improve students' self-regulation skills through continuous reflection and self-assessment. Within Ghanaian Colleges of Education, where students often experience highly structured instructional environments, the promotion of independent learning represents an important educational advancement. The ePortfolio system created space for students to exercise greater autonomy over their learning pathways, aligning with contemporary competency-based reform agendas being implemented through Ghana's National Teaching Council.

The mechanisms underlying these improvements warrant consideration. The requirement to regularly document learning strategies, challenges, and adjustments likely activated the self-monitoring processes central to the performance phase of self-regulated learning. The retrospective analysis embedded in reflection prompts facilitated the self-evaluation and causal attribution processes of the self-reflection phase. Over four years, these repeated cycles of planning, monitoring, and reflection appear to have been progressively internalised, moving from externally scaffolded processes toward more autonomous self-direction. This internalisation process represents a critical mechanism through which ePortfolio engagement translates into enduring changes in learning capacity.

Theme 3 Discussion: Infrastructure and Connectivity Challenges

The finding that infrastructural barriers constrained ePortfolio effectiveness mirrors prior research identifying infrastructural barriers as major obstacles to technology integration in Ghanaian educational institutions. Studies have highlighted the persistent digital divide affecting online learning in Sub-Saharan Africa. The present study extends these earlier findings by documenting how infrastructure challenges specifically constrain ePortfolio effectiveness within a longitudinal implementation context, even when pedagogical design and institutional commitment are strong.

The infrastructure challenges documented represent substantial impediments to equitable access and engagement. Unstable internet connectivity creates particular problems for portfolio submission deadlines, generating anxiety and disrupting the regularised reflection routines that appear essential for developing reflective and self-regulatory capacities. Students from rural and less-equipped campuses reported greater barriers, suggesting that ePortfolio implementation may inadvertently exacerbate existing educational inequities if infrastructure issues are not proactively addressed. This finding has important implications for Ghana Education Service policy, which must attend to infrastructure disparities across Colleges of Education if technology-enhanced pedagogies are to benefit all students equitably.

However, the finding that many students demonstrated resilience and adaptability by utilising smartphones, sharing devices, and accessing alternative internet facilities demonstrates important human capacity for problem-solving in resource-constrained contexts. While this resilience is admirable, it should not excuse institutional failure to provide necessary infrastructure. The Ghanaian context specifically illuminates how ePortfolio implementation must be adapted to local conditions, with careful attention to platform selection, prioritising options that function effectively on lower bandwidth and mobile devices.

Theme 4 Discussion: Lecturer Support as a Critical Success Factor

The emergence of lecturer support as a critical success factor aligns with broader literature on faculty development for ePortfolio implementation. Research has emphasised that teachers benefit from professional development addressing assessment design, rubric development, and strategies for providing meaningful feedback on reflective writing. Studies have found that teacher professional development is emphasised by the majority of teachers as essential for effective ePortfolio programmes.

The variability in lecturer engagement documented in this study represents both a challenge and an opportunity. When lecturers provided substantive, thoughtful feedback that modelled reflective thinking and pushed students to deeper analysis, students reported transformative learning experiences. When lecturer engagement was minimal or perfunctory, ePortfolios became compliance exercises with limited developmental value. This variability suggests that ePortfolio effectiveness is not solely a function of platform design or student motivation but is fundamentally shaped by the quality of pedagogical interaction surrounding portfolio activities.

Within the Ghanaian context, this finding has significant implications for Colleges of Education. Faculty preparation for ePortfolio assessment requires sustained investment beyond initial training workshops. Lecturers need ongoing support to develop assessment literacy specific to reflective writing, strategies for providing developmental feedback, and an understanding of how their engagement shapes student motivation and learning. The finding also suggests that institutional accountability mechanisms should attend not only to whether portfolios are submitted but to the quality of feedback students receive.

Integrated Discussion of Quantitative and Qualitative Findings

This longitudinal mixed-methods study reveals a nuanced and compelling picture of how ePortfolio engagement influences metacognitive development and self-regulated learning in teacher education contexts. The convergence of quantitative and qualitative results offers strong evidence that sustained use of ePortfolios significantly enhances student learning outcomes while also highlighting key contextual and infrastructural factors that influence these effects.

The substantial quantitative effect (eta-squared = .55) on metacognitive regulation finds parallel support in qualitative evidence of progressive sophistication in reflective thinking and autonomous goal-setting. The consistent linear growth trajectory (beta = 0.52) matches students' reports of continuous improvement in their ability to reflect critically on their learning. However, the qualitative data extend and deepen the quantitative findings by revealing the mechanisms through which this change occurred: students internalised self-regulatory processes through repeated cycles of reflection and feedback, gradually shifting from external dependence on lecturer guidance toward autonomous self-direction.

The mixed-methods convergence also highlights implementation complexity. The large quantitative effects might suggest that ePortfolios are a simple, universally applicable solution to enhancing self-regulation. The qualitative findings temper this optimism by documenting how infrastructural barriers, variable lecturer engagement, and unclear pedagogical framing created differential student experiences. For some students, ePortfolios became transformative tools supporting deep learning. For others, particularly those facing greater infrastructural challenges or receiving limited faculty feedback, ePortfolios represented frustrating obstacles or compliance exercises rather than learning opportunities.

Theoretical Contributions

This study contributes to theoretical understanding by documenting how developmental processes of reflection and self-regulation unfold over extended timescales. Prior studies have documented correlational relationships between ePortfolios and learning outcomes or short-term changes in reflective thinking. This four-year longitudinal study reveals that both reflection and self-regulation develop progressively through repeated cycles of engagement, feedback, and metacognitive practice. The absence of ceiling effects or diminishing returns suggests that these competencies continue developing even after years of practice, supporting theories that emphasise the ongoing, lifelong nature of learning development.

The study also illuminates how platform affordances, pedagogical design, and instructional support interact to shape learning outcomes. ePortfolios are not neutral technological tools but rather sociotechnical systems whose effectiveness depends fundamentally on how they are implemented, supported, and integrated into broader curricular contexts. This finding advances understanding beyond technological determinism toward a more nuanced appreciation of how technology, pedagogy, and institutional context co-produce learning outcomes.

Limitations

While this study provides valuable longitudinal evidence, important limitations should be acknowledged. Participant attrition across the four years reduced the final sample size from 138 to 112, potentially introducing attrition bias if students with particular characteristics were more likely to remain. The study was carried out in a specific institutional setting (Ghanaian Colleges of Education) with unique characteristics that may restrict the generalisability of the findings to other teacher education systems. The reliance on self-report measures for SRL assessment introduces potential response bias. Future research should replicate these longitudinal designs across diverse institutional contexts to clarify which findings are context-specific versus broadly generalisable.

CONCLUSION AND RECOMMENDATIONS

Conclusion: This longitudinal mixed-methods study contributes substantial empirical evidence to the growing body of research demonstrating that ePortfolio implementation, when thoughtfully designed and adequately supported, significantly enhances students' metacognitive regulation and self-regulated learning capacities. Across four years of undergraduate teacher education, students using ePortfolios showed consistent, substantial improvements in metacognitive awareness, reflective thinking, goal-setting, and autonomous learning behaviours. These quantitative gains were complemented by qualitative evidence of progressive development in the sophistication and authenticity of students' reflective practices.

The study's particular contributions lie in three domains. First, it provides rare longitudinal evidence spanning an entire undergraduate programme, demonstrating that self-regulatory competencies develop progressively through sustained engagement with reflective practices and that benefits do not diminish over extended timeframes. Second, it illuminates the mechanisms through which ePortfolios support learning development: through creating persistent digital spaces for reflection, providing visible evidence of progress, and facilitating the gradual internalisation of self-regulatory processes. Third, it identifies critical contextual factors - particularly infrastructural conditions, lecturer support quality, and institutional investment in faculty development - that mediate ePortfolio effectiveness.

The study was carried out within Ghanaian Colleges of Education, an institutional context marked by examination-oriented traditions, structured teaching environments, and infrastructural limitations. The findings within this context carry particular significance: they demonstrate that ePortfolios can support transformative learning even in systems that traditionally emphasise examination performance, yet they also illuminate how technological innovations can reproduce existing inequities if adequate infrastructure and institutional support are lacking.

Recommendations: This study offers several recommendations for Ghana, particularly for the Ministry of Education, the Ghana Education Service, Colleges of Education, and future research directions. At the policy level, the Ministry of Education should prioritise investment in digital infrastructure within Colleges of Education, especially those located in rural areas. This should include reliable internet connectivity, adequately resourced computer laboratories, and subsidised data access to support sustained student engagement with ePortfolio activities. In addition, the National Teaching Council should consider integrating ePortfolio competencies into the Teacher Education Curriculum Framework, with clearly defined standards for reflective practice development that align with professional teaching standards. Furthermore, the Ghana Education Service should establish monitoring mechanisms to identify and address disparities in ePortfolio access and learning outcomes across Colleges of Education, ensuring targeted support for institutions experiencing greater infrastructural constraints.

At the institutional level, Colleges of Education should invest in continuous professional development for lecturers, focusing on ePortfolio assessment literacy, strategies for providing effective feedback on reflective writing, and pedagogical approaches that scaffold metacognitive development. Such training should go beyond one-off workshops to include sustained mentoring and the development of professional learning communities. Institutions should also prioritise ePortfolio platforms that are optimised for low-bandwidth environments and mobile device accessibility, given existing connectivity challenges. Furthermore, ePortfolio implementation should be structured with explicit instruction in reflective writing frameworks, clear assessment rubrics, and staged scaffolding to progressively develop students' reflective capacity. Colleges should also strengthen quality assurance mechanisms to ensure consistency in lecturer feedback, recognising its critical influence on student outcomes.

For future research, comparative studies should examine ePortfolio implementation across different Colleges of Education to identify factors associated with more effective practice. Further research is also needed to determine which forms of lecturer professional development most effectively enhance feedback quality and student learning outcomes. In addition, studies should evaluate different ePortfolio platforms in resource-constrained contexts, particularly with regard to mobile accessibility and offline functionality. Finally, longitudinal research should track graduates into their professional teaching careers to determine whether reflective and metacognitive skills developed through ePortfolios are transferred into ongoing professional practice.

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