

Academic Literacies and the Pedagogical Demands of Technology-Based Education

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Abstract

As technology-intensive programmes become increasingly complex and multimodal, the literacy demands placed on students extend beyond traditional expectations. Drawing on the Academic Literacies framework and contemporary scholarship in digital pedagogy, this paper argues that academic literacy is a central determinant of student success in science and technology education. Effective engagement with technical texts and the production of discipline-specific outputs require advanced literacy practices that cannot be assumed. Persistent difficulties in these programmes reveal a structural pedagogical gap, wherein reading and writing are treated as generic skills rather than as discipline-specific competencies requiring explicit instruction. This paper advocates for curricula that embed targeted literacy pedagogies attuned to disciplinary and technological contexts. By positioning academic reading, writing and digital communication as foundational competencies, institutions can enhance students' comprehension, problem-solving capacities, and professional communication. The paper concludes by outlining evidence-based strategies for integrating literacy instruction into technology programmes to strengthen student achievement and promote educational equity.

Key words: Academic literacies, Technology-based education, Discipline-specific literacies, Digital pedagogies, Student engagement

Introduction

Advances in digital technologies have transformed the structure, content, and delivery of science and technology education producing programmes that are increasingly complex, multimodal and cognitively demanding. Students are now required to engage with technical

documentation, software interfaces, specialised vocabularies and discipline-specific genres, often simultaneously, as part of their academic and professional training. In Nigeria, these demands are compounded by educational trajectories that frequently do not prioritise structured reading and writing practices

at the secondary level which leaves many students underprepared for the literacy-intensive requirements of technology-based university programmes. Despite these increased demands, dominant pedagogical models in Nigerian universities continue to treat reading and writing as generic transferable skills that students are presumed to possess upon entry.

This paper adopts the academic literacies framework advanced by Lea & Street (1998) as a conceptual lens to interrogate the disjuncture between the literacy demands of technology-based programmes and the limited pedagogical attention paid to explicit literacy instruction. By conceptualising literacy as socially situated, epistemologically grounded, and discipline-specific, the framework highlights the ways in which students' challenges stem not from individual shortcomings but from complex highly specialised communicative practices that structure academic and professional work in technological fields. These practices encompass far more than technical proficiency as they involve navigating multimodal texts, interpreting symbolic and graphical representations, articulating design rationales and engaging in forms of reasoning that are conventional within engineering, computing and applied science domains. Persistent literacy challenges therefore reveal a deeper structural gap in science

and technology curricula where disciplinary expectations remain unexamined and insufficiently scaffolded. Addressing this gap requires recognising academic literacy not as a generic skill but as an integral component of disciplinary knowledge-making, with implications for curriculum design, instructional practices, and the equitable participation of diverse learners.

Positioning academic literacies as central to student success, this paper contends that the escalating literacy demands of technology-based programmes require a pedagogical shift where reading and writing are treated as explicit discipline-specific practices rather than assumed competencies. Without such attention, educational inequities are likely to be exacerbated and student achievement unevenly distributed. The paper argues for embedding targeted literacy instruction within science and technology curricula as a foundational pedagogical component. This approach enhances comprehension, problem-solving, and professional communication, ensuring that technology supports learning rather than creating additional barriers.

Literature Review

In the Nigerian educational context, challenges in reading and writing are compounded by systemic gaps in earlier schooling which affect students'

engagement with technology-intensive programmes. Many enter higher education with limited vocabulary, weak comprehension and underdeveloped critical reading strategies leading to difficulties in interpreting problem statements, understanding technical concepts and assimilating instructional materials (Mangvwat & Meshak, 2025). Writing competence is equally critical as students must articulate complex technical ideas, document processes and communicate findings clearly. In technology-based programmes, writing is a primary medium for producing, evaluating, and sharing knowledge across genres such as technical reports, project proposals, software documentation, and research papers (Pitse & Balibi, 2024). Yet many students struggle to produce cohesive, evidence-based outputs, a challenge that is intensified by the use of digital platforms which demand multimodal communication, critical engagement with sources, and synthesis of diverse materials. These persistent gaps highlight the importance of the academic literacies perspective which situates reading and writing as socially and disciplinarily embedded practices essential for success in technology-based education.

Building on documented literacy challenges in technology education, the academic literacies framework offers a robust lens for examining the structural and pedagogical factors underlying these

difficulties. Unlike traditional *study skills* models that conceptualise reading and writing as generic, transferable competencies, the academic literacies perspective sees literacy as a socially situated, discipline-specific set of practices shaped by institutional norms, power relations and epistemic expectations. From this perspective, literacy challenges do not stem from individual skill gaps but from hidden expectations embedded within academic and professional contexts (Lillis & Scott, 2007). Although both approaches seek to enhance student learning, they differ markedly in scope and purpose. Study skills models emphasise general learning strategies such as note-taking, summarising, time management, exam preparation and assume that literacy is a neutral competence that any student can acquire. In contrast, academic literacies focuses on the specialised reading, writing, reasoning and communication practices required to participate effectively in specific disciplinary communities.

This distinction is highlighted in Nigerian higher education where English for Scientific Purposes (ESP) programme introduced into the first five Universities of Technology and Agriculture in the 1980s aimed to equip science and technology students with language resources, genre awareness, and communicative competencies necessary for technical reporting, data

interpretation and professional discourse, rather than merely teaching generic reading and writing strategies (Shehu, 2022; Bankole, Ayoola, & Adegite, 2023). Whereas the study skills approach helps students manage academic tasks, academic literacies enable them to produce field-specific texts, engage critically with complex knowledge and participate meaningfully in disciplinary communities. In essence, study skills address “how to learn,” while academic literacies address “how to be literate within a discipline,” a distinction that is especially significant for STEM (Science, Technology, Engineering, Mathematics) and technology-based educational contexts.

In technology-intensive programmes, students are required to navigate complex multimodal texts, produce discipline-specific documentation and communicate findings using highly codified scientific and technical genres. The academic literacies framework foregrounds the notion that students’ struggles arise not from individual deficits but from the complex communicative demands embedded within academic and professional practices (Lea & Street, 1998; Lillis & Scott, 2007). Further evidence can be found in international researches which focus on the difficulties students encounter when interpreting and synthesising information across verbal, visual and numerical modes as well as

when attempting to align their writing with specialised disciplinary conventions (Lin & Morrison, 2021). These challenges are intensified in contexts where instructional scaffolding is limited, underscoring the inadequacy of assuming that literacy skills are automatically transferable across disciplinary boundaries.

In the Nigerian higher education context, research similarly shows that literacy-related challenges are especially pronounced in technology-based programmes where curricula often presume that students already possess the foundational literacy and digital competencies required for disciplinary engagement. This assumption limits opportunities for explicit, discipline-specific literacy instruction within digital learning environments thus reinforcing the need for pedagogical approaches that integrate academic and professional literacies into the design of technical programmes (Akinwamide, 2021; Yakubu, 2024; Aremu & Udofia, 2025). Empirical studies reveal a persistent misalignment between the literacy demands of technology-oriented disciplines and the instructional practices employed in Nigerian institutions. They note that students frequently struggle with information literacy, data processing and professional communication, difficulties that are linked to underdeveloped curricula, limited access to digital resources, and

the inadequate integration of literacy instruction into technical coursework.

Studies indicate persistent gaps in students' abilities to search for, evaluate, and apply digital information in academic tasks, with many of them relying on unreliable online sources due to limited learner evaluation skills (Aremu & Udofia, 2025; Adams, Ogedengbe, & Aliyu, 2025). For instance, a civil engineering student developing a sustainable water management plan may be able to locate relevant research but then struggle to synthesize data from multiple sources or cite references appropriately. Such findings demonstrate that literacy gaps are not merely student deficits but structural and pedagogical issues embedded within programme design. Recent research has expanded this concern to include emerging forms of technology-related literacies such as artificial intelligence literacy among pre-service science teachers revealing continued challenges in preparing learners for technologically complex educational environments (Tsakeni & Nwafor, 2025). These gaps reflect broader structural constraints including inconsistent pedagogical training, resource limitations and infrastructural deficits which exacerbate inequities and restrict student achievement.

Thus, both international and Nigerian research demonstrate that literacy

challenges within technology-intensive education are systemic, cutting across student competencies, pedagogical approaches, and institutional structures. Integrating an academic literacies perspective into programme design therefore provides a robust foundation for pedagogical strategies that position reading, writing, and digital competencies as core, not peripheral, elements of the curriculum. When explicit literacy instruction is embedded within disciplinary teaching, educators are better able to equip students to meet the complex cognitive, communicative and interpretive demands of contemporary technology-mediated learning environments, thereby supporting more equitable and effective learning outcomes.

The academic literacies framework is particularly valuable because it foregrounds the explicit articulation of disciplinary ways of knowing and promotes pedagogical practices that make disciplinary expectations transparent to learners. Within STEM education, such scaffolding extends beyond conventional content delivery. It requires guiding students in navigating and interpreting diverse technical texts including schematics, research articles, software documentation, and data narratives while modeling the production of professional and academic outputs such as lab reports, code documentation, design rationales and technical

presentations. Through engagement with these processes, students internalize the rhetorical conventions, genre structures and epistemic reasoning that define their fields.

Providing iterative, developmental feedback further reinforces learners' comprehension and communicative performance, enabling the gradual refinement of higher-order literacy skills such as critical analysis, synthesis and problem-solving. This pedagogical orientation reframes literacy not as an individual deficit to be corrected but as a set of socially situated practices that must be explicitly taught, modeled, and embedded within disciplinary learning. Structured yet interactive forms of engagement help bridge the gap between technical proficiency and the complex literacy demands of professional STEM practice.

By seeing literacy as central to disciplinary meaning-making, the academic literacies perspective underscores the need to integrate targeted literacy support across the curriculum to strengthen comprehension, problem-solving capacities, professional communication, and equitable learning outcomes. Embedding it within programme design thus offers a conceptual and pedagogical foundation for rethinking curriculum ensuring that literacy is recognized as a core competency that will enable students to

navigate the increasingly complex demands of contemporary technological learning environments.

Pedagogical Imperatives of Academic Literacies

Increasingly, digital literacy has become a critical determinant of students' capacity to engage meaningfully with technology-mediated learning and research. Studies indicate that gaps in information processing, data evaluation and research skills negatively affect academic performance, particularly among science and technology students (Aremu & Udofia, 2025). Similarly, the use of Computer-Assisted Language Learning (CALL) tools demonstrates the potential of digital literacy to facilitate engagement with electronic resources. However, limited training, intermittent access to technology and infrastructural challenges continue to constrain effective implementation. Findings from Aremu and Udofia (2025) underscore that literacy in Nigerian higher education is a multidimensional construct encompassing student skills, pedagogical practices, and institutional support. Consequently, deficiencies in any of these areas impede learning outcomes, especially in technology-intensive disciplines. Addressing these systemic challenges requires explicit pedagogical interventions that integrate reading, writing, and digital competencies as core components of curriculum design, ensuring that students are prepared to

meet the demands of contemporary technology-driven learning environments.

Furthermore, technical proficiency does not automatically translate into effective communication and the difficulties that students encounter do not indicate individual deficits but rather they reflect the socially situated and discipline-specific nature of technical communication. For instance, electrical engineering students may competently operate simulation software yet struggle to interpret the underlying circuit diagrams or articulate coherent design rationales, tasks that require an understanding of the epistemic conventions and communicative norms of the discipline (Okorie & Ibrahim, 2025). Similarly, computer science students may produce functional code but effective documentation demands that they articulate the logic and rationale of their solutions in ways that align with the expectations of peers and professional collaborators. These examples illustrate that literacy in STEM fields involves engaging with the social practices, genres, and conventions that structure knowledge production, rather than simply applying generic reading or writing skills. Without instruction in these discipline-specific literacy practices, students struggle to extract relevant information, make meaningful connections or present ideas clearly, leading to gaps in both comprehension

and professional preparedness (Pitse & Balibi, 2024). This illustrates that the demands of technology-based education extend beyond mere digital competence, encompassing the full spectrum of academic literacies.

Students in STEM fields engage with complex multimodal texts such as technical reports, schematics, software documentation, research articles and professional discourse that require specialised literacy competencies for both interpretation and production. The significance of such discipline-specific language instruction has been widely acknowledged in ESP programmes such as English for Scientific Purposes and English for Science and Technology which are deliberate efforts to align language instruction with the literacy demands of technological disciplines (Hyland, 2004). From an academic literacies perspective, these programmes recognise that students' challenges are not indicators of individual deficits but in fact reflect the socially situated and discipline-bound nature of technical communication. By tailoring instruction to the genres, conventions, and rhetorical practices characteristic of science and technology fields, ESP enables students to interpret technical texts, construct coherent reports, and communicate complex reasoning with clarity and precision.

ESP programmes in Nigerian are aimed to address students' difficulties with advanced reading and writing in scientific and technological domains. They attempt to promote learner-centred instruction that align with the communicative demands of specialised fields (Sharndama & Ijem, 2025). However, their effectiveness has largely been constrained by persistent challenges such as limited institutional support, insufficient teacher preparation, and weak policy frameworks (Shehu, 2022). Despite these limitations, empirical comparisons with general English instruction demonstrate that ESP yields stronger gains in academic and professional communicative competence (Bankole, Ayoola, & Adegite, 2023). Such findings underscore that well-resourced and effectively integrated field-specific language instruction can bridge the gap between technical proficiency and academic literacy to equip students to meet the complex communicative demands of technology-mediated education.

The disjunction between technical performance and academic literacy is further exacerbated by pedagogical practices that privilege autonomous learning in digital environments without adequate structured support. Students are often left to navigate complex disciplinary discourses and genres with minimal guidance resulting in uneven learning outcomes. Addressing this gap

requires structured scaffolded literacy support directly within disciplinary curricula. This includes explicit modeling of technical writing conventions such as structuring lab reports, interpreting data narratives and documenting code alongside exercises that link technical tasks to analytical explanations. Iterative feedback cycles should accompany these processes to promote revision, reflection, and the gradual development of higher-order communicative competence.

Technology-Enhanced Platforms for Literacy Development

To address these demands, targeted literacy-based interventions are essential. Accordingly, alongside English for Specific Purposes (ESP) programmes, several digital platforms—including Moodle peer-review modules, GitHub-based collaborative workflows, and cloud-based writing tools such as Google Docs and Microsoft Word Online—offer significant opportunities to strengthen these pedagogical efforts.

Moodle's peer-review modules provide a structured environment in which students can submit drafts, evaluate one another's work, and receive guided feedback. Instructors can establish clear rubrics, automate the allocation of review tasks, and monitor the quality of peer responses. For learners, the platform supports iterative drafting, reflective

engagement with feedback, and a deepened understanding of disciplinary writing conventions, all within a broader learning-management framework designed to scaffold academic literacy. Beyond simple task management, Moodle's peer-assessment functions draw on established research indicating that structured opportunities to analyse and respond to the work of others are central to developing critical literacy and disciplinary reasoning. Tools such as the Workshop activity facilitate iterative review, comparison of multiple exemplars, and the articulation of criteria-based feedback—processes shown to enhance metacognitive awareness and promote more sophisticated engagement with academic conventions.

GitHub-based collaborative workflows, although originally developed for software engineering, have become increasingly valuable in writing-intensive and research-focused learning environments. Its version-control system allows multiple contributors to work on the same document while preserving each stage of revision. Features such as pull requests, branch comparisons, and issue tracking encourage dialogue around drafts, support peer editing, and make the evolution of a text transparent. These affordances strengthen students' understanding of revision processes, foster collaborative authorship, and cultivate digital literacy competencies

that are essential in academic and professional contexts.

Similarly, Google Docs and Microsoft Word Online offer real-time collaborative writing spaces that integrate commenting tools, suggestion modes, and accessible version histories. These platforms enable students to co-construct texts, visualise the development of ideas, and participate in sustained feedback cycles. Their cloud-based accessibility allows collaboration to occur synchronously or asynchronously, facilitating joint problem-solving, peer critique, and the negotiation of meaning in real time. Collectively, these digital platforms create learning environments that immerse students in authentic communicative and disciplinary practices. They encourage learners to justify compositional decisions, critically engage with peer contributions, and align their writing with established academic norms—thereby contributing meaningfully to the development of advanced academic literacy.

In STEM contexts specifically, peer-review activities embedded within learning management systems have been shown to support conceptual clarification, promote collaborative troubleshooting and strengthen students' ability to communicate technical ideas with precision (Luo, Robinson, & Park, 2014). Such environments, whether

implemented through Moodle or comparable platforms, prompt learners to justify design decisions, critique methodological approaches and interpret multimodal artefacts such as code, schematics and data visualisations. In doing so, they help cultivate the analytical literacy and reasoning skills required in scientific and technological practice. Importantly, the effectiveness of these digital peer-review spaces depends on explicit instructor guidance and well-designed tasks, without such structure, students may prioritise procedural compliance over developing deeper analytical and communicative competencies (Nkomo & Butson, 2021).

Similarly, version-control and collaborative coding platforms used in professional software development offer valuable pedagogical possibilities across computing, engineering and related fields. GitHub is widely adopted example, but not the only one. Such platforms allow instructors to scaffold iterative problem-solving and make disciplinary workflows visible to students. Core functionalities such as branching, commit histories, and review mechanisms encourage learners to test alternative solutions, articulate their reasoning and engage productively with peer feedback. These support teamwork, project management and the co-

construction of shared outputs, skills that studies show are strengthened when students engage with structured collaborative coding environments (Patani, Tiwari, & Rathore, 2024). Rather than endorsing any specific application, the emphasis here is on how these systems, in general, combine technical skill development with opportunities for reflection, feedback and collaborative meaning-making, thereby supporting epistemic growth within technology-focused disciplines.

Taken together, these platforms create participatory learning environments in which students actively engage with disciplinary discourse and develop higher-order literacy practices essential for technology-based education. To avoid over emphasising any single platform and to provide a clearer overview of the wider technological landscape, it is useful to situate Moodle, GitHub, and similar tools within a broader set of digital platforms that support literacy and learning in technology-based educational contexts. Table 1 below summarises key categories of platforms, examples of widely used tools, and their major pedagogical functionalities, offering a comparative perspective that aligns with the reviewer's recommendation.

Table 1

Digital Platforms and Functionalities Supporting Literacy and Learning in Technology-Based Education

Platform Type	Examples of Tools	Key Functionalities for Tech-Based Education	Literacy and Reasoning Benefits
Learning Management Systems (LMS)	Moodle, Canvas, Blackboard	Structured peer review, rubric-guided assessment, iterative feedback cycles	Supports critical reading, structured evaluation, and understanding of disciplinary writing conventions
Collaborative Writing Tools	Google Docs, Microsoft Word Online	Real-time editing, commenting features, suggestion modes, version history	Enhances collaborative reasoning, co-construction of texts, and reflective revision practices
Version-Control and Collaborative Coding Platforms	GitHub, GitLab, Bitbucket	Branching, commit histories, review workflows, issue tracking	Develops analytical reasoning, revision transparency, teamwork, and documentation skills
Coding and Simulation Environments	Jupyter Notebook, Replit	Integrated code–text environments, executable examples, immediate feedback loops	Strengthens multimodal literacy through interpretation of code, narrative explanation, and visual outputs
Communication and Discussion Tools	Slack, Microsoft Teams	Threaded discussions, file-sharing, synchronous/asynchronous communication	Supports dialogic engagement, articulation of ideas, and collaborative problem-solving

This table highlights categories of digital platforms commonly used in technology-based education and summarises their core pedagogical functionalities. As

demonstrated here, these digital platforms collectively create participatory learning environments in which students can actively engage with disciplinary discourse and develop the higher-order literacy practices essential for technology-based education. Rather than functioning as ancillary technological add-ons, these tools enable learners to communicate technical ideas clearly, reason through complex problems collaboratively, and engage in iterative feedback processes that mirror professional practice. Their pedagogical value derives not from the specific brand or application used but from how instructors integrate these functionalities into purposeful curriculum design. When supported by explicit guidance and institutional resources, such platforms could bridge the gap between technical competence and academic literacy thereby ensuring more equitable and meaningful learning within digitally mediated educational environments.

Therefore as academic literacies are a pedagogical imperative, educators need to position reading, writing and digital communication at the core of student success rather than treating them as peripheral skills. Embedding these practices into technology-based curricula will not only foster comprehension and technical proficiency but also professional readiness, critical thinking, and equitable participation in increasingly complex and digitally

mediated learning environments. This approach is a shared responsibility that requires coordinated attention from instructors, institutions and policy-makers to ensure that all students can navigate the cognitive and communicative demands of contemporary science and technology education.

Conclusion

Academic literacy is a foundational component of meaningful participation and success in technology-mediated education. Curricula that embed discipline-sensitive literacy pedagogies equip students to interpret complex content, engage critically with technological knowledge, and communicate effectively in both academic and professional contexts. When literacy is neglected or assumed to be pre-existing, learning outcomes become uneven and educational inequities are exacerbated, particularly for students from under-resourced backgrounds who may lack prior experience with structured reading, writing and digital practices. Conversely, intentional, scaffolded, and digitally-mediated literacy instruction fosters equitable access to knowledge. Students are thus enabled to develop the cognitive and communicative skills required to interpret, produce and critically evaluate discipline-specific texts. Such approaches also prepare learners to participate confidently in increasingly

globalised and technologically mediated professional environments, transforming technology from a potential barrier into a tool for empowerment. By integrating theoretical frameworks, empirical evidence and illustrative examples, this paper demonstrates that academic literacies are recognised as a central pillar of technology-based pedagogy. Achieving this goal requires coordinated efforts from policymakers, educators, and institutions to embed explicit literacy instruction within curricula, provide sustained pedagogical support, and cultivate learning environments that fully enable students to thrive in contemporary science and technology education.

Recommendations

As technology-based education continues to expand in Nigerian higher institutions, there is a pressing need for research that captures the differentiated literacy demands of technological disciplines and assesses the effectiveness of emerging digital and multimodal pedagogies. Policy frameworks must evolve to position academic literacies as a core dimension of technological competence informing decisions on curriculum development, lecturer training and equitable access to digital infrastructure. Addressing these gaps will not only deepen the evidence base for effective pedagogy but also ensure that the transformative potential of technology-enhanced education is

realised across diverse learning environments.

The following recommendations outline key strategies for strengthening Academic Literacies within technology-based programmes:

1. Empirical Research on Discipline-Specific Literacies in Technology Programmes

Future studies should map the specific literacy demands of fields such as electrical engineering, computer science, information science and telecommunications. This includes investigating how students interpret technical diagrams, write design reports, document code or articulate problem-solving processes. Specific discipline-sensitive studies will offer clearer guidance for curriculum design.

2. Strengthen Lecturer Capacity in Academic Literacy Pedagogies

Even the best curriculum cannot succeed if the lecturers are not equipped to teach disciplinary communication. Building lecturer competence in multimodal and digital literacies, scaffolding strategies and discipline-sensitive writing instruction would create system-wide and long-term change.

3. Investigations into Equity, Access and the Digital Divide

More evidence is needed on how structural inequities such as access to high-speed internet, devices, and prior

literacy preparation shape students' engagement with technology-based courses. Research could explore how targeted literacy support can mitigate these inequities, especially for learners from under-resourced areas.

4. Research on the Efficacy of Digital and Multimodal Literacy Pedagogies

With the shift toward simulation-based and project-oriented learning, future research need to evaluate which types of multimodal literacy instruction (e.g., annotation tools, code-documentation frameworks, digital peer review platforms) are most effective in improving students' disciplinary communication. Comparative studies across institutions would also help identify scalable models.

5. Policy-Oriented Research on Institutional Literacy Infrastructure

Studies could examine how institutional policies such as curriculum review processes, lecturer training, funding for writing centres and support for digital learning enable or constrain the integration of academic literacies into technology curricula. This includes evaluating how universities implement ICT-in-education policies. Adopting these recommendations will help bridge literacy gaps, improve academic performance and prepare students to thrive in increasingly digital and technology-intensive learning environments.

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