ARTIFICIAL INTELLIGENCE IN EDUCATION

DIGITALIZED LEARNING AND RESEARCH PROCESSES

EDITOR
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PREFACE

This volume examines the transformative role of digital technologies in education, beginning with AI-powered research tools that are reshaping academic writing through enhanced data analysis, citation management, and literature synthesis. These innovations mark a shift toward more efficient and intelligent scholarly practices.

Subsequently, the integration of educational technology in Nigeria is critically assessed, with attention to policy, infrastructure, and pedagogical strategies. The chapter highlights both opportunities and systemic challenges in adopting digital tools across diverse learning environments.

The final chapter investigates the effects of e-content on student achievement and interest in technical education, focusing on automobile lighting systems in Niger State. It underscores the pedagogical impact of digital materials and their potential to improve engagement and learning outcomes.

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CHAPTER 1
AI-POWERED RESEARCH TOOLS: REVOLUTIONIZING ACADEMIC WRITING

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INTRODUCTION

The research landscape is undergoing rapid transformation; as traditional methods; manual literature reviews, keyword searches, and linear data analysis struggle to scale effectively. However, academic research has historically relied on curated bibliographic databases like Scopus and Web of Science, which provide high-quality, peer-reviewed, and well-indexed sources. While reliable, these traditional tools are increasingly inadequate in terms of speed and adaptability, especially as the volume of global publications continues to rise (Tomczyk et al., 2024). With knowledge production accelerating across disciplines, researchers are overwhelmed by the sheer volume of literature and the growing complexity of academic enquiry and writing. Academic writing is therefore, a key aspect of research and education, involving a structured method of expressing ideas. It is commonly used by researchers and educators in scholarly works to present data-driven arguments and logical reasoning. This form of writing helps readers to understand a topic thoroughly. It allows authors to deeply analyse concepts, leading to a well-explained theory or conclusion. Different fields use academic writing for various purposes. However, academic writing can be challenging, with difficulties varying depending on the writer and the field (Birjali, Kasri& Beni-Hssane, 2021).

In academic writing, one needs to handle vast amounts of information, complex ideas, theories and empirical data with understanding and clarity. This requires not only a deep understanding of the subject but also the ability to simplify complex ideas for the reader. Additionally, mastering the formal tone and specific terminology of academic writing can be difficult, especially for beginners. Asides that, maintaining academic integrity through proper referencing and citing of sources is crucial, but it can be time-consuming and challenging, particularly for those who are not native English speakers (Morris, 2018). Also, the pressure to publish in academia, known as the "publish or perish" ethos, adds stress and can lead to burnout. Meanwhile, writers must balance being informative with keeping the reader engaged. The need for coherence must therefore, be balanced with effective time management, as academic writing often competes with other responsibilities (Wieczorek & Mitręga, 2017).

The rapid acceleration in scholarly publication, combined with escalating demands on researchers' time and the increasing complexity of interdisciplinary work, has placed new burdens on academic writing. Moreover, when engaging in interdisciplinary research, writers face the challenge of combining different methodologies, terminologies and concepts from various fields, adding complexity to their work. Given these challenges, AI has become an invaluable tool in academic writing. Thus, AI-driven research tools offer an alternative. Applications like Elicit, Semantic Scholar, and SciSpace can interpret natural language queries, cluster documents by topic, and even summarise findings—thereby accelerating the discovery process. However, these benefits come with trade-offs, as AI-generated outputs can sometimes lack accuracy, completeness, or transparency (Bjelobaba et al., 2024). In this context, artificial intelligence (AI) – especially generative AI tools and AI enhanced literature discovery platforms – is emerging as a transformative force.

Nonetheless, AI-powered research tools are emerging as pivotal innovations that support the discovery, synthesis, and generation of knowledge. These tools, which leverage natural language processing (NLP), machine learning, and large language models (LLMs), are revolutionising how research is conducted, while also introducing new ethical and methodological challenges (Bjelobaba et al., 2024). According to de Villiers-Botha (2023), Artificial intelligence is becoming increasingly important in educational pedagogy, particularly in academic writing. By employing a qualitative methodology and a literature review as research design and methodology, the study effectively contributed to the achievement of its goal. To succeed in academic writing, scholars must develop AIED literacy, which includes application, reliability, accountability, and engagement (de Villiers-Botha, 2023). Also, the integration of Artificial Intelligence (AI) into educational practice has taken a transformative turn, particularly in the domain of academic writing. With the rise of AI-powered tools such as ChatGPT, Grammarly, Quillbot, and Elicit, the traditional process of writing—often seen as a linear, cognitively demanding task—has shifted toward a more dynamic, AI-assisted workflow. In the field of Education, this transformation is particularly significant. Academic writing is not only a means of assessment but also a central vehicle for developing pedagogical knowledge, critical reflection, and scholarly identity.

Educators, pre-service teachers, and educational researchers are increasingly leveraging AI tools for drafting assignments, generating research ideas, refining literature reviews, and ensuring linguistic accuracy. These tools are now shaping how education students learn to write and how scholars communicate findings.

More importantly, AI-powered writing assistants help with grammar, structure, citations and adherence to disciplinary standards. These tools are not just helpful but central to improving the efficiency and quality of academic writing. They enable writers to focus on the critical and innovative aspects of their research. Therefore, while academic writing can be challenging, AI tools greatly aid in this process, enhancing research productivity and improving work efficiency. However, while these tools offer undeniable benefits, they also raise pressing ethical, pedagoical, and professional concerns: What does it mean to "write" in an era when machines can generate text? How can educators ensure that AI augments rather than replaces student learning? This chapter addresses these questions by critically exploring the integration of AI-powered research tools in educational contexts, their benefits and risks, and the policy implications for responsible and equitable use. This chapter examines how AI is reshaping the academic writing process, considers its benefits and challenges, addresses ethical issues, and offers guidelines for responsible integration of AI in research and writing workflows. Thus, the chapter highlights the major ways in which AI tools can assist in academic writing, demonstrating their importance in advancing knowledge, supporting productivity and contributing to academic discourse.

1. VARIOUS ARTIFICIAL INTELLIGENCE TOOLS USED IN ACADEMIC WRITING

The area of academic writing and research is increasingly supported by a variety of AI tools, each tailored to meet specific needs. Tools like Zotero, Mendeley and EndNote are indispensable for literature management, efficiently organizing research materials, generating citations and seamlessly integrating with word processors. However, these tools do not extend support to text generation or writing assistance.

For enhancing writing quality, Grammarly and OpenAI's ChatGPT are pivotal, offering AI-driven grammar checks, plagiarism detection and text generation capabilities, which are crucial for crafting clear and original academic content. Yet, they lack in providing data analysis or reference management features.

Turnitin and Copyscape stand out in the domain of plagiarism detection, employing extensive databases to verify the originality of academic works. However, their functionalities are limited to plagiarism checking and do not encompass text processing or data analysis. In the sphere of data analysis, Tableau makes a significant impact by transforming complex data into visually comprehensible formats. Despite its strengths in data visualization, Tableau does not offer AI-generated content capabilities. Specialized AI tools like ArXiv and Semantic Scholar revolutionize the way researchers' access and summarize relevant academic papers, keeping them abreast of the latest developments in their fields through AI-driven mechanisms. For qualitative data analysis, NVivo, MAXQDA, Leximancer, Quirkos, ATLAS.ti and Dedoose are prominent, offering features like automated coding, sentiment analysisand pattern identification in voluminous text data.

Additionally, Provalis Research and RapidMiner amalgamate AI with text analytics, facilitating sophisticated qualitative analysis. Each of these tools, with their distinct AI integrations and functionalities, are selected based on the unique requirements of the research project, highlighting the diverse applications of AI in academic research and writing.

2. WHY RESEARCHERS NEED AI

The explosion of AI-powered tools includes several academic search engines designed to simplify the research process. These tools aim to help researchers grasp scientific papers and summarize major findings across a field. The key needs AI fulfills in this space are:

Managing the Growing Volume of Research

Academic research is growing exponentially, with thousands of papers published daily across fields.

Keeping up with this deluge of information is daunting, especially for researchers in fast-evolving disciplines like machine learning, where each year is dense with a century's worth of progress.

Literature Discovery

AI enables researchers to identify relevant papers efficiently. Tools like Consensus and Elicit use advanced search algorithms to surface highly relevant studies tailored to specific queries, reducing time spent manually sifting through databases.

Streamlining Literature Reviews

Synthesizing insights from hundreds of papers can be overwhelming. AI tools aid in summarizing findings, clustering related works and highlighting major themes.

Simplifying Reference Management

Properly organizing and formatting citations can be tedious. AI-powered reference tools streamline this process, saving researchers hours of manual effort. Incoporations with platforms like Zotero or EndNote enhance efficiency.

Enhancing Interdisciplinary Research

AI helps bridge gaps across disciplines by identifying connections between seemingly unrelated fields.

3. KEY CAPABILITIES OF AI-POWERED RESEARCH TOOLS

The following are the key capabilities of AI-Powered Research Tools:

Literature Search and Discovery

AI tools enable more flexible and dynamic search capabilities than traditional Boolean keyword searches.

For instance, in a comparative study, Tomczyk et al. (2024) found that while traditional databases such as Scopus and Web of Science excelled in the accuracy and quality of results, AI-powered tools like Elicit demonstrated greater uniqueness—surfacing less obvious but still relevant literature that traditional tools overlooked

Summarisation and Evidence Synthesis

Generative AI can summarise complex articles, compare methodologies across studies, and generate systematic review tables. This is particularly useful during scoping reviews and rapid evidence assessments.

Data Analysis and Modelling

AI is increasingly used in text mining, statistical modelling, and the detection of patterns in large datasets. It can also assist with data visualization and predictive analytics in fields such as healthcare, economics, and climate science (Bjelobaba et al., 2024).

Writing Assistance

From grammar correction and language translation to content structuring and referencing, generative AI tools like ChatGPT and GrammarlyGo offer robust writing support, particularly for early-career researchers and non-native English speakers (Eacersall et al., 2024).

Hypothesis Generation and Trend Mapping

By identifying gaps and trends in literature, AI tools can help formulate novel hypotheses. For instance, tools trained on interdisciplinary corpora can link concepts across seemingly unrelated domains, aiding exploratory research.

4. THE SIX DOMAINS WHERE AI CAN IMPROVE ACADEMIC FUNCTIONS

According to Khalifa and Albadawy (2024), the following are the six domains AI support in academics:

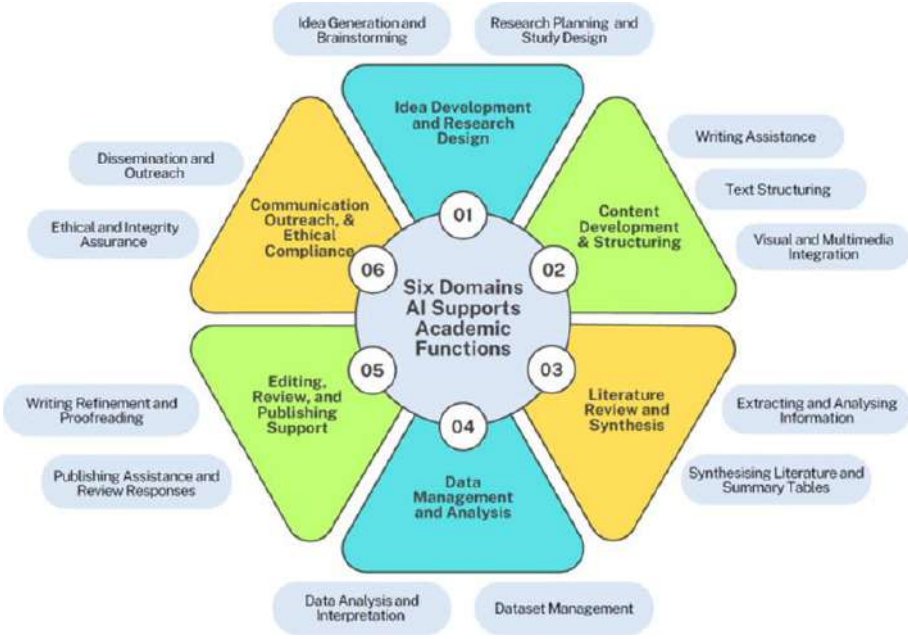

Figure 1. The Six Domains AI Supports in Academic Contexts

1. Idea Generation and Research Design: This include using AI to help brainstorm topics, identify gaps in literature, generate hypotheses and design studies.
2. Content Development and Structuring: AIhelps with expanding text, structuring (outlining), predictive or autocompletion, organising content so that ideas flow well.
3. Literature Review and Synthesis: This domain covers extracting, summarizing, comparing studies; synthesizing ideas from multiple sources; literature search and semantic analysis.
4. Data Management and Analysis: AI in this domainhelps with handling of datasets (curation, cleaning), interpreting data, visualising, doing statistical or computational analyses.
5. Editing, Review and Publishing Support: This involves AI tools for grammar correction, style editing, peer review assistance, formatting and preparing manuscripts for publication.

6. Communication, Outreach and Ethical Compliance: AI helps with communicating results to broader audiences, outreach activities, ensuring ethical integrity, avoiding bias, plagiarism and maintaining transparenc

4.1 AI Usage in Educational Contexts: Emerging Trends

Recent studies show that students in education faculties are among the most active users of AI writing tools, especially for support in language, structure, and academic tone. According to Trinka (2024), 86% of global university students report using AI-powered writing aids, with 42% using them for grammar correction and 33% for summarizing academic texts. In the United Kingdom, 92% of students in teacher education programs used generative AI for academic tasks in 2025 (Anara, 2025). Pre-service teachers often cite time constraints, academic pressure, and linguistic insecurity as reasons for adopting such tools (Ya'u & Mohammed, 2024).

Among educational researchers, the trend is also evident. Xu (2025), in a cross-disciplinary study of AI declarations in scholarly articles, found that education researchers were among the most transparent in disclosing the use of AI tools—mostly for editing and refining language rather than producing content. Moreover, faculty in education departments have been early adopters of AI-powered literature review tools like Research Rabbit and Elicit, which help synthesize pedagogical trends and theoretical frameworks.

However, adoption is not always accompanied by understanding. Bjelobaba et al. (2024) warn that in many teacher education programs, AI is being used without critical awareness of its limitations—particularly around bias, data provenance, and ethical considerations. This dual reality—high usage but uneven understanding—necessitates more structured approaches to AI literacy within education faculties.

5. BENEFITS AND OPPORTUNITIES OF AI IN ACADEMIC WRITING

Increased Efficiency: One of the most immediate advantages of AI is the time saved in drafting and revising academic work.

By automating mundane tasks—such as grammar correction, citation formatting, and summarizing articles—AI enables scholars to focus more on substantive intellectual contributions (Xu, 2025). This efficiency can be particularly beneficial for researchers working on tight deadlines, such as grant applications or time-sensitive publications. Enhanced Language and Readability: For non-native English speakers, AI tools serve as valuable aids in improving language fluency and clarity. These tools can help users rephrase sentences, correct idiomatic errors, and generate more academically appropriate language. In fact, students from linguistically diverse backgrounds report increased confidence and better engagement with academic writing tasks when supported by AI (Ya'u & Mohammed, 2024).

Improved Literature Discovery: AI-enhanced search platforms now allow for semantic searching—matching concepts rather than keywords—and topic clustering. This greatly improves the ability of researchers to uncover relevant literature that might otherwise be missed in traditional search engines. By offering smart recommendations, AI can help construct more robust and comprehensive literature reviews (Bjelobaba et al., 2024). Support for Drafting and Creativity: Generative AI tools such as ChatGPT can assist in overcoming writer's block by suggesting outlines, alternative phrasings, or paragraph transitions. This type of assistance, when used appropriately, enhances creative exploration without replacing the researcher's intellectual contribution (Xu, 2025).

Democratization of Access: Many AI tools are available at little to no cost, making them accessible to students and researchers who might not otherwise afford professional editing or academic consulting services. This lowers barriers for under-resourced institutions and contributes to a more equitable academic environment (Open Information Science, 2025). Literature Discovery and Efficiency: AI tools have significantly enhanced the discovery of literature. Semantic search engines, AI assisted databases, and smart recommendation systems enable scholars to identify relevant work more rapidly and with greater precision than traditional keyword based search alone. For example, some platforms now allow searches by concept rather than specific terms, facilitating uncovering publications that might otherwise be missed.

In consequence, researchers can build more comprehensive reviews in shorter periods, mitigating the effects of information overload that have long troubled academia. Beyond discovery, AI tools accelerate text summarization. By generating concise summaries of papers, AI helps writers grasp trends, arguments, and methodologies without reading every detail. Especially in the early stages of research, these tools reduce the cognitive burden and allow the researcher to allocate more attention to synthesis and critical insight rather than merely acquiring information.

Writing Assistance and Drafting: In addition to helping with discovery, AI tools provide assistance throughout the writing process itself. Grammar and style checkers can improve clarity, coherence, and readability; paraphrasing aids may help non native speakers rephrase sentences in idiomatic English; and generative models can assist with structuring an introduction, creating transitions, or proposing outlines. According to recent studies, tools like AI writing assistants and large language models are often used to enhance fluency, reduce drafting time, and improve textual clarity, particularly in contexts where access to human editing or mentoring is limited (MDPI, 2024; Xu, 2025).

These tools also show promise in helping to overcome writer's block by suggesting prompts or next-steps, or by offering alternative phrasings. When used appropriately, they thus serve as enablers of creativity rather than replacements. Productivity, Quality, and Access: Empirical research suggests that AI powered tools contribute to enhanced productivity. Users report being able to produce polished drafts more quickly, spend less time on routine writing tasks (grammar, style, citation), and focus their energy on argumentation, conceptual framing, and interpretation. For non native speakers, AI tools are especially valuable: they help bridge linguistic gaps, improving writing quality and, in many cases, increasing confidence in manuscript preparation (MDPI, 2024; Xu, 2025).

AI also lowers barriers to accessibility. Researchers and students with limited institutional support can use AI tools to perform literatures searches, generate summaries, or get feedback on writing structure. Moreover, when tools are made freely available or at low cost, they democratize access to certain writing supports.

Enhancing Academic Literacy: For students in education—particularly non-native English speakers or first-generation college attendees—AI tools offer scaffolding for improving academic literacy. Writing in education often demands precision, critical reflection, and alignment with specific citation styles (APA 7, for example). Tools like Grammarly or Quillbot help students improve clarity, sentence structure, and formal tone, thereby supporting writing development (Ya'u & Mohammed, 2024). These tools also aid in genre awareness—helping students distinguish between reflective writing, research essays, and lesson plan documentation. When guided by instructors, such tools can accelerate students' mastery of academic conventions.

Reducing Cognitive Load and Supporting Inclusive Pedagogy: Educational writing often requires complex synthesis: integrating theory with classroom practice, using reflective frameworks (e.g., Schön's Reflective Practitioner), and applying research methods. AI can support these tasks by helping students organize ideas, generate outlines, and propose initial thesis statements. This is particularly valuable for neurodivergent learners or students with disabilities, who may struggle with organizing long-form writing (Open Information Science, 2025). When used within Universal Design for Learning (UDL) frameworks, AI can act as a tool for differentiation—providing alternative entry points into academic tasks for learners with varied strengths.

Supporting Teacher Workload and Research Productivity: Educators themselves are leveraging AI to manage writing-intensive workloads. Whether preparing conference papers, policy briefs, or action research reports, tools like ChatGPT assist with preliminary drafting, editing, and formatting. For education faculty balancing teaching, supervision, and publication, these tools enhance productivity without compromising scholarly rigor—if used responsibly (Xu, 2025). Facilitating Literature Reviews and Pedagogical Research: AI-powered search tools like Elicit and Semantic Scholar are improving how education researchers conduct literature reviews. These tools allow for thematic clustering (e.g., studies on culturally responsive teaching or social-emotional learning), automatic summarization, and citation extraction—reducing the time required for systematic reviews or scoping studies (Bjelobaba et al., 2024). This is especially useful in fast-evolving subfields such as EdTech or equity-focused pedagogy.

Other benefits of AI in academic writing are as follows:

- AI-powered research tools offer several compelling advantages, such as:
- Speed and Efficiency: Automated literature reviews and data synthesis save significant time, enabling faster progression through research cycles (Tomczyk et al., 2024).
- Handling Volume and Complexity: AI enables researchers to navigate vast and interdisciplinary bodies of knowledge that would be overwhelming to review manually (Bjelobaba et al., 2024
- Novel Insight Generation: By uncovering underrepresented themes and unexpected correlations, AI tools can support creative academic enquiry.
- Equity and Access: These tools help democratize research by supporting scholars with limited access to research infrastructure or language expertise (Eacersall et al., 2024).

6. OBSTACLES OF USING ARTIFICIAL INTELLIGENCE IN RESEARCH: CHALLENGES, ETHICAL RISKS, AND LIMITATIONS

Despite the considerable promise, the use of AI tools in academic writing involves several significant risks.

Accuracy, Bias, and Hallucination: One of the most serious risks is the possibility of errors or "hallucinations" – AI generating content that is misleading or false (e.g., invented references or misstatements). AI models are trained on large datasets, which may contain biases, outdated information, or perspectives particular to certain regions or disciplines; these may be reproduced or even amplified in AI generated text (Bjelobaba, Waddington, Perkins, Foltýnek, Bhattacharyya, & Weber Wulff, 2024). Researchers must therefore verify facts, citations, and arguments supplied or suggested by AI tools.

Over reliance, Skill Erosion, and Critical Thinking: Another concern is over reliance on AI. When writers use AI for paraphrasing, sentence restructuring, or drafting, there is a risk that they may engage less deeply with the content and reduce their development of writing skills, critical thinking, and independent analytical skills (MDPI, 2024).

Education scholars warn that while AI can support self directed learning when integrated judiciously into curricula, it may undermine those very skills if used as a crutch. While AI can support learning, overreliance may hinder students' development of independent writing skills—central to becoming reflective educators. Ju (2023) found that students who used AI-generated responses for science writing tasks performed 25.1% worse in comprehension and critical reasoning tests. Similar risks may apply in education, where reflection and synthesis are key learning outcomes. Moreover, some students may misuse AI to generate entire assignments, raising concerns about plagiarism and academic dishonesty. Many institutions lack clear guidelines about what constitutes acceptable AI use in educational writing (Xu, 2025).

Authorship, Originality, Intellectual Property and Academic Integrity: Authorship and originality are complex issues. The use of AI raises the question of what counts as one's own intellectual work. Ethical guidelines increasingly stipulate that authors should disclose how AI was used in manuscript preparation (e.g., ChatGPT to generate drafts or paraphrase), to avoid misleading reviewers and readers. Failure to do so risks accusations of misrepresentation or plagiarism (Editage Insights, 2023; Bjelobaba et al., 2024). Moreover, AI's tendency to draw from existing texts may blur boundaries between legitimate paraphrase and unattributed reuse. Tendency of ambiguity concerning ownership and credibility when AI tool contributes to generation of ides, analysis, or writing.

Access, Cost, and Digital Literacy: While AI tools promise enhanced access, disparities in access remain. Many tools are subscription based or require infrastructure (fast internet, powerful hardware) not always available in less resourced regions or institutions. In addition, effective use of AI tools requires digital literacy: users must know how to evaluate AI output, spot errors, correct or reject suggestions, and integrate tools into their workflows. Studies have identified lack of access and limited digital literacy as major barriers (Open Information Science, 2025).

Ethical and Policy Challenges: Beyond individual skill and access, there are broader ethical and policy issues. Journals and institutions are developing different policies regarding disclosure of AI use in writing, criteria for authorship, and detection of AI-originated text.

There remains no global consensus, and researchers may be uncertain about acceptable practices (Xu, 2025; Bjelobaba et al., 2024). Privacy concerns (especially when uploading unpublished manuscripts or sensitive data to external platforms) and copyright concerns (if AI used texts draw from copyrighted material) are further ethical dimensions that must be addressed.

Transparency and Explainability/Trust Issues: Many AI models especially deep learning systems operate as "black boxes," making it difficult to understand how decisions are made.

Skill Concern and Interdisciplinary Obstacle: Some researchers lack formal training in AI, data science or machine learning, making it difficult to integrate these tools effectively.

Hallucinations and Accuracy Problem: Generative tools are more likely to produce fabricated or misleading contents, such as non-existent references or misattributed quotes.

Lack of Research Integrity: Improper use of AI tools can lead to plagiarism, duplication, or manipulation of data—violating norms of academic integrity (Bjelobaba et al., 2024).

Erosion of Reflective Practice: Reflective writing is a cornerstone of teacher education—used to evaluate teaching experiences, analyze classroom dilemmas, and develop pedagogical philosophy. If students delegate this process to AI tools, the deep metacognitive benefits of reflection may be lost (Ya'u & Mohammed, 2024). Teachers learn from reflecting, not just writing; this process must remain human-led.

Equity and the Digital Divide: Despite the promise of democratization, access to AI tools remains unequal. Students in under-resourced schools or Global South institutions often lack reliable internet, devices, or paid subscriptions. Without institutional support, AI may exacerbate existing inequities in education access and performance (Open Information Science, 2025).

Digital literacy: Digital literacy is another concern, not all students know how to prompt effectively, verify AI-generated content, or distinguish between reliable and misleading outputs.

Bias and Cultural Misrepresentation: AI tools trained on Western-centric datasets may fail to recognize culturally responsive practices or indigenous knowledge systems. This is problematic in education, where contextual relevance and cultural competence are vital. Biases in AI outputs can subtly reinforce deficit narratives or exclude diverse pedagogical perspectives (Bjelobaba et al., 2024).

7. BEST PRACTICES FOR RESPONSIBLE INTEGRATION

Given both the opportunities and risks, researchers and institutions should follow certain guidelines to ensure that AI tools enhance rather than compromise academic writing.

- Maintain Human Oversight: AI should assist, not replace, human critical judgment. All content suggested or generated by AI must be reviewed, verified, and edited by the author(s).
- Disclosure and Transparency: Authors should explicitly acknowledge the use of AI tools in manuscript or writing preparation, specifying which tools were used and in what capacity. This transparency aids peer reviewers, editors, and readers in assessing the authors' contributions and the fidelity of the work.
- Ethical and Institutional Policies: Universities and journals need clear policies defining acceptable use of AI, authorship implications, and criteria for integrity. These policies should align with broader norms of research ethics and intellectual property.
- Capacity Building & Digital Literacy: Training is essential: users should be taught not just how to use tools, but how to evaluate AI output critically, how to spot bias or error, and how to integrate AI use in ways that develop rather than diminish writing and analytic skills.
- Equitable Access: Efforts should be made to reduce disparities in access to AI tools. This might include licensing agreements, institutional support, open access tools, or funding to subsidize tool access in lower resourced settings.

- Verification and Accuracy Checks: Fact checking, source validation, citation accuracy, and avoiding over reliance on AI generated references are all critical. Tools should be used in conjunction with traditional scholarship practices.
- Digital Literacy Training: Institutions should provide training on how to use AI tools responsibly, interpret outputs critically, and integrate AI into research workflows without undermining intellectual rigor (Ju, 2023).
- Policy Development Universities and journals should develop clear, field-specific guidelines on AI usage, authorship, and integrity. These should address issues such as data privacy, citation standards, and the limits of acceptable AI contribution (Bjelobaba et al., 2024).

Moreover, to harness the benefits of AI while safeguarding educational integrity, the following practices are recommended:

- Integrate AI Literacy into Teacher Education Curricula Courses should include modules on the capabilities and limitations of AI in education, ethical usage, prompt engineering, and verification strategies. This prepares future teachers to both use and teach AI critically.
- Design AI-Transparent Assessments: Educators can ask students to reflect on how they used AI tools in their writing. This meta-cognitive element promotes honesty and encourages critical engagement rather than blind dependence.
- Use AI as a Formative Tool, not a Final Solution: Encourage students to use AI for brainstorming, outlining, or editing, but require them to submit drafts, peer feedback, and reflective logs that demonstrate their writing process.
- Promote Equity through Institutional Access; Schools and universities should provide free or subsidized access to vetted AI tools and ensure that students from disadvantaged backgrounds are not left behind in the AI revolution.
- Ensure AI Content is Reviewed by Humans: All AI-generated suggestions must be reviewed and critically evaluated. Human judgment remains essential, especially in fields like education where nuance, ethics, and context matter deeply.

7.1 Governance and Frameworks

Efforts are underway to establish ethical guidelines for the responsible use of AI in academic research:

AI Ethics and Regulatory Frameworks

As AI becomes more embedded in academia, national and international bodies will likely introduce ethical and regulatory frameworks governing its use. These may include auditability requirements, transparency in training data, and compliance with academic codes of conduct (Bjelobaba et al., 2024). The Ethical Framework (Eacersall et al., 2024) offers a practical approach to ethical GenAI use, focusing on transparency, critical engagement, and alignment with institutional policies.

AI Ethics and Regulatory Frameworks

As AI becomes more embedded in academia, national and international bodies will likely introduce ethical and regulatory frameworks governing its use. These may include auditability requirements, transparency in training data, and compliance with academic codes of conduct (Bjelobaba et al., 2024). Bjelobaba et al. (2024) highlight the need for clear disclosure of AI use, validation of AI outputs, and the incorporation of human oversight at all stages of the research process. Institutions are beginning to adopt internal guidelines for the ethical use of generative AI, including policies on plagiarism detection, authorship, and data protection (Ateriya et al., 2025).

7.2 Case Study: Comparing Traditional vs AI-Based Literature Search

In a notable study, Tomczyk et al. (2024) assessed nine e-commerce topics across four tools: Scopus, Web of Science, Elicit, and SciSpace. They found that: Traditional tools had higher reliability and recall, making them suitable for systematic reviews where completeness and precision are paramount. AI tools introduced novelty and relevance through semantic search, helping identify papers overlooked by traditional methods.

8. IMPLICATIONS FOR RESEARCHERS, INSTITUTIONS, AND POLICYMAKERS

- Researchers must develop AI literacy to use these tools critically and ethically, avoiding overreliance or misuse.
- Institutions should provide training and infrastructure, create usage policies, and ensure equitable access to advanced AI tools.

Journals and Publishers need to clarify standards for AI disclosure, authorship attribution, and the use of generative tools in manuscript preparation. Funding Agencies and Policymakers must support open-source AI research, ensure ethical governance, and address systemic disparities in access and digital literacy (Bjelobaba et al., 2024).

8.1 Empirical Findings and Patterns of Use: Adoption and Usage Trends

The adoption of AI in academic writing is now widespread among students and faculty alike. A recent global survey found that 86% of students use AI tools in their academic work, with common applications including grammar correction, paraphrasing, summarization, and idea generation (Trinka, 2024 Recent studies illuminate how AI tools are currently used and perceived in academic writing. For example, an analysis of AI declarations in scholarly articles found that ChatGPT was cited in 77% of AI usage declarations, with improving readability and grammar being the most common reported purposes (Xu, 2025).

In the United Kingdom, 92% of students reported using AI at least once for academic tasks in 2025—a significant increase from 66% the previous year (Anara, 2025). Similarly, AI adoption among faculty is growing, particularly for literature discovery, research organization, and drafting support (AACSB, 2025). Another study of PhD scholars in India reported that over 90% of respondents use AI tools, especially for literature reviews and research writing tasks, and identified cost, reliability, digital literacy, and ethical concerns as main barriers (Open Information Science, 2025). These empirical findings suggest both high uptake where possible and significant concern among users about misuse or unintended consequences.

Xu (2025) analyzed 8,859 research articles across 27 academic disciplines and found that 168 explicitly declared AI tool usage, most often ChatGPT. Among these, improving readability (51%) and grammar (22%) were the most common use cases, while very few reported using AI for conceptual development or data interpretation. In the Global South, the picture is similar. Ya'u and Mohammed (2024) surveyed 350 undergraduates in Nigerian universities and found that 75% had used AI tools—primarily for correcting grammar (85%) and structuring sentences (70%). However, a smaller percentage found AI effective for enhancing argument organization or thesis clarity, and nearly half of the participants expressed ethical concerns regarding AI use, particularly related to plagiarism.

9. TOWARD THE FUTURE: TRENDS AND RESEARCH DIRECTIONS

Several emergent trends point to how AI's role in academic writing may evolve. First, there is movement toward domain specific models trained in particular fields (e.g., law, medicine, humanities) that better understand discipline conventions, technical vocabulary, and methodological norms. Second, improvements in automatic fact verification, citation accuracy, and linking statements to primary sources are developing, which may reduce risks of hallucination or error. Third, collaborative research environments integrating AI tools — for literature mapping, visualization, drafting, peer feedback — are likely to become more seamless and user friendly.

Further research is needed in comparative studies across disciplines; longitudinal studies that assess effects of AI usage on writers' skills, critical thinking, and creative originality; and policy studies examining how institutions can harmonize ethical guidelines to support both innovation and accountability.

9.1 Future Directions

Discipline-Specific AI Tools: Next-generation AI tools are being designed for specific academic disciplines, enabling more accurate terminology usage and context-aware suggestions. For example, domain-trained models in medicine or law may soon surpass generalist models in utility and accuracy.

Integrated Research Platforms: AI tools are increasingly being integrated into collaborative platforms that support the entire research process—from idea generation and literature review to drafting, peer review, and publication. This could reshape research workflows entirely, especially in interdisciplinary collaborations. Fact-Linked Generative AI: Efforts are underway to build AI systems that link outputs directly to verifiable sources, reducing hallucinations and improving traceability. Such advances would support more ethical and robust research writing (Xu, 2025).

9.2 The Future of AI in Academic Research

As AI continues to evolve, more sophisticated tools and techniques are expected to emerge, while addressing all the current challenges.

Some potential areas for future development therefore include:

Advanced Natural Language Processing: Improved ability to understand and generate human-like text, leading to more accurate summaries and insights.

Cross-lingual Research: AI tools that can seamlessly translate and synthesize research from multiple languages, breaking down language barriers in academia.

Predictive Analytics: AI systems that can identify emerging research trends and potential breakthroughs before they become mainstream. In addition, as AI continues to evolve, its role in educational writing will deepen. Several future trends are worth noting:

AI Tutors for Writing Development: Personalized AI-driven feedback systems may soon guide students through scaffolded writing tasks—offering grammar tips, argument structure advice, and content suggestions based on learning progress.

Culturally Inclusive AI Models: Efforts are underway to train AI on multilingual and multicultural education data, improving inclusivity and reducing representational bias in AI outputs.

AI Policy Integration in Accreditation: National education bodies and accreditation agencies may soon require institutions to develop policies on AI use, both for student learning and faculty research.

Collaborative AI Platforms for Action Research: Integrated AI platforms may support teacher-researchers conducting classroom-based inquiry—helping with data coding, literature synthesis, and reporting.

AI is poised to transform academic research, offering powerful tools to manage information overload, streamline literature reviews and foster interdisciplinary collaboration. While challenges like hallucinations persist, ongoing innovations are addressing these issues, paving the way for more efficient and effective research processes. As AI continues to evolve, researchers who embrace these tools while maintaining critical thinking and verification practices will be best positioned to advance their fields and make groundbreaking discoveries.

AI research tools are likely to become even more embedded in academic workflows. Future systems may integrate real-time literature monitoring, predictive modeling of research trends and multimodal analysis combining text, images and data. If deployed responsibly, these technologies can democratize knowledge production, giving researchers in low-resource settings access to the same capabilities as those in well-funded institutions (Brynjolfsson & McAfee, 2014). However, achieving this vision requires robust governance frameworks, open-source alternatives to prevent over-commercialization, and interdisciplinary collaboration among computer scientists, ethicists, and domain researchers. This will ensure that AI serves as an enabler of rigorous, equitable and impactful scholarship.

CONCLUSION

AI-powered research tools are not a substitute for academic rigour, but they represent a powerful augmentation of it. As shown in comparative studies and systematic analyses; these tools can enhance research productivity, uncover novel insights, and democratize academic participation. AI-powered research tools are reshaping the landscape of academic writing in education. They offer unprecedented support in drafting, revising, and researching—particularly for students and educators navigating linguistic or cognitive barriers. However, they also raise pedagogical and ethical dilemmas that must be addressed with care. In the field of Education, writing is more than output—it's a process of learning, reflection, and identity formation.

To preserve this richness, AI tools must be used thoughtfully, ethically, and equitably. By embedding AI literacy into teacher education, designing responsible assessments, and promoting inclusive access, we can ensure that AI enhances rather than diminishes the transformative potential of educational writing. However, their use must be tempered by a strong commitment to ethical principles, transparency, and human oversight. The future of academic enquiry will be shaped not just by the capabilities of machines, but by how responsibly we integrate them into the scholarly ecosystem. In other words, AI-powered research tools are not a panacea. When used thoughtfully with human oversight, clear documentation and ethical guardrails, they can accelerate discovery, expand access and free scholars to focus on interpretation and theory. In sum. AI powered research tools are revolutionizing academic writing. When used judiciously, they promise greater efficiency, higher quality of expression, and more equitable access. However, these tools also carry risks – errors, bias, loss of originality, ethical ambiguity, and unequal access among them. The challenge for scholars, institutions, and publishers is to integrate AI tools in ways that uphold academic integrity, foster skill development, and ensure that the human intellectual contribution remains central. As the tools evolve, so too must accompanying practices, policies, and ethical frameworks.

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CHAPTER 2
EVALUATING EDUCATIONAL TECHNOLOGY AND INTEGRATION STRATEGIES IN NIGERIAN EDUCATIONAL SYSTEM

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INTRODUCTION

Education remains a cornerstone of national development, functioning as a catalyst for social transformation, human capital formation, and technological advancement. In the 21st century, its role has evolved beyond the transmission of knowledge to equipping learners with critical thinking, problem-solving abilities, and digital literacy skills that are essential for thriving in a highly interconnected and knowledge-driven world (UNESCO, 2022). The rise of educational technology has opened new frontiers for achieving these goals by providing innovative tools and platforms that redefine the processes of teaching and learning. Globally, the integration of technology into education has been acknowledged as a powerful driver of improved access, equity, quality, and efficiency in learning outcomes (Anderson & Dexter, 2020).

Educational technology encompasses the use of digital devices, software, online platforms, and multimedia resources to enhance teaching and learning experiences. Its applications are diverse, ranging from e-learning platforms, digital classrooms, and interactive simulations to virtual laboratories, mobile learning applications, and online assessment tools. The strength of these tools lies in their capacity to foster learner-centered education, promote collaboration, grant access to vast knowledge repositories, and facilitate personalized learning tailored to the unique needs of students (Johnson, Adams Becker & Cummins, 2019). Consequently, many nations have prioritized investments in ICT-driven education policies and infrastructure to strengthen their systems and prepare learners for participation in the global knowledge economy.

In Nigeria, the recognition of educational technology as a critical driver of change is reflected in policy initiatives such as the National Policy on ICT in Education (2019), which emphasizes the integration of ICT at all levels of the educational system. Complementary interventions, including the Nigeria Education Sector Plan and collaborative efforts with international partners such as UNESCO, UNICEF, and the World Bank, have further advanced the digitalization of learning in schools and higher institutions. Additionally, private stakeholders have introduced e-learning platforms, virtual libraries, and online courses designed to complement traditional teaching methods.

The COVID-19 pandemic highlighted the indispensability of educational technology in Nigeria, as schools and universities adopted digital tools to sustain academic activities amid nationwide lockdowns (Olatunji & Adebayo, 2021). Despite these commendable efforts, Nigeria continues to face serious obstacles in fully leveraging the benefits of educational technology. Challenges such as inadequate ICT infrastructure, unstable electricity supply, poor internet connectivity, and the high cost of digital devices hinder widespread adoption (Okebukola, 2020). Furthermore, disparities between urban and rural schools exacerbate the digital divide, leaving many students with limited or no access to digital resources. Teacher preparedness is another critical barrier, as many educators lack sufficient training in digital pedagogy and struggle to incorporate technology effectively into their instructional practices. In addition, gaps in policy implementation, insufficient funding, and resistance to change further impede the integration process (Adedokun-Shittu & Shittu, 2022).

These challenges underscore the need for a systematic evaluation of the strategies employed in integrating educational technology into Nigeria's educational system. Such an evaluation is vital not only for assessing progress but also for identifying gaps and proposing context-specific solutions that can drive sustainable outcomes. By examining both opportunities and constraints, this study aims to enrich the growing body of knowledge on ICT in education and provide evidence-based recommendations to policymakers, educators, and stakeholders. Accordingly, this study evaluates educational technology and integration strategies in the Nigerian educational system, focusing on the extent of digital tool utilization, the effectiveness of current approaches, and the barriers that limit full adoption. The study is particularly significant as it addresses the urgent need for a sustainable, inclusive, and transformative educational model that aligns with global best practices and adequately prepares Nigerian learners for the realities of the digital age.

1. CONSIDERATIONS IN EVALUATING EDUCATIONAL TECHNOLOGY AND SOFTWARE APPLICATIONS

Evaluating educational technology and software applications requires a balance between pedagogical and technical dimensions to ensure that digital tools are not only functional but also meaningful for teaching and learning. Several criteria considerations inform this evaluation process.

Pedagogical Relevance

A primary consideration is whether technology supports curriculum standards and instructional objectives. Reeves and Hedberg (2021) argue that educational technologies should be evaluated based on their capacity to promote active learning, foster critical thinking, and enhance knowledge retention. Digital simulations in science classrooms, for example, have been shown to improve conceptual understanding more effectively than traditional lecture-based methods (Johnson, Adams Becker & Cummins, 2019). However, Nigerian studies indicate that many applications introduced into schools lack contextual adaptation, thereby limiting their pedagogical relevance and overall impact (Okebukola, 2020).

Usability and User Experience

The usability of a system significantly influences its acceptance and sustained use by teachers and students. Nielsen (2012) highlights usability features such as intuitive navigation, clarity, and error prevention as critical factors in digital applications. Afolabi and Akinwale (2021) observed that Nigerian undergraduates were more inclined to engage with e-learning platforms that were simple, mobile-friendly, and easy to navigate, while overly complex interfaces discouraged participation, particularly among learners with low digital literacy skills.

Accessibility and Inclusivity

Accessibility ensures equal participation for all learners, including those with disabilities and students from underserved regions. UNESCO (2022) emphasizes inclusive design features such as screen readers, multilingual support, and offline capabilities.

Unfortunately, Adedokun-Shittu and Shittu (2022) report that many e-learning platforms in Nigeria are not optimized for rural settings with poor internet connectivity, thereby deepening the digital divide between urban and rural schools.

Technical Compatibility and Infrastructure

Another important factor is the extent to which technology is compatible with existing devices, networks, and institutional ICT infrastructure. Al-Fraihat et al. (2020), highlight that the effectiveness of e-learning platforms is closely tied to bandwidth, device performance, and technical support availability. In the Nigerian context, weak internet penetration, limited ICT facilities, and unstable power supply remain significant barriers to smooth technology adoption (Okebukola, 2020).

Cost and Sustainability

Financial feasibility is also a major determinant of successful technology integration. Subscription fees, licensing requirements, and maintenance costs must align with institutional budgets. Okebukola (2020), notes that many ICT projects in Nigerian schools are discontinued after initial implementation because of unsustainable costs. Therefore, evaluators must consider both affordability and long-term sustainability in resource-constrained environments.

Data Privacy and Security

The growing use of cloud-based applications raises concerns about data privacy and protection. Cavanagh and Finkelstein (2021) emphasize that compliance with privacy laws and the secure handling of student data are non-negotiable in evaluating educational technology. However, in many developing contexts, including Nigeria, weak enforcement of digital rights laws complicates efforts to safeguard sensitive student information.

Impact on Learning Outcomes

Ultimately, the effectiveness of educational technology must be measured by its impact on student learning. Siemens and Long (2019) argue that learning analytics provide valuable evidence of improvements in engagement, participation, and achievement. Afolabi and Akinwale (2021) found that platforms such as Google Classroom and WhatsApp enhanced student collaboration in Nigeria, although the benefits were uneven due to infrastructural constraints.

2. TOOLS AND FRAMEWORKS FOR EVALUATING EDUCATIONAL TECHNOLOGY

A range of models and frameworks guide systematic evaluation of educational technologies, ensuring a structured approach to adoption and assessment. These include:

Technology Acceptance Model (TAM)

Proposed by Davis (1989), the Technology Acceptance Model (TAM) evaluates adoption based on perceived usefulness and ease of use. In Nigeria, Adedokun-Shittu and Shittu (2022) applied TAM in higher institutions and found that perceived usefulness, rather than ease of use, was the strongest predictor of students' acceptance of e-learning platforms.

SAMR Model

Puentedura's (2014) SAMR model categorizes technology integration into Substitution, Augmentation, Modification, and Redefinition. Al-Emran, Mezhuyev, and Kamaludin (2018) reveal that in most developing nations, technology adoption remains at the substitution or augmentation stages, with limited progress toward redefinition. Similarly, Nigerian schools often replicate traditional teaching methods using digital tools instead of leveraging technology for innovative pedagogy.

TPACK Framework

The Technological Pedagogical Content Knowledge (TPACK) framework, developed by Mishra and Koehler (2006), assesses how teachers integrate content knowledge, pedagogy, and technology. Nigerian studies (Afolabi & Akinwale, 2021) suggest that many educators lack strong TPACK competencies, highlighting the importance of professional development in digital pedagogy.

ISO/IEC 25010 Software Quality Model

The ISO/IEC 25010 model provides an international standard for evaluating software quality across dimensions such as usability, functionality, and maintainability (ISO, 2011). While it is widely used in the corporate sector, its application in Nigerian education remains limited, though it offers a structured approach for assessing the robustness of educational software.

E-Learning Readiness Assessment Tools

E-learning readiness assessments examine institutional infrastructure, skills, and organizational support for digital education. Afolabi and Akinwale (2021) applied such frameworks in Nigerian universities and found significant gaps in technical infrastructure and digital literacy, which limit the effectiveness of blended learning initiatives.

Learning Analytics Dashboards

Learning Management Systems (LMS) such as Moodle and Google Classroom provide analytics dashboards that capture real-time data on learner engagement, participation, and performance. Siemens and Long (2019) note that such dashboards are invaluable for evidence-based evaluation and continuous improvement of technology-enhanced learning.

Usability Testing Instruments

Nielsen's (2012) heuristic evaluation and usability testing tools provide practical ways to assess user interfaces. In Nigeria, informal usability studies have shown that simplicity of language and mobile accessibility are critical for encouraging student engagement (Okebukola, 2020).

3. TECHNOLOGY INTEGRATION STRATEGIES BY CLASSROOM LAYOUT IN NIGERIA'S EDUCATIONAL SYSTEM

The design and arrangement of classrooms significantly influence how technology is integrated into the teaching and learning process. In Nigeria, classrooms range from conventional lecture-style seating to more flexible and technology-driven spaces. Each layout supports distinct strategies for incorporating digital tools and resources, with unique strengths and limitations.

The traditional row-and-column classroom layout remains one of the most common seating arrangements in Nigeria's educational system, especially in public schools where resources are limited and class sizes are often large. In this design, desks and chairs are arranged in straight rows facing the front of the classroom, where the teacher's desk and instructional board (chalkboard, whiteboard, or interactive board) are typically located. This arrangement reflects a teacher-centered model of instruction, emphasizing lecture-based delivery and one-way communication, with the teacher as the primary source of knowledge and authority (Okebukola, 2020).

One of the advantages of this layout is that it provides structure, order, and ease of classroom management. Teachers can maintain discipline more effectively since students' attention is directed toward the front, minimizing distractions from peer interactions. Furthermore, the arrangement accommodates a large number of learners, making it suitable for overcrowded Nigerian classrooms where student–teacher ratios are often high (Alalade, & IGE, 2023). This efficiency in space management is one reason it remains dominant in many schools across rural and urban settings.

However, the row-and-column arrangement has significant limitations, especially in the context of 21st-century education that emphasizes collaboration, problem-solving, and technology integration. The rigid seating pattern restricts group activities and student-to-student interaction, making it less effective for active or cooperative learning approaches (Olatunji & Adebayo, 2021). Technology use is also hindered, as devices like laptops, tablets, or interactive boards are more difficult to integrate seamlessly within such a static layout.

Students at the back rows may experience reduced visibility and engagement, which negatively affects inclusivity and equal participation in lessons (Alalade & Bamidele, 2023). In the Nigerian educational context, the traditional row-and-column model continues to persist because of infrastructural and financial challenges, such as inadequate classroom space, insufficient furniture, and limited access to digital tools. While it serves the purpose of order and teacher authority, researchers argue that it does not fully support innovative pedagogies or digital media integration, which are critical for preparing students for a knowledge-driven society (Musa, et al 2023).

In essence, the traditional row-and-column layout is a structured and practical arrangement that supports large class management in Nigeria. However, it is increasingly being criticized for its limitations in fostering collaborative learning, critical thinking, and digital technology adoption in classrooms.

4. CLUSTER OR GROUP LAYOUT IN NIGERIA'S EDUCATIONAL SYSTEM

The cluster or group layout is a classroom arrangement in which desks or tables are organized into small groups, usually made up of four to eight students facing each other. Unlike the traditional row-and-column arrangement, which emphasizes teacher authority and one-directional communication, the cluster layout is designed to promote collaborative and student-centered learning. In Nigeria, this approach is gradually gaining recognition under reforms such as the Universal Basic Education (UBE), which highlight the importance of active learning, teamwork, and digital integration. However, its adoption remains limited due to overcrowded classrooms, infrastructural deficits, and teachers' reliance on lecture-driven pedagogy (Adediran and Bello 2024).

The main purpose of the cluster arrangement is to encourage collaboration, peer learning, and student engagement. Within this structure, students are able to work in groups on assignments, research projects, and problem-solving activities, which enhance critical thinking and creativity. Peer-to-peer learning becomes more effective, as weaker students benefit from the guidance of stronger ones during collaborative discussions and digital tasks.

In addition, communication skills are improved because students engage in group debates, presentations, and teamwork activities that require negotiation and cooperation (Grewa, et al, 2023) The cluster layout also provides a flexible platform for technology integration. Mobile phones, laptops, and tablets can be shared among group members, making it possible to incorporate e-learning platforms and applications such as Google Classroom, Edmodo, Microsoft Teams, and WhatsApp groups. These tools enable students to collaborate on projects, share ideas, and complete assignments both within and outside the classroom. Furthermore, multimedia resources such as videos, simulations, and digital presentations can be projected for group discussion, thereby enriching the teaching and learning process (Alalade, & IGE, 2023). Recent empirical studies in Nigeria highlight both the potential and the challenges of this layout. For instance, Ogunbanjo and Adewale (2022) found that cluster-based seating arrangements in Lagos secondary schools significantly improved students' engagement in ICT-supported lessons when compared with traditional classroom setups. Similarly, Olatunji and Adebayo (2021) reported that Nigerian undergraduates in cluster classrooms demonstrated higher interaction with collaborative digital platforms such as Google Docs and Zoom breakout sessions than those in conventional lecture halls. In another study, Adediran and Bello (2024) observed that cluster arrangements enhanced peer-assisted digital learning, as students with stronger ICT skills supported their peers in navigating digital tasks.

Despite its benefits, the cluster layout faces significant barriers within the Nigerian context. Overcrowded classrooms, particularly in public schools, often with more than sixty students per class, make it difficult to arrange seating into clusters (Okebukola, 2020). In addition, infrastructural constraints such as inadequate internet access, lack of digital devices, and unstable electricity supply limit the effectiveness of ICT integration. Teacher preparedness is another major obstacle. Many Nigerian teachers are not adequately trained in digital pedagogy and classroom management for collaborative work, which hinders the success of group-based activities (Nwachukwu and Joseph, 2023). Assessment is also problematic, as measuring individual contributions within group projects can be challenging.

To address these challenges, scholars have made several recommendations. Ogunbanjo and Adewale (2022) suggest reducing class sizes and equipping schools with modular furniture that allows flexible arrangements. Odey, et al, (2024), recommend greater adoption of collaborative digital platforms such as Pad let, Jam board, and Google Docs to strengthen teamwork in cluster settings. Furthermore, Adediran and Bello (2024) emphasize the need for intensive teacher training in digital pedagogy, ensuring that educators acquire the skills to facilitate and assess group-based learning effectively.

In summary, the cluster or group layout has proven to be a powerful strategy for fostering collaboration, peer learning, and digital integration in Nigerian classrooms. While it holds promise for improving student-centered education, its success depends on addressing systemic challenges such as overcrowding, poor infrastructure, and inadequate teacher training. By investing in supportive policies and resources, Nigeria can maximize the benefits of the cluster layout to create more interactive, technology-driven, and inclusive learning environments.

5. COMPUTER LABORATORY LAYOUT IN NIGERIA'S EDUCATIONAL SYSTEM

The computer laboratory layout represents one of the most structured approaches to integrating technology into teaching and learning in Nigerian schools. In this arrangement, computers are installed in a dedicated room, often arranged in rows along the walls or clustered in groups around the center. Students rotate into the laboratory for specific lessons, particularly ICT-related subjects, digital literacy programs, or technology-enhanced instruction. This setup is common in urban secondary schools, polytechnics, and universities, although its availability and effectiveness vary widely across Nigeria depending on funding, infrastructure, and policy implementation.

The central purpose of the computer laboratory is to provide students with hands-on experience in the use of technology, ranging from basic computer operations to advanced digital applications. In such spaces, learners are exposed to productivity tools such as Microsoft Office, CorelDraw, and SPSS, as well as programming languages and internet-based research.

According to Al-Fraihat et al. (2020), lab-based learning environments provide structured opportunities for students to acquire digital competencies, enhance problem-solving skills, and access online educational resources. Nigerian studies similarly indicate that ICT labs have significantly improved digital literacy among students where functional (Afolabi & Akinwale, 2021).

A key advantage of the laboratory layout is that it allows direct supervision and guidance by the teacher. Educators often stand at the front or move around the lab, offering assistance while students engage individually or in small groups with the computers. This controlled environment makes it possible to deliver structured lessons such as step-by-step tutorials, software demonstrations, and supervised digital projects. Olori, & Saka, (2024) note that this arrangement fosters practical engagement, which is often absent in traditional classrooms where technology is teacher-centered and limited to projectors or whiteboards.

The computer lab also supports collaborative and blended learning. With internet connectivity, students can access e-learning platforms such as Moodle, Google Classroom, or Canvas to complete assignments and interact with digital resources. In higher institutions, some computer laboratories serve as hubs for online examinations, virtual labs, and research training. For example, Ekine & Chinwenwaru, (2024), found that undergraduates using university ICT labs for blended learning demonstrated higher proficiency in digital research and collaborative projects compared to peers relying only on mobile devices.

Despite these benefits, the effectiveness of computer laboratories in Nigeria is hampered by persistent challenges. Most laboratories are underfunded and poorly maintained, leading to outdated hardware, obsolete software, and frequent breakdowns (Okebukola, 2020). Internet connectivity, where available, is often slow and unreliable, particularly in public institutions. In rural schools, many computer labs are non-functional due to lack of electricity, inadequate funding, or insufficient technical support. In addition, access is often restricted because of large class sizes, meaning that students must share devices, which limits hands-on experience. Olori & Saka (2024), emphasizes that in many Nigerian secondary schools, the ratio of students to computers is far above UNESCO's recommended standard, undermining the goal of equitable digital literacy.

Teacher preparedness also poses a challenge. While some instructors are proficient in using ICT for teaching, many lack the necessary skills to effectively integrate digital tools into classroom practices. This results in underutilization of laboratory resources, where computers are confined to basic tasks such as typing practice rather than being applied to innovative or project-based learning (Olori & Saka, 2024)

Scholars have proposed several measures to strengthen the role of computer labs in Nigeria's educational system. Afolabi and Akinwale (2021) recommend sustained investment in ICT infrastructure, including regular upgrades and maintenance of laboratory facilities. Musa, et al (2023) stress the importance of internet-enabled labs to support blended learning, while Nwobodo, & Udoka, (2025) highlights the need for government partnerships with private organizations to equip rural schools with solar-powered labs. Furthermore, Obaje, et al (2023), argue that continuous teacher training in ICT pedagogy is essential to ensure that educators can maximize the potential of laboratory environments for student learning.

In conclusion, the computer laboratory layout remains one of the most practical strategies for integrating educational technology in Nigeria. It provides structured opportunities for digital literacy, collaborative projects, and internet-based learning. However, its success depends on sustained investment, infrastructural upgrades, teacher training, and policies that ensure equitable access across both urban and rural contexts. If properly developed, the computer laboratory can play a transformative role in preparing Nigerian students for participation in the digital economy.

6. THE U-SHAPED CLASSROOM LAYOUT

This has increasingly gained attention within Nigeria's educational system as a flexible and interactive arrangement that enhances both teaching and learning. In this layout, desks and chairs are arranged in a U-formation, leaving an open space in the center for the teacher or facilitator. This design encourages greater face-to-face interaction among students while also allowing the teacher to maintain eye contact with every learner in the classroom.

Unlike the traditional row-and-column format, which often limits collaboration, the U-shaped arrangement fosters active participation, peer-to-peer discussion, and a more student-centered learning atmosphere (Okebukola, 2020). One of the major strengths of the U-shaped layout is its ability to integrate technology seamlessly. For example, digital projectors, interactive whiteboards, or smart screens can be placed at the open end of the "U," ensuring all learners have a clear line of sight. Additionally, mobile devices such as tablets or laptops can be easily incorporated into group discussions, making the classroom more dynamic and technology-friendly. This configuration also supports blended learning approaches, where both face-to-face interaction and digital platforms complement each other (Bamidele & Fakuade, 2023).

Moreover, research highlights that the U-shaped design enhances classroom management and reduces disciplinary issues since the teacher can freely move within the open central area to monitor students' engagement (Emovavwerhe & Peretomode, 2024). In the Nigerian educational system, where large class sizes are common, this layout has been found particularly effective in promoting inclusivity and encouraging quieter students to contribute to discussions. It is especially beneficial in subjects that require critical thinking, debate, or project-based learning, as it shifts the emphasis from teacher-centered lectures to collaborative learning.

In summary, the U-shaped classroom layout provides an effective strategy for integrating technology into the Nigerian educational system while promoting collaboration, inclusivity, and active learning. By combining physical design with digital tools, this approach aligns with the global shift toward more interactive, student-centered pedagogy.

7. INTEGRATING TECHNOLOGY INTO SPECIFIC SECONDARY SCHOOL SUBJECTS IN NIGERIA

Integrating digital tools into the secondary curriculum in Nigeria is not a one-size-fits-all process; it depends on the nature of each subject, the pedagogical goals, and local constraints such as electricity, internet access, and teacher preparation.

Recent Nigerian studies show promising subject-specific models especially the use of virtual laboratories in the sciences, interactive simulations in mathematics and physics, digital storytelling for social studies and language arts, and learning-management tools for blended instruction — but they also highlight persistent equity and infrastructure challenges that shape what is feasible in practice.(Ubom, et al, 2025)

Biology (and other life sciences)

Biology is a subject that traditionally depends on practical laboratory work, and where virtual laboratories and simulations have the clearest, most immediate pedagogical payoff. In Nigerian secondary schools, validated virtual-lab packages and simulation tools have been developed and trialed; controlled studies report that students using virtual lab instruction perform better on achievement tests and retain concepts longer than peers taught by conventional demonstration or lecture-only methods. Virtual labs allow learners to manipulate diagrams, run experiments that would be unsafe or unaffordable in a physical lab, and repeat procedures until they master techniques advantages especially critical for schools with limited wet-lab facilities. However, the literature also shows a strong urban–rural gap: urban schools and well-funded institutions are much more likely to have the devices, connectivity, and teacher support needed to use virtual labs effectively, while many rural schools lack even basic ICT access. To realize the benefits at scale, authors advocate pairing virtual labs with teacher training, localized content, and offline-capable packages that work without continuous internet (Nura, et al, 2024)

Physics and Chemistry

Physics and chemistry benefit from interactive simulations and data-logging tools that make abstract concepts concrete. Nigerian studies using virtual lab or simulation strategies in physics classrooms show significant gains in both achievement and student interest: simulations let learners visualize forces, circuits, waves, and laboratory phenomena that would otherwise be difficult to demonstrate in under-resourced labs.

When combined with inquiry-based tasks (students design experiments, collect simulated data, and interpret results), simulations promote higher-order thinking and better conceptual understanding. The common constraints mirror those in biology: unreliable power, few classroom devices, and limited teacher expertise in running and contextualizing simulations for Nigerian curricula. Authors therefore recommend a blended approach that mixes low-bandwidth simulations, short teacher demonstrations, and hands-on activities where real materials are available (Anari, et al, 2024).

Mathematics

Mathematics instruction in Nigerian secondary schools benefits from dynamic visualization tools (e.g., GeoGebra, Desmos, localized interactive applets) that turn abstract algebraic and geometric relationships into manipulable objects. Empirical reviews and local studies indicate that students exposed to interactive mathematics software show improved understanding and retention, particularly when teachers use the tools to scaffold problem solving rather than merely as presentation aids. A recurring theme in Nigeria is that technology amplifies student interest and supports differentiation for example, adaptive practice apps can give weaker students more practice while extending advanced learners but the effectiveness depends on teacher skill in integrating these tools into lesson sequences and assessments. Recent work therefore emphasizes teacher professional development in technological pedagogical content knowledge (TPACK) and the localization of apps and examples to Nigerian contexts (Umer & Musa, 2022).

English Language and Literature / Languages

In language subjects, digital tools are used to support reading fluency, writing practice, vocabulary development, and spoken language skills. Digital storytelling, audio books, and collaborative writing platforms (e.g., Google Docs) have been trialed in Nigerian secondary classrooms with positive results: students become more engaged, produce richer written work, and gain confidence in oral presentations when multimedia is integrated into tasks.

Digital storytelling packages which combine narrative writing, images, audio and video have been shown in Nigerian studies to raise motivation and learning outcomes in civic education and language lessons. However, scalability is again constrained by device availability and teachers' familiarity with multimedia production; authors recommend simple, low-threshold tools (mobile apps, voice recordings, storyboards) and scaffolded teacher training (Celestine, et al, 2024).

Social Studies, Civic Education and History

Social sciences and history lend themselves to multimedia resources and local digital archives. Integrating documentary video, geo-mapping, primary source digitization, and digital storytelling enriches contextual understanding and civic literacy. Recent Nigerian research using digital storytelling in civic education found improved engagement and positive attitudes toward the subject, demonstrating how multimedia can make abstract civic concepts more tangible for adolescents. As with language subjects, authors stress culturally relevant content and teacher facilitation, rather than tech use for its own sake. (Celestine, et al, 2024).

Computer Studies / ICT and Vocational Subjects

For Computer Studies and vocational subjects, technology is both the medium and the content: practical, hands-on exposure to office productivity suites, basic programming environments (e.g., Scratch, Python), and business-simulation software is essential. Nigerian tertiary and some secondary institutions that maintain functional computer labs report better digital skills outcomes, and CBT (computer-based testing) preparation has accelerated the development of networked labs. The priority here is ensuring reliable lab maintenance, up-to-date software, and teacher capacity to teach project-based ICT skills rather than rote commands. Hybrid lab models (desktops + low-cost tablets or shared laptops) and solar-powered solutions are proposed to mitigate power and maintenance challenges in less resourced schools (Nura, et al, 2024).

8. BLENDED AND LMS-SUPPORTED APPROACHES ACROSS SUBJECTS

Across subjects, Nigerian studies during and after the COVID-19 disruption documented increased use of LMS platforms (Google Classroom, Moodle), messaging apps (WhatsApp) and video conferencing for blended instruction. Where used well, these platforms extended classroom dialogue, supported flipped-classroom models (students view content at home, apply knowledge in class), and simplified assignment tracking. Empirical work indicates these platforms are particularly effective when integrated into assessment practices and when teachers receive ongoing technical and pedagogical support. The evidence also highlights that many implementations were emergency responses with uneven quality; to achieve sustainable blended models, researchers recommend investments in teacher training, offline content caches, and policies that subsidize data or provide school-based connectivity (Cristie-Ann, 2022).

9. CROSS-CUTTING CONSTRAINTS AND MITIGATION STRATEGIES

The Nigerian literature consistently identifies several cross-cutting barriers that shape how technology integration actually plays out in classrooms: unstable power supply, inconsistent internet connectivity, shortage of devices, lack of routine maintenance, and gaps in teacher competence. These structural issues explain why many high-impact interventions (virtual labs, simulations, LMS-driven blended learning) succeed in pilot urban settings but struggle to scale into rural or underfunded schools. Current authors therefore recommend layered strategies: (1) design or procure offline-capable or low-bandwidth digital resources; (2) prioritize teacher professional development focused on subject-specific tech pedagogy (TPACK); (3) deploy solar or generator backup for critical lab infrastructure; (4) localize digital content (language and curriculum alignment); and (5) foster school–industry partnerships for maintenance and device provision. These combined measures increase the likelihood that pedagogically appropriate technologies actually improve learning outcomes across diverse Nigerian contexts (Nura, et al, 2024).

Finally, Subject-by-subject integration in Nigeria shows clear patterns: virtual labs and simulations work particularly well in science and mathematics; digital storytelling and multimedia enhance language and social-science learning; and blended LMS approaches support continuity and flipped pedagogy. However, structural constraints — power, connectivity, devices, and teacher preparation — determine whether these benefits materialize for the majority of students. Recent Nigerian research therefore argues for pragmatic, context-sensitive implementations: prioritize low-bandwidth/offline solutions, invest in subject-specific teacher training, and pair technology deployments with sustained maintenance and policy support.

CONCLUSION

The assessment of educational technology and its integration strategies within Nigeria's educational system highlights a dual landscape of promise and limitation. While digital tools, platforms, and instructional technologies hold significant potential to transform teaching, learning, and administrative processes, numerous challenges persist. These include inadequate infrastructure, limited digital literacy, insufficient teacher preparation, and gaps in policy implementation. Traditional classroom layouts such as the row-and-column arrangement remain prevalent, offering structure and control but limiting collaboration and interactive technology use. By contrast, alternative layouts—such as clusters, laboratories, and U-shaped designs—create opportunities for more student-centered, interactive, and technology-driven learning experiences.

Overall, the findings emphasize that successful integration of educational technology in Nigeria extends beyond the mere availability of devices or platforms. It requires a comprehensive and context-sensitive approach that incorporates the redesign of classroom environments, continuous teacher capacity building, sustained investment in ICT infrastructure, and inclusive policy frameworks. Ultimately, meaningful adoption will depend on strategies that reflect Nigeria's unique educational, cultural, and socio-economic realities.

Recommendations

Based on the findings of this study the following recommendation were made:

- The Nigerian government, in partnership with the private sector, should prioritize investment in ICT infrastructure. This includes ensuring stable electricity supply, expanding broadband internet access, and equipping classrooms with modern digital technologies, especially in rural and underserved regions.
- Sustained professional development is essential for effective technology integration. Regular workshops, seminars, and continuous in-service training should be provided to enhance teachers' digital literacy and equip them with practical pedagogical skills for integrating technology into daily classroom instruction.
- ICT-in-education policies must move beyond documentation to actionable implementation. Existing policies should be reviewed, updated, and supported with robust monitoring and evaluation frameworks to track progress and ensure accountability.
- Schools should gradually transition from the traditional row-and-column seating arrangement to more flexible layouts such as clusters, laboratories, and U-shaped designs. These layouts encourage collaboration, creativity, and more effective use of technology in teaching and learning.
- Collaborations between government agencies, NGOs, and private technology firms should be expanded to provide funding, technical expertise, and innovative solutions that sustain ICT initiatives in schools across Nigeria.
- Closing the digital divide requires deliberate measures to ensure inclusivity. Affordable devices, subsidized internet services, and locally relevant digital content should be provided to learners across socio-economic groups, including those in remote communities.
- Digital resources and educational software should be developed to reflect Nigeria's curriculum, indigenous languages, and cultural context. This will enhance learner engagement and ensure relevance to the Nigerian educational environment.

- There is a need for ongoing research to evaluate the effectiveness of various technology integration strategies. Findings from such studies will inform policy adjustments, guide best practices, and ensure that Nigeria's educational system remains adaptive to evolving digital trends.

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CHAPTER 3
EFFECTS OF e-CONTENT ON STUDENTS' ACHIEVEMENT AND INTEREST IN LEARNING OF AUTOMOBILE LIGHTING SYSTEM IN TECHNICAL COLLEGES IN NIGER STATE, NIGERIA

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INTRODUCTION

The standpoint for the vocational institutions in Nigeria is the Technical Colleges (TC). At the TC, training in Motor Vehicle Mechanic (MVM) is conducted from TC I to TC III. The primary objective of the MVM at the TC is to equip students with the necessary skills and knowledge for employment in the workforce (Mustapha et al., 2024). In accordance with the stated objective, the curriculum emphasises, among other things, field studies and guided discovery. At the TC, Auto-mechanics is divided into the following departments: engine maintenance and refurbishing, and auto-electricity. The automotive electrical system is further divided into the following components: sensors, battery, ignition, charging, starting, and the lighting system (Idris et al., 2014). The automobile lighting system syllabus encompasses headlights, filament lamps, headlight alignment, lighting circuits, direction indicators (also known as turn signals or flashing lights), and lighting faults, along with their corresponding remedies. This study aims to provide the MVM course that meets societal needs through its relevance and functionality in content, application, process, and teaching method.

The method employed for successful teaching and learning is a concern to educators, as the teaching methods play a crucial role in stimulating students' creative and critical thinking by encouraging teamwork in viewing an event or problem from multiple perspectives (Chiu & Hwang, 2024). These can only be achieved when a proper instructional method is used that enables MVM practitioners to acquire both cognitive and psychomotor competencies in the use of automobiles (Aliyu & Ewugi, 2015; Mustapha et al., 2020).

Today, the complexity in the automobile industry is growing exponentially in response to the need for technologies to achieve low pollutant discharge and to maintain the pace of its development through Information and Communication Technology (ICT). ICT is an acronym that combines Information Technology (IT) and Communication Technology (CT). Mustapha et al. (2024) defined the terms IT and CT, respectively, as tools to process, manipulate, and manage information, while the latter refers to everything linked with the utilisation of tools to process and convey data from one device to another. Mustapha et al. (2022) stated that the application of ICTs in education is divided into two broad categories: ICTs in education and ICTs for education.

The former deals with the implementation of general components of ICTs in the teaching and learning process, while the latter involves the development of ICT for teaching and learning purposes (Zhiri et al., 2024).

The introduction of ICT into automobile technology has brought about a notable revolution in the organisation of instruction, tests, and exams for automobile students. As such, the applications of ICTs in the school depend on the teacher (Khan et al., 2025). On the other hand, mastering and utilising ICT skills to create an improved teaching and learning environment is of utmost importance for teachers in fostering a new learning culture (Divya & Sindhu, 2025). As a result, Abdullahi et al. (2025) stated that to address the inadequacy of curriculum-aligned content for students and teachers in secondary schools and tertiary institutions in Nigeria, a resourceful, stimulating, and creative approach is needed, with a greater emphasis on self-directed learning rather than relying solely on handbooks and syllabi. This necessitates the development of an e-content platform.

E-content means content in electronic form. Abubakar et al. (2019) defined e-content as digital images and text intended for display on web pages. Similarly, Bankar et al. (2023) viewed it as any digitalised content that can facilitate the progress of the learning process and/or outcome. Eremenko & Simakova (2024) further explain that e-content is a blending of animation, audio, video, images, and text. Four different channels are required for the possession of these contents, including the procurement of materials, the use of freely available content on the internet, the creation of new material, and the exchange of available content within a network with other institutions of higher education (Chen et al., 2025). e-content learning materials focus on the cognitive, emotional, behavioural, and contextual perspectives of both the teacher and the student (Martínez-Borreguero et al., 2020; Sahraie et al., 2024). The future teacher will understand that they are transitioning from a provider of facts to one that facilitates a learning environment, and the student will be placed at the centre instead of the educator. Asad et al. (2021) argue that information does not automatically become knowledge until learners have been actively involved in its processing. In developing a knowledge society, integrating ICT (e-content) at all levels of education is essential.

Aligning the significant demands and preferences of students with the higher learning achievement of teachers and students in learning automobile lighting systems in Niger State technical colleges, the method of learning automobile lighting systems in technical colleges in Niger State will entail a rethink in the methodology used in teaching automobile trade. Such a methodology should incorporate the use of e-content. In teaching automobile lighting systems via e-content, the processes of giving and taking, talking and listening, describing and witnessing help expand horizons and foster common understanding among students, enabling them to gain knowledge when appropriate information is presented and processed. This approach enhances students' interest and achievement in automobile lighting systems. Teachers' inappropriate teaching methods appear to weaken students' interest in learning. Given its central role in shaping how students engage with and sustain learning, it becomes necessary to investigate how e-content instruction influences students' interest in learning the automobile lighting system.

Beyond academic achievement, students' level of interest serves as a powerful indicator of how well e-content instruction can foster motivation and sustained engagement in learning the automobile lighting system. Potvin et al. (2020) identified individual interest as a factor that determines achievement. A most favourable level of students' interest must be maintained and fostered to ensure effective learning. Höft & Bernholt (2021) define interest as the feeling of intentness or curiosity about something. Students listen with rapt attention and engage deeply in a learning activity that captures their interest and holds their attention. Interest can influence how well one learns and what one knows. Renninger & Hidi (2022) assert that learners attend to and remember events, images, and readings that are related to their interests. Thorsen et al. (2021) argue that poor academic achievement is due to students' lack of interest in the subject matter and the attitude of the teachers who teach the students. The type of interest a student brings to the classroom significantly influences the student's level of achievement or failure in a particular subject (de Vries et al., 2024; Neroni et al., 2022). This implies that if a student has a positive interest in studying a specific topic, that student would also derive satisfaction from the knowledge of the subject, irrespective of gender.

Gender is, therefore, another factor that seems to influence pupils' achievement in learning. Ivan et al. (2023) view gender as a range of characteristics distinguishing males and females, particularly in the masculine and feminine attributes assigned to them. Over the years, education has focused on closing the gender registration gap, while insufficient attention has been paid to the achievement and retention, as well as the quality and fundamental role, of Technical Vocational Education and Training (TVET).

Despite the fundamental function played by TVET, the method of teaching it is, to a certain extent, not highly effective in most of the technical colleges in Nigeria to give the student-teachers the prospect to think autonomously and conceptualise the strong points of the subject matter due to inadequate and low-quality instructional strategies in the classroom. For this reason, the method used by teachers in sharing information with students is an aspect influencing learning at all levels of the education system (Kasim & Joseph, 2022; Zobia et al., 2025). This is because today's society is becoming increasingly dependent on digitalised devices. As such, it has become inevitable for students to live and work in the digital world. As a result of the above-mentioned problems, United Nations Educational, Scientific and Cultural Organization (UNESCO) expressed concern that traditional structures and methods of teaching and learning are less responsive to the challenges of turbulent times, as the instructional delivery system fails to effectively keep pace with the rapid obsolescence of skills, especially in the automobile industry (He et al., 2024). Hence, this necessitates a change in the instructional methods used in teaching and learning automobile lighting systems in technical colleges in Niger State, to enable the products of these colleges to obtain an integrated knowledge of the affective, cognitive, and psychomotor skills required in the work.

1. AIM AND OBJECTIVES OF THE STUDY

This study aims to determine the effects of e-content on students' achievement and retention in learning the automobile lighting system in technical colleges in Niger State, Nigeria. Distinctively, the study seeks to identify the effect of e-content on students':

1. Achievement in Learning Automobile Lighting Systems in Technical Colleges in Niger State.
2. Achievement in Learning Automobile Lighting Systems in Technical Colleges in Niger State, Based on Gender.
3. Interest in Learning Automobile Lighting Systems in Technical Colleges in Niger State.

1.1 Research Questions

The study provides answers to the following questions:

1. What are the effects of e-content on students' achievement in learning the automobile lighting system in technical colleges in Niger State?
2. What are the effects of e-content on students' achievement in learning automobile lighting systems in technical colleges in Niger State based on gender?
3. What are the effects of e-content on students' interest in learning automobile lighting systems in technical colleges in Niger State?

1.2 Hypotheses

The following null hypotheses were formulated and tested at a $P < .05$ level of significance.

HO1: There is no significant difference in the mean achievement scores of students taught an automobile lighting system using the e-content instructional strategy and the conventional method of teaching

HO2: There is no significant difference in the mean achievement scores of students taught an automobile lighting system using the e-content instructional strategy based on gender.

2. METHODOLOGY

The study employed a quasi-experimental design with a pre-test and post-test, using a nonequivalent comparison group. Intact classes were assigned to treatment groups. The study population consisted of 203 TC II Motor Vehicle Mechanic (MVM) students, comprising 197 males and six females. Sixty-four TC II students in GTC Minna constituted the treatment group assigned to the conventional teaching method.

In contrast, 139 TC II students in Sulaiman Barau Technical College (SBTC), Suleja, were assigned to the e-content instruction method. SBTC Suleja was purposively sampled, as the study aims to determine students' achievement based on gender. SBTC Suleja is the only technical college in Niger State that had female students in the 2017/2018 academic session. GTC Minna was randomly selected among the technical colleges in Niger State. The instrument used for data collection was the Automobile Lighting System Achievement Test (ALSAT). ALSAT was subjected to face and content validation by three experts in MVM. ALSAT was trial-tested to determine its psychometric indices. A total of 20 items of ALSAT had good difficulty and discrimination indices. Cronbach's Alpha was used to determine the reliability coefficient of ALSAT, and it was found to be 0.86.

A pre-test was administered to the sampled students in their intact classes. This lasted for 30 minutes. To achieve the study's objective, the students underwent 6 weeks of formal instruction. The subject teachers were used as research assistants. The researcher provides a written lesson plan that has been validated by experts in MVM. The lesson plan serves as a guide for the research assistant to use for the treatment groups. The research assistants taught all the topics in the treatment groups. The method of teaching in the treatment groups involved the use of e-content.

In contrast, the experimental and control groups received conventional teaching methods, respectively. The questions administered as a pre-test were also given as a post-test as formal instruction in the class. The scores acquired from the post-test exercise provided post-treatment data for the study. The ALSAT was re-administered as a retention test after a two-week interval.

The ALSII was developed based on the study's objectives and the literature reviewed. ALSII consisted of two (2) sections, in which the first section indicates the introductory part of the respondents, and the second part is the questionnaire items. Twenty item statements were generated for the study. The mean and standard deviation are used to answer the research questions. In contrast, Analysis of Covariance (ANCOVA) was used to answer the null hypotheses.

3. RESULTS

Research Question 1: What are the effects of e-content on students' achievement in learning automobile lighting systems in technical colleges in Niger State?

Table 1. Mean and standard deviation of experimental and control groups on the effects of e-content

Achievement						
		Pre-test		Post-test		
Group	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean Gain**
Experimental	139	48.35	2.728	88.63	3.912	40.28
Control	64	47.86	2.836	59.88	3.108	12.02

The data in Table 1 show that the experimental group had a mean of 48.35 and a standard deviation of 2.728 in the pre-test, and a mean score of 47.86 and a standard deviation of 2.836 in the post-test, resulting in a pre-test-post-test gain of 0.49. The control group had a mean score of 47.86 and a standard deviation of 2.836 in the pre-test and a mean of 59.88 and a standard deviation of 3.108 in the post-test, resulting in a gain of 12.02. With this result, the treatment groups are effective in enhancing students' achievement in automobile lighting systems; however, the effect of e-content on students' achievement in automobile lighting systems is higher than that of the conventional teaching method.

Research Question 2: What are the effects of e-content on students' achievement in learning automobile lighting systems in technical colleges in Niger State based on gender?

Table 2. Mean and standard deviation of experimental and control groups on the effects of e-content

Achievement (Gender)						
		Pre-test		Post-test		
Gender	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean Gain**
Female	6	1.68	0.73	2.77	0.73	1.09
Male	197	21.76	0.86	48.81	0.81	27.05

The data in Table 2 indicate that the female had a mean of 1.68 and a standard deviation of 0.73 in the pre-test, and a mean score of 2.77 and a standard deviation of 0.73 in the post-test, resulting in a pre-test to post-test gain of 1.09. The male had a mean score of 21.76 and a standard deviation of 0.86 in the pre-test and a mean of 48.81 and a standard deviation of 0.81 in the post-test, resulting in a gain of 27.05. This implies that the male performed better than the female in teaching and learning of the automobile lighting system using e-content.

Research Question 3: What are the effects of e-content on students' interest in learning automobile lighting systems in technical colleges in Niger State?

Table 3. Mean and Standard Deviation of Respondents on Pre-test and Post-test Interest Scores

Students Interest						
		Pre-test		**Post-test**		
Group	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean Gain**
Experimental	139	38.52	2.95	76.49	3.91	37.97
Control	64	35.21	2.84	69.62	3.11	34.41

The data in Table 4.3 show that the experimental group had a mean of 38.52 and a standard deviation of 2.95 in the pre-test, and a mean score of 76.49 and a standard deviation of 3.91 in the post-test, resulting in a mean gain of 37.97 from the pre-test to the post-test in the experimental group. The control group had a mean score of 35.21 and a standard deviation of 2.84 in the pre-test and a mean of 69.62 and a standard deviation of 3.11 in the post-test, resulting in a mean gain of 34.41. Therefore, the experimental group had a higher mean interest gain of 37.97, which appears to have a greater effect on students' interest in automobile lighting systems within the covered content areas than the control group, with a mean interest gain of 34.14.

Test of Hypotheses

All the stated hypotheses were tested at 0.05 level of significance:

Table 4. Summary of Analysis of Covariance (ANCOVA) of the Students' Achievement and Interest Scores in Automobile Lighting System

Source	Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	209.2270	2	17.437	2.432	0.000
Intercept	504.2260	1	504.224	84.230	0.000
Pre-test	0.9500	1	0.950	4.589	0.003
Method	202.9422	2	488.790	3.768	0.059
Gender	0.0020	1	0.443	2.936	0.106
Method and Gender	0.3270	2	0.446	2.623	0.105
Error	93.9780	454	0.208		
Total	1011.6452	463			
Corrected Total	209.6435				

The data presented in Table 4 show that e-content, as a main effect, is significant on students' achievement in ALSAT. This is demonstrated by the calculated F-value of 3.768, which is substantial at p = 0.059 and therefore equally important at the 0.05 level of probability. Hence, the null hypothesis of no significant difference is rejected in favour of the alternative. This implies that there is a substantial difference in the mean achievement scores of students in the treatment groups. Therefore, e-content is significantly superior to the conventional teaching method in enhancing students' achievement.

It was also revealed that the observed difference in the main achievement scores of students based on gender was not significant. This is indicated by the calculated F-value of 2.936, which is not significant at p = 0.106 because it is greater than 0.05. Consequently, the null hypothesis was accepted. This provides the impetus to conclude that there was no significant difference in students' achievement in automobile lighting systems based on gender.

4. FINDINGS OF THE STUDY

The results of the findings indicated that:

- E-content has a significant positive effect on students' achievement in learning the automobile lighting system.
- E-content has a more substantial positive effect on students' interest in learning the automobile lighting system compared to conventional teaching.
- The effect of e-content on students' achievement based on gender was not statistically significant.
- There is no significant interaction effect of method and gender on students' achievement.

4.1 Discussion of Findings

The effect of e-content on students' achievement is higher than the effect of the conventional teaching method on students' achievement. This implies that students in the experimental group had a higher mean gain compared to their counterparts in the control group after treatment. In this connection, there is a significant difference between the treatment group's achievement. The findings support those of Mustapha et al. (2024), Odika (2024), and Ike et al. (2020), who reported that the use of technology in this way plays a vital role in the teaching and learning process, especially in improving student academic achievement, retention, and skill performance in MVM. In a similar vein, the findings of Dap-og & Orongan (2022) also revealed that students' achievements increase when the Computer-Based Instruction (CBI) technique is used for instructional delivery.

The study revealed no significant differences in the achievement of male and female students based on the use of e-content in automobile lighting systems. Therefore, it can be concluded that the use of an e-content-based learning package is effective in enhancing student achievement in automobile lighting systems, benefiting both male and female students. In support of the findings of this study, Stoet & Geary (2018) reported that gender was not a significant factor in the students' achievement in science and technology classes when technology was used.

Contrary to the findings of this study, Qazi et al. (2022) and Campos & Scherer (2024) found significant gender differences in students' computer attitudes and skill performance in using technology during classroom activities.

The findings also revealed that both e-content and conventional teaching modes enhanced students' interest in learning the automobile lighting system. However, students in the experimental group recorded a higher mean gain compared to their counterparts in the control group. This implies that while both approaches stimulated interest, e-content was more effective in sustaining motivation and engagement among students. This finding aligns with Mustapha et al. (2024), who acknowledged that students demonstrate better retention and higher levels of interest when taught using ICT facilities such as e-content.

The study's findings also revealed a significant difference between the mean scores of the experimental and control groups in terms of student achievement in the Automobile Lighting System. Therefore, the experimental group's mean achievement scores are notably higher than those of the control group in the achievement test. This implies that the e-content was significantly more effective than the conventional teaching method in enhancing students' learning achievement, aligning with a growing body of literature that emphasises the pedagogical value of digital instructional tools. E-content provides students with interactive, visual, and self-paced learning opportunities that extend beyond the limitations of traditional classroom delivery.

According to Oltinboyevna & Khahhorova (2025), multimedia-based instruction supports the dual coding of information through both verbal and visual channels, thereby improving comprehension and retention. Similarly, Save & Kumar (2020) reported that e-content enhanced the performance of technical education students by providing simulations and demonstrations that facilitated deeper conceptual understanding compared to conventional methods. Moreover, the adaptability of e-content enables differentiated learning, allowing students to revisit complex topics at their own pace, a feature that conventional teaching often lacks. This flexibility has been shown to improve learner autonomy and motivation, both of which are critical to achievement (Kessels et al., 2024).

In the context of technical subjects such as automobile systems, where visualisation and process demonstration are essential, e-content bridges the gap between theory and practice more effectively than lecture-based methods. Based on the findings of this study, there was no interaction effect between the method and gender on the influence of e-content on students' achievement. This finding contradicts Wammes et al. (2023), which showed that pupils of varying ability levels perform differently depending on the type of instructional method and material used. Therefore, it can be concluded that, in the use of technology, such as e-content, to enhance students' achievement in automobile lighting systems, neither method nor gender differences mediate students' achievement and understanding. This implies that students of varying ability levels and both genders are the beneficiaries when this type of technology is used to facilitate students' learning.

CONCLUSION

The results of this study revealed that student achievement and interest in learning were enhanced through the use of e-content. The use of e-content has value as an instructional tool in learning about the automobile lighting system via computer applications. The e-content approach appears to have value as an instructional tool in learning the automobile lighting system. The fact that these students achieved better results in the e-content approach indicates that it is a viable instructional option. The one-to-one tutoring function in e-content enables it to adapt tutoring strategies to the individual needs of each student. Thus, educators can spend more time guiding weaker students while others learn via e-content. It does not attempt to change the process of education radically. However, it recognises the strengths of a human. It alleviates the burden on both teachers and students in the teaching and learning process.

Recommendations

Based on the findings of the study, the researcher recommends the following:

- A replica of the study in other schools should be adopted. This would provide a source for a larger overview of the conclusions drawn from the findings of this study.
- A similar study should be conducted with larger samples, using qualitative data from both teachers and students, to investigate their attitudes towards the use of e-content instructional methods in the teaching and learning processes.
- Similar empirical studies should be conducted on the use of e-content instructional methods in other technical courses and at various levels of technical education to provide a solid foundation for integrating e-content into technical education in Nigerian schools.
- The study can be replicated in other states or local government areas of Nigeria.

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