



Blended Learning and Utilisation: An Effective Means of Teaching and Learning of Stem in University of Maiduguri, Borno State, Nigeria

ADAMU JIDDAH GABASA, ABDULLAHI AUDU BANUS,
APAGU BULUS KIDLINDILLAH, MOHAMMED GONI BUKAR,
University of Maiduguri, Nigeria

Abstract. The study examined the utilisation of blended learning in teaching and learning of STEM in university of Maiduguri with specific objectives to examine the extent to which blended learning provides flexible and accessible learning opportunities in teaching STEM, assess the role of multimedia tools in enhancing students understanding of STEM concepts through blended learning, evaluate how blended learning promotes student centered approaches in the teaching and learning of STEM and determine how interactive and collaborative features of blended learning influence the teaching and learning of STEM. Research Design adopted was descriptive survey research design. The population of this study comprises all STEM lecturers and undergraduate students of Science Education at the University of Maiduguri, Borno State. The sample size for this study comprises 200 undergraduate science education students, with 50 students drawn from each academic level and 15 Science education lecturers were selected. The instrument for data collection was a structured questionnaire developed by the researchers. Descriptive statistics such as frequencies, percentages were employed to answer the research questions based on respondents' opinions. The findings among others revealed that blended learning provides significant flexibility and accessibility in STEM (Science education), With regard to the role of multimedia, the results indicated that the use of tools such as videos, animations, and simulations improves students' understanding of STEM concepts, Based on the findings, the study concludes that blended learning significantly improves the teaching and learning of STEM in higher institutions and Recommended that Universities and colleges should provide adequate technological infrastructure such as reliable internet access, learning management systems, and multimedia facilities to support blended learning, Regular training workshops and seminars should be organized to build lecturers' capacity on the

effective use of multimedia tools and online teaching platforms, Students should be given orientation on how to effectively utilize blended learning platforms for independent and collaborative learning, Blended learning strategies should be integrated into the STEM curriculum to ensure a balanced mix of face-to-face and online learning activities, Institutions should adopt continuous monitoring and evaluation mechanisms to assess the effectiveness of blended learning and make improvements where necessary and Lecturers should design activities that encourage group work, peer-to-peer learning, and student-lecturer interaction to maximize the collaborative benefits of blended learning.

Keywords: Utilisation, Blended Learning, Teaching and Learning Stem

1. Introduction

Science, Technology, Education and Mathematics are branches of natural and applied sciences, deals with the study of living and non-living objects, including their structure, function, growth, evolution, distribution, and taxonomy. They are core subjects taught in Nigerian tertiary institutions as a foundational component of the natural and applied science curriculum. In universities such as the University of Maiduguri, STEM is not only central to scientific literacy but also essential for students pursuing careers in health sciences, agriculture, biotechnology, and education (Okebukola, 2021). The teaching of STEM aims to cultivate scientific knowledge, critical thinking, and problem-solving skills among students.

Despite its importance, teaching STEM effectively has faced various challenges. Traditional lecture based instructional approaches are still widely used, which often results in limited students' engagement, passive learning, and there is no comparison

between theoretical knowledge and real-life application (Yusuf & Adigun, 2022). Furthermore, the abstract and experimental nature of STEM concepts such as cellular process, chemical bondings and ecological interactions necessitates teaching strategies that can provide visual and interactive experiences (Eze, 2023). When these needs are unmet, students tend to develop misconceptions, reduced interest, and poor academic performance in STEM.

In addition, the global COVID-19 pandemic exposed and exacerbated the weaknesses of conventional teaching models. The temporary closure of educational institutions forced a shift to remote learning and highlighted the necessity for adaptive, flexible, and technology-integrated teaching methods, especially in science education (Oni & Lawal, 2021). This shift emphasized the need to explore alternative pedagogical practices such as blended learning that may improve the teaching and learning of STEM in universities, especially in developing contexts like Nigeria. Blended learning refers to the integration of traditional face-to-face classroom instruction with online or digital learning experiences. This hybrid model allows students to engage in personalized, self-paced, and flexible learning while maintaining instructor-led classroom interactions (Garrison & Vaughan, 2020). In the context of higher education, blended learning typically includes a mix of synchronous and asynchronous teaching, use of digital tools such as Learning Management Systems (LMS), multimedia content, virtual laboratories, online assessments, and discussion forums (Hrastinski, 2022).

Blended learning has been widely recognized as a promising pedagogical approach for improving student learning outcomes, enhancing instructional delivery, and fostering deeper understanding, especially in science disciplines like Science Education (Adamu & Obielodan, 2023). It accommodates diverse learning styles, encourages learner autonomy, and allows for differentiated instruction. In particular, the multimedia features of blended learning such as animations, simulations, and virtual experiments are beneficial in teaching abstract and complex STEM concepts (Bawa & Katcha, 2021).

Nevertheless, the successful adoption of blended learning depends on several factors including availability of technological infrastructure, digital literacy among faculty and students, institutional support, and pedagogical readiness (Salami & James, 2022). In the Nigerian context, many institutions, especially in the northern part of the country like Borno State, face infrastructural and socio-economic challenges that can hinder the

effective implementation of blended learning models (Umar & Goni, 2021). Therefore, there is a growing need to assess how blended learning is utilized in specific settings such as the University of Maiduguri, with a focus on its application in teaching and learning of STEM subjects.

The Nigerian higher education sector has seen gradual efforts to embrace technology in teaching, especially since the aftermath of the COVID-19 pandemic. Government policies, international development programs, and institutional initiatives have encouraged universities to integrate ICT tools into academic delivery (NOUN, 2022). In the University of Maiduguri, several blended learning initiatives have been introduced in response to both global educational trends and local disruptions, including insecurity in the North-East region.

Despite the push towards digitalization, the extent and quality of blended learning utilization in Nigerian universities remain uneven. Limited access to internet connectivity, unreliable power supply, insufficient technical support, and lack of digital competencies continue to constrain its effectiveness (Olanrewaju & Mustapha, 2020). Additionally, lecturers and students often receive little or no training on how to maximize blended learning platforms, which affects the quality of teaching and learning outcomes (Ezeanya & Udo, 2023).

This is particularly crucial for science-based courses like STEM, where hands-on experimentation, laboratory work, and visualizations are essential components of learning. Blended learning, when used effectively, can supplement these through virtual simulations, recorded lab procedures, interactive models, and other e-learning tools. Therefore, evaluating how well blended learning is being utilized in teaching STEM can provide insights into its effectiveness, challenges, and opportunities for improvement.

The University of Maiduguri, located in the North-Eastern region of Nigeria, plays a vital role in the development of education and research in Borno State and beyond. Given the insecurity challenges posed by insurgency in the region, the university has had to adapt its academic operations, including exploring flexible learning options like blended learning to maintain continuity in education (Ahmed, 2021). As a result, the use of technology in teaching and learning has become not only an academic innovation but also a necessity for resilience.

Assessing the utilization of blended learning in teaching STEM at the University of Maiduguri is therefore important for several reasons. Firstly, it provides evidence-based insight into how digital

pedagogies are shaping science education in crisis affected areas. Secondly, it helps to identify the specific benefits and limitations of blended learning in the context of STEM instruction. Finally, it informs institutional policy and pedagogical strategies aimed at enhancing teaching effectiveness, student engagement, and academic performance.

The foregoing discussion has highlighted the critical importance of teaching STEM as a foundational science education discipline and the limitations posed by traditional instructional approaches. It has also examined the growing relevance and pedagogical potential of blended learning as a modern instructional model that enhances interactivity, engagement, and learner autonomy. However, the success of blended learning depends on various contextual factors such as infrastructure, digital literacy, and faculty preparedness, especially within under-resourced and conflict-prone environments like Borno State.

As such, the University of Maiduguri represents a unique academic setting where the utilization of blended learning in teaching STEM deserves critical assessment. This is particularly crucial as the institution continues to navigate the challenges of higher education delivery in the face of insecurity, limited resources, and growing demands for innovation in pedagogy.

In summary, while STEM remains a crucial discipline for national development and scientific advancement, its effective teaching is hindered by conventional methods that do not align with modern learning needs. Blended learning offers an alternative pedagogical approach that combines the strengths of traditional and digital methods to enhance science education. Yet, its utilization and impact must be assessed within specific institutional and regional contexts. Given its academic and geographical relevance, the University of Maiduguri provides an ideal setting for investigating how blended learning is applied in teaching STEM and what implications it holds for educational improvement in Nigeria.

STEM as a foundational natural and applied science subjects plays a critical role in the development of scientific knowledge, innovation, and national development. In higher education, particularly at the University of Maiduguri, STEM is offered as core courses for students in life sciences, medical sciences, education, and agriculture. However, over the years, there has been consistent concern about the low academic performance, reduced interest, and disengagement of students in STEM courses. This trend has been attributed in large part to the continued dominance of traditional face-to-face

teaching methods, which often do not cater to students' diverse learning needs or promote deep conceptual understanding (Yusuf & Adigun, 2022).

To address this problem, educational stakeholders and institutions have promoted the integration of Information and Communication Technology (ICT) in teaching through approaches such as blended learning. Blended learning combines traditional classroom methods with online digital media, allowing students greater flexibility, interactivity, and access to a variety of learning resources. This approach has shown significant promise in improving teaching and learning outcomes in science-based courses globally (Garrison & Vaughan, 2020). However, its utilization in Nigerian universities, including the University of Maiduguri, remains largely under explored and under researched.

Moreover, the unique socio-political context of Borno State characterized by a history of insurgency and infrastructural instability has made it even more urgent for institutions like the University of Maiduguri to embrace resilient and adaptable pedagogical models. Despite this need, there appears to be little empirical data on the extent to which blended learning is being utilized in teaching and learning of STEM at the university, what forms it takes, how effective it is, and what challenges educators and students face in its application.

Additionally, most previous studies have focused broadly on ICT integration in education, with few specifically targeting blended learning in STEM instruction. Even fewer have looked into the practical implementation and evaluation of blended learning in a conflict-affected area such as Borno State. This leaves a significant gap in knowledge and practice, making it difficult for educational planners, policy-makers, and instructors to develop evidence-based strategies for improving the teaching and learning of STEM through blended learning in this region.

It is against this background that this study becomes imperative. There is a pressing need to systematically assess how blended learning is being utilized in the teaching of STEM at the University of Maiduguri. Such an assessment will help to determine whether blended learning has been effectively integrated into the instructional process, what technological and pedagogical resources are available, what challenges are being faced, and how students perceive its impact on their understanding of STEM concepts. The findings will serve as a foundation for recommending strategies to improve teaching effectiveness, enhance students' engagement, and ultimately boost academic performance in STEM subjects.

1.1 Objectives of the Study

The main objective of this study is to assess the utilization of blended learning in the teaching and learning of STEM at the University of Maiduguri, Borno State, Nigeria.

The specific objectives were to:

- Examine the extent to which blended learning provides flexible and accessible learning opportunities in teaching STEM at the University of Maiduguri.
- Assess the role of multimedia tools in enhancing students' understanding of STEM concepts through blended learning.
- Evaluate how blended learning promotes student-centered approaches in the teaching and learning of STEM.
- Determine how interactive and collaborative features of blended learning influence the teaching and learning of STEM.

1.2 Research Questions

- To what extent does blended learning provide flexible and accessible learning opportunities in the teaching and learning of STEM subjects?
- How do multimedia tools used in blended learning to enhance students' understanding of STEM concepts?
- In what ways does blended learning promote student-centered teaching and learning approaches in STEM subjects?
- How do the interactive and collaborative components of blended learning influence the teaching and learning of STEM subjects?

2. Literature Review

Conceptual Framework: A conceptual framework serves as a guide that illustrates the relationships between variables in a research study. It helps the researcher visualize how the independent variables (inputs) affect the dependent variable (outcome), and it provides a foundation for interpreting findings and drawing conclusions.

In this study, the focus is on how blended learning, as the independent variable, influences the teaching and learning of STEM at the university level. The framework is built upon the premise that integrating digital and face-to-face methods can enhance students' understanding, participation, and overall academic performance in STEM subjects.

Blended learning is an instructional strategy that merges traditional classroom teaching with online or digital learning experiences, creating a more flexible

and engaging learning environment. In the context of higher education, especially in science-related disciplines like Science, Technology, Engineering, and Mathematics, this approach is increasingly adopted to enhance students' understanding of complex concepts. By allowing learners to interact with content both physically and virtually, blended learning provides an opportunity to improve access, personalize instruction, and support a range of learning styles.

Flexibility in learning is a central benefit of blended instruction. It allows students to determine when, where, and how they engage with content, making it particularly useful in contexts where students face challenges related to time, distance, or limited resources. For science education students, this means they can review recorded lectures, watch simulations of biological processes, and complete interactive tasks outside of regular class hours. This level of accessibility supports independent learning and reinforces classroom instruction. The use of multimedia tools is an essential feature of blended learning that contributes significantly to the teaching of STEM. Topics such as cellular respiration, genetics, and ecological systems are often abstract and difficult for students to visualize through text alone. Incorporating videos, animations, simulations, and virtual labs helps to break down complex processes, making them easier to understand. Multimedia instruction also supports cognitive engagement by appealing to both visual and auditory learning channels, leading to improved retention and academic performance.

Blended learning promotes a shift from teacher-centered instruction to a more student-centered approach. This pedagogical model encourages active participation, critical thinking, and collaborative problem-solving. Students are no longer passive recipients of knowledge but are given the opportunity to explore, ask questions, and interact with learning materials at their own pace. In Science education, where observation, inquiry, and experimentation are vital, student-centered learning leads to deeper understanding and application of scientific knowledge.

Furthermore, interactive and collaborative features of blended learning enhance communication among students and between students and instructors. Through discussion forums, group chats, shared digital workspaces, and peer feedback mechanisms, learners engage in meaningful exchanges that promote teamwork and reinforce concepts. In Biology, this type of collaborative learning mirrors the nature of real scientific inquiry, which often involves cooperation and shared investigation. The integration of blended learning into the teaching of STEM in Nigerian universities responds to global

trends and educational demands for more dynamic, inclusive, and technology-enhanced learning environments. As institutions adapt to evolving teaching methods, understanding the conceptual

foundation of blended learning becomes essential for evaluating its effectiveness in improving both teaching practices and student outcomes.

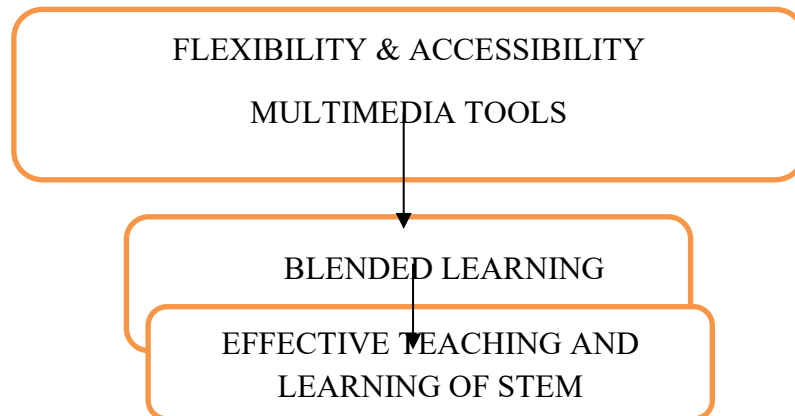


Fig. 1: Concept of Blended Learning

2.1 Concept of Blended Learning

Blended learning is a modern instructional approach that merges traditional face-to-face teaching methods with online learning tools and resources to create a more flexible and engaging learning environment. It allows students to benefit from the structured interaction of classroom settings while leveraging the accessibility and interactivity of digital platforms.

According to Singh and Thurman (2020), blended learning is “an instructional approach that combines online and in person learning experiences, where the learner has some control over time, place, path, or pace.” This model of learning enables students to take responsibility for their learning process while still benefiting from teacher guidance and peer collaboration.

Blended learning is not just about using technology in education; rather, it involves a pedagogical redesign that integrates technology in meaningful ways to improve learning outcomes. Research has shown that blended learning improves student motivation, learning flexibility, and academic achievement (Alammery, 2021). The approach is especially effective in science subjects like Biology, mathematics, chemistry, physics, technology and engineering where students can combine practical experiments with virtual simulations and interactive content.

2.2 Tools and Models of Blended Teaching and Learning

Blended learning utilizes a variety of digital tools and structured models to enhance instruction, foster

collaboration, and personalize learning experiences. These tools, when effectively integrated, support interactive, flexible, and student-centered education across different subject areas, including STEM. One of the foundational tools in blended learning is the Learning Management System (LMS), which acts as the central hub for organizing course materials, tracking student progress, and enabling communication between teachers and learners; common LMS platforms include Moodle, Google Classroom, Canvas, and Blackboard.

To support real-time engagement, video conferencing tools such as Zoom, Microsoft Teams, and Google Meet are frequently used for live lectures, virtual group discussions, and teacher-student interaction. In addition, content creation tools like Edpuzzle, Nearpod, PowerPoint (with audio/video narration), and Canva empower educators to design multimedia-rich lessons that enhance student engagement and understanding. For evaluating learning outcomes, both formative and summative assessment tools such as Kahoot!, Quizizz, Google Forms, and Socrative are employed, allowing teachers to gather data on student performance and provide timely feedback.

Collaboration and peer learning are further facilitated by digital collaboration tools including Padlet, Jamboard, discussion boards embedded in LMS platforms, and even instant messaging platforms like WhatsApp and Telegram, which are increasingly used in informal academic communication and group work, especially in contexts with limited access to formal tools. In science education, particularly Biology, subject-specific tools like PhET Interactive Simulations, Labster’s virtual lab environments, and BioMan

games play a critical role in enabling students to explore complex scientific processes through digital experimentation.

2.3 Benefits and Challenges of Blended Learning

Blended learning offers numerous benefits that make it an attractive instructional strategy in both formal and informal educational settings. Its most prominent advantage lies in its flexibility and convenience, allowing learners to access course materials anytime and from any location, thereby enabling self-paced learning. This flexibility is particularly beneficial for adult learners, students in remote areas, and those with demanding schedules. Alammary (2021) observed that students appreciate having control over their learning pace, which enhances their autonomy and sense of responsibility.

Another key advantage is the improvement in student engagement, as blended environments often integrate multimedia elements such as videos, simulations, interactive quizzes, and gamified activities. These elements cater to various learning styles visual, auditory, and kinesthetic and foster deeper interest in learning. Supporting this, Lo and Hew (2022) found that the use of interactive technologies significantly enhances motivation and active participation, especially in science-based subjects like STEM subjects.

Additionally, blended learning promotes personalized instruction, as it allows teachers to analyze learner data and adjust their strategies based on individual strengths, weaknesses, and progress. Boelens et al. (2020) emphasized that adaptive technologies and formative assessments facilitate differentiated learning pathways. Furthermore, blended learning environments encourage collaboration and communication, as students engage in group discussions, share ideas via online forums, and co-create content using tools like Google Docs and LMS-integrated discussion boards. According to Owston et al. (2021), this environment fosters peer-to-peer interaction and improves teamwork competencies.

From an institutional perspective, blended learning offers cost-effectiveness and resource efficiency, enabling schools and universities to reduce expenditures on infrastructure, printed materials, and physical resources while maintaining educational quality. Singh and Thurman (2020) noted that digital delivery models can lower operating costs significantly. Most notably, the resilience of blended learning became evident during the COVID-19 pandemic, as it enabled educational continuity when schools were closed, illustrating its value in emergency and post-pandemic education planning.

2.4 Teaching of STEM

The teaching of STEM is a dynamic process aimed at imparting scientific knowledge, critical thinking, and practical skills related to living organisms, their functions, and their interactions with the environment. As a core science subject, STEM plays a central role in shaping students' understanding of health, agriculture, environmental sustainability, biotechnology, mathematics, technology, and engineering. The teaching of STEM has evolved from being predominantly teacher-centred and textbook-driven to adopting more learner-centred, inquiry-based, and technology-enhanced approaches (Mayer, 2021).

In modern classrooms, particularly in secondary schools and higher education, STEM educators use diverse pedagogical strategies such as demonstrations, laboratory experiments, field studies, digital simulations, and problem-solving activities to engage students and enhance conceptual understanding. Blended learning, which combines online and face-to-face instruction, has become increasingly popular, especially after the COVID-19 pandemic highlighted the need for flexible and resilient teaching models (Iro, Ugwu, & Abubakar, 2022).

However, the teaching of STEM faces significant challenges, particularly in resource-constrained environments like many Nigerian schools. These challenges include limited laboratory infrastructure, inadequate instructional materials, overcrowded classrooms, and insufficient teacher training in the use of emerging technologies (Nwachukwu, Agbo, & Oguche, 2023). Despite these barriers, research shows that when Biology is taught using interactive multimedia tools, collaborative activities, and student-centered methodologies, students show improved academic achievement and retention of complex biological concepts (Singh & Thurman, 2020).

Additionally, curriculum reforms and teacher professional development programs are essential for improving the quality of Biology teaching. Training teachers to use virtual labs, simulations, and digital microscopes, for example, can help compensate for the lack of physical resources, while fostering scientific inquiry and critical analysis among students.

In Nigerian universities, the traditional approach to teaching is primarily teacher-centered, characterized by face-to-face lectures, chalk-and-talk methods, printed handouts, and minimal student interaction, where students are passive recipients of information. In contrast, the modern or blended learning approach combines face-to-face instruction with

online technologies such as Zoom, Moodle, Google Classroom, and multimedia tools, allowing students to engage in both synchronous and asynchronous learning environments (Adedoyin & Soykan, 2020). While traditional methods offer structure and familiarity, they often limit flexibility, discourage active participation, and lack real-time feedback mechanisms. Modern approaches, on the other hand, promote student-centered learning by incorporating videos, simulations, online quizzes, forums, and collaborative tools that foster critical thinking, engagement, and individualized learning (Boelens et al., 2020; Iro et al., 2022).

Science education in Nigeria faces numerous challenges that hinder effective teaching and learning, especially at the secondary and tertiary levels. One of the most critical challenges is inadequate instructional materials, including lack of up-to-date textbooks, laboratory equipment, visual aids, and digital resources that are essential for practical and conceptual understanding of biological processes (Iro et al., 2022). Many schools and universities operate with poorly equipped laboratories, which limits hands-on experiments and reduces students' scientific inquiry skills, thus making the subjects abstract and difficult to comprehend (Eze et al., 2021).

2.5 Blended Learning and Flexibility in Teaching and Learning STEM

Blended learning introduces a significant level of flexibility into teaching and learning of STEM by enabling instructors to combine traditional face-to-face classroom methods with digital learning tools that allow for asynchronous and self-paced learning. This instructional model is particularly beneficial in STEM, subjects that requires both theoretical understanding and practical engagement, as it allows educators to present complex topics such as cell division, genetics, and ecological systems through animations, virtual labs, recorded lectures, and interactive content and many more in STEM subjects (Singh & Thurman, 2020). Flexibility is enhanced as students are no longer confined to physical classrooms; they can access materials at any time and location, review difficult concepts repeatedly, and engage with learning resources tailored to their pace and preferences (Boelens et al., 2020).

In the context of teaching and learning STEM in Nigeria, where infrastructural constraints and teacher shortages often hinder effective instruction, blended learning offers a sustainable solution. It provides the opportunity for teachers to deliver core concepts through in-person lessons while reinforcing them with online resources such as quizzes, video demonstrations of laboratory procedures, and peer discussions via digital platforms like Google Classroom or Moodle (Iro,

et al., 2022). This flexible approach accommodates diverse student needs, especially in large classrooms where personalized instruction may be limited.

Blended learning offers remarkable time and location flexibility by allowing students and teachers to access educational content and participate in learning activities without the limitations of a fixed schedule or physical classroom. This flexibility enables learners to engage with Biology topics such as photosynthesis, human anatomy, and genetics at their own convenience, whether during the day or night, and from any location with internet access or digital resources (Singh & Thurman, 2020). Through platforms like Google Classroom, Moodle, and mobile-based applications, students can download lecture slides, watch experiment demonstrations, complete assignments, and join discussion forums asynchronously, which is especially beneficial for those balancing academic work with family, employment, or other personal responsibilities (Eze et al., 2021).

Blended learning integrates both asynchronous and synchronous tools to provide a balanced and flexible learning experience, especially in subjects like STEM where visualization, interaction, and experimentation are must to practical contents. Asynchronous tools refer to digital resources that students can access at their convenience without real-time interaction, such as recorded lecture videos, discussion forums, email, e-books, virtual simulations, and learning management systems like Moodle or Google Classroom. These tools allow learners to study at their own pace, revisit challenging STEM topics such as DNA replication or photosynthesis and reflect on feedback before responding and so many in STEM subjects (Singh & Thurman, 2020).

2.6 Role of Multimedia Tools in Enhancing STEM Understanding

Multimedia tools play a vital role in enhancing students' understanding of STEM subjects by transforming abstract and complex scientific concepts into interactive, visual, and engaging learning experiences. In topics such as cell structure, photosynthesis, gene expression, and ecological cycles, multimedia resources including animations, videos, simulations, virtual labs, interactive diagrams, and augmented reality help bridge the gap between theoretical explanations and real-world STEM processes (Singh & Thurman, 2020). These tools provide dynamic representations that are more effective than static textbook images, making it easier for students to visualize microscopic and molecular phenomena that are otherwise difficult to grasp through traditional methods alone.

For example, 3D animations and virtual dissections allow students to explore human anatomy or cellular components in a detailed and repeatable manner, encouraging active learning and critical thinking. This is particularly important in settings where access to physical laboratories or live specimens is limited, as multimedia can simulate hands on experience (Iro et al., 2022). Moreover, interactive tools such as quizzes, gamified activities, and drag and drop exercises promote learner participation and immediate feedback, which boosts retention and deepens conceptual understanding.

In Nigerian secondary and tertiary institutions, the integration of multimedia into Biology instruction has shown promising results. A study by Eze, Chinedu-Eze and Bello (2021) revealed that students who learned STEM through blended models incorporating multimedia tools performed significantly better in assessments than those taught through lecture-only methods. Additionally, multimedia facilitates inclusive learning by catering to various learning styles visual, auditory, and kinesthetic and can be adapted for students with special needs.

3. Definition and Types of Multimedia Tools (Animations, Simulations, Videos, Virtual Labs)

Multimedia tools refers to digital resources that combine two or more types of media such as text, audio, images, animation, and video to create rich, interactive educational experiences. In Science education, multimedia tools are used to simplify abstract scientific concepts, support visual learning, and stimulate engagement among students (Singh & Thurman, 2020). These tools are especially effective when integrated into blended learning environments where students can access materials both online and offline.

There are several types of multimedia tools commonly used in STEM teaching. Animations are short, moving graphical sequences that visually demonstrate STEM processes such as biology, mitosis, protein synthesis, or photosynthesis, making them easier to understand. Simulations are interactive programs that mimic real-world STEM experiments or systems, allowing students to manipulate variables in virtual environments for example, modeling population genetics or testing enzyme activity under different conditions (Boelens et al., 2020).

Videos, another popular tool, include recorded lectures, documentary clips, or experiment demonstrations, which provide learners with auditory and visual explanations of complex topics. Videos help to contextualize theory by showing real-

life applications and scientific practices. Virtual labs replicate laboratory experiments in a computer-generated environment, enabling students to perform STEM practicals such as microscope use, dissections, and chemical testing without the need for physical lab equipment. This is particularly useful in under-resourced schools or during remote learning (Eze et al., 2021).

3.1 The Multimedia Principles and Cognitive Load Theory

The multimedia principle, rooted in the Cognitive Theory of Multimedia Learning by Mayer, asserts that learners understand and retain information more effectively when it is presented using both words (spoken or written) and relevant images (such as diagrams, animations, or videos) rather than through text alone (Mayer, 2021). This principle is particularly valuable in Science education, where complex and abstract topics such as cellular respiration, genetic inheritance, or the structure of the heart require visual representation to facilitate deeper understanding.

Closely related is the cognitive load theory, which explains how the human brain processes and stores information. According to this theory, learners have a limited capacity for processing information at one time, and instructional materials must be designed to avoid overwhelming this capacity (Sweller, van Merriënboer & Paas, 2019). There are three types of cognitive load: intrinsic load (the complexity of the content itself), extraneous load (unnecessary or poorly designed material that distracts learners), and germane load (the mental effort required to form new knowledge structures).

3.2 Evidence of Multimedia Improving STEM Concept Retention

Multiple studies conducted in recent years have provided compelling evidence that the use of multimedia tools significantly improves students' retention and understanding of Biology concepts. For instance, Eze, Chinedu-Eze, and Bello (2021) found that Nigerian university students exposed to Biology instruction using multimedia such as animations and video simulations scored higher on post-instruction tests and retained information longer than those taught using traditional lecture methods. The interactive nature of multimedia enhances cognitive engagement by allowing learners to visualize dynamic processes like mitosis, ecological interactions, and photosynthesis. Challenges in Multimedia Use (Infrastructure, Teacher Skill etc).

Despite its numerous benefits, the effective use of multimedia in Biology education faces several

challenges, particularly in developing contexts such as Nigeria. One of the foremost issues is inadequate infrastructure, including limited access to computers, projectors, stable electricity, and reliable internet connections in many schools and universities (Eze, Chinedu-Eze & Bello, 2021). In rural and under-resourced institutions, the absence of basic digital tools hinders the integration of videos, simulations, and virtual labs into the curriculum.

Another significant barrier is the lack of technical skills among teachers, many of whom have limited training in using multimedia platforms or designing digital content. Iro, Ugwu, and Abubakar (2022) observed that while younger teachers tend to be more digitally literate, a large portion of science educators are either unfamiliar with or resistant to adopting new technologies due to insufficient professional development opportunities and fear of complexity. As a result, even when tools are available, they are underutilized or used ineffectively.

3.3 Blended Learning and Student-Centred Approaches

Blended learning promotes student-centred approaches by shifting the focus of instruction from the teacher to the learner, allowing students to take greater control of their learning pace, style, and engagement with content. In a blended environment, learners interact with both face-to-face and digital elements, such as videos, simulations, and online discussions, which enable personalized and flexible learning paths (Singh & Thurman, 2020). This model encourages autonomy and responsibility as students are no longer passive recipients of knowledge but active participants in the learning process.

Through tools like learning management systems (LMS), quizzes, multimedia content, and collaborative platforms, blended learning supports differentiated instruction tailored to learners' individual needs and preferences. This personalization is a core feature of student-centered education, which emphasizes critical thinking, inquiry, and real-world application rather than rote memorization (Mayer, 2021). For instance, STEM students may review interactive videos on photosynthesis at their own pace online, then return to the classroom for collaborative problem-solving or experiments related to plant physiology.

3.4 Comparison of Teacher-Centred vs. Student-centred Instruction

Teacher-centred instruction is a traditional approach where the teacher serves as the primary source of knowledge, controlling the flow of content, pace of

delivery, and classroom interactions. In this model, students typically assume passive roles, listening to lectures, taking notes, and memorizing facts, often with limited opportunities for critical thinking or active engagement (Eze, Chinedu-Eze & Bello, 2021). This approach, while efficient for covering large amounts of material quickly, often limits deep understanding, especially in science subjects like Biology that require inquiry, visualization, and practical application.

In contrast, student-centered instruction focuses on the learners' needs, abilities, and interests, allowing them to actively participate in constructing knowledge. This method encourages collaboration, exploration, and problem solving, and is especially compatible with blended learning, where digital tools support personalized learning paths, peer interaction, and independent study (Singh & Thurman, 2020). In a student-centred STEM class, for example, students might watch animations of the circulatory system online, engage in group discussions, and conduct hands-on experiments to test hypotheses.

While teacher-centered methods are often still dominant in many Nigerian classrooms due to curriculum pressures and large class sizes, student-centred instruction is increasingly being recognized as more effective for long-term retention and higher-order thinking. Iro, Ugwu, and Abubakar (2022) found that STEM students exposed to student-centred, technology-enhanced instruction displayed greater engagement, motivation, and performance compared to those in traditional lecture settings.

3.5 How Blended Learning Encourages Active, Self-directed Learning

Blended learning encourages active and self-directed learning by combining traditional face-to-face instruction with digital platforms that give students greater control over how, when, and where they learn. This model shifts the responsibilities of learning from the teacher to the learners, enabling students to set their own pace, revisit content as needed and engages with materials that suit their preferred learning styles (Singh & Thurman, 2020). In Biology education, for example, students can review virtual lab simulations or video tutorials on topics like photosynthesis or cell division outside class hours, thereby reinforcing understanding through independent exploration.

By integrating tools such as online quizzes, discussion forums, video lectures, and interactive simulations, blended learning environments allow students to take initiative, monitor their progress, and develop metacognitive skills the ability to plan, evaluate, and adjust their learning strategies (Mayer,

2021). These experiences not only deepen engagement but also foster lifelong learning habits, a key goal of 21st-century education.

Iro, Ugwu, and Abubakar (2022) reported that students in Nigerian universities who engaged with blended learning platforms demonstrated greater motivation and self-discipline, often taking responsibility for their academic progress through consistent interaction with digital content and peer collaboration. Similarly, Nwachukwu et al. (2023) found that blended learning helped students become more confident in seeking information, solving problems, and asking questions, as opposed to depending solely on instructors.

3.6 Strategies (Flipped Classroom, Inquiry-based Learning)

Within blended learning environments, flipped classroom and inquiry-based learning have emerged as powerful strategies that promote student engagement, critical thinking, and deeper understanding of scientific concepts. The flipped classroom model reverses the traditional teaching sequence by having student's access instructional materials such as recorded lectures, animations, and reading resources at home, while classroom time is reserved for active learning activities like discussions, group work, or experiments (Mayer, 2021). This approach allows STEM students, for instance, to study the theory behind genetics or human anatomy online, then apply the knowledge through classroom experiments or problem-solving sessions.

Inquiry-based learning, on the other hand, emphasizes student exploration, questioning, and investigation, enabling learners to construct their own understanding of scientific phenomena. In a blended STEM class, this may involve students using online simulations to explore ecological systems, formulating hypotheses, and presenting their findings during in-person sessions. According to Iro, Ugwu, and Abubakar (2022), inquiry-based activities integrated with digital platforms foster scientific reasoning and help students link theoretical content to real-life applications.

3.7 Research Evidence Linking Student-Centredness to Better Learning Outcomes

Recent research provides strong evidence that student-centred instructional approaches, particularly within blended learning environments, are linked to improved academic performance, engagement, and long-term retention in science education. Unlike traditional lecture-based models, student-centred strategies prioritize learner autonomy, critical thinking, and hands-on

exploration qualities that enhance understanding and application of complex STEM concepts (Singh & Thurman, 2020). For example, science education students who engage in problem based and inquiry driven tasks, supported by digital tools, are more likely to develop analytical skills and retain content more effectively.

In a large scale study of Nigerian universities, Iro, Ugwu, and Abubakar (2022) found that students exposed to student-centred, technology-enhanced instruction demonstrated significantly better academic outcomes and reported higher motivation levels compared to their peers in teacher-centred classrooms. Similarly, Nwachukwu, Agbo, and Oguiche (2023) showed that when learners are encouraged to direct their own learning such as through multimedia resources, flipped classroom formats, and peer collaboration they are more engaged and achieve deeper understanding, especially in STEM courses like Biology, chemistry, mathematics etc.

3.8 Interactivity and Collaboration in Blended Learning

Interactivity and collaboration are core elements of blended learning that significantly enhance student engagement, motivation, and academic outcomes by promoting meaningful exchanges among learners and between learners and content. In a blended learning environment, interactivity is achieved through digital tools such as simulations, online quizzes, discussion boards, live chats, and interactive videos, which allow students to engage actively with subject matter rather than passively receiving information (Mayer, 2021). In STEM education, for instance, virtual labs and interactive animations of cellular processes help learners visualize and manipulate biological systems, thus deepening conceptual understanding.

Collaboration, on the other hand, is facilitated through both online and face-to-face platforms that support teamwork, peer review, and joint problem-solving. Tools such as Google Docs, discussion forums, and Learning Management Systems (LMS) enable students to work together on assignments, share ideas, and provide feedback across time and space. This collaborative dynamic fosters a sense of community and accountability, which is crucial for sustained academic engagement (Singh & Thurman, 2020).

Research by Iro, Ugwu, and Abubakar (2022) in Nigerian universities revealed that students who frequently interacted with peers and instructors in blended environments demonstrated higher levels of participation and improved academic performance. These students reported feeling more supported and intellectually stimulated, especially during online

group projects and face-to-face brainstorming sessions in science-related courses.

In blended learning environments, several digital tools are used to facilitate interaction and collaboration, including discussion boards, breakout rooms, peer review systems, and group projects, all of which are essential for creating engaging and student-centered educational experiences. Discussion boards, often integrated into Learning Management Systems (LMS), provide asynchronous platforms where students can ask questions, exchange ideas, and reflect on course content at their own pace. In STEM classes, this might involve students debating the ethical implications of genetic modification or clarifying complex processes like mitosis through peer-to-peer explanations (Singh & Thurman, 2020).

Breakout rooms, commonly used during synchronous video sessions on platforms like Zoom or Microsoft Teams, enable smaller groups of students to work collaboratively on tasks, engage in real-time discussions, and solve problems interactively. This is especially valuable in scientific inquiry and lab-based simulations, where students benefit from immediate feedback and teamwork (Nwachukwu et al., 2023).

The literature reviewed has established that blended learning a strategic integration of traditional face-to-face methods with digital and online tools has the potential to significantly improve science education, particularly Biology, by fostering student-centered learning, interaction, flexibility, and conceptual understanding. The review highlighted key components of blended learning including multimedia tools, asynchronous and synchronous delivery modes, collaborative strategies, and student engagement techniques. It also outlined the theoretical frameworks supporting blended learning, such as social learning theory and cognitive load theory, which explain how interaction and multimedia enhance comprehension and critical thinking.

Research findings show that the use of multimedia tools like simulations, animations, and virtual labs can enhance students' retention of complex biological concepts, while flexible learning models accommodate diverse student needs across time, location, and device accessibility. Additionally, blended learning has been found to promote active participation, peer interaction, and collaborative problem-solving, which are essential for fostering scientific inquiry and lifelong learning. However, challenges persist, especially in developing countries like Nigeria, where technological limitations, lack of infrastructure, and digital illiteracy can hinder the effective implementation of

interactive and blended learning strategies. Furthermore, disparities in access to devices, internet connectivity, and teacher training were frequently noted as obstacles to equity in educational outcomes.

Despite the growing body of international literature on blended learning, few empirical studies have specifically focused on its application in Science education within Nigerian universities. Most existing studies either address general e-learning or focus broadly on science education without examining how blended approaches impact the flexibility, interactivity, and conceptual understanding in STEM specifically.

4. Research Methodology

Research Design of This study adopted a descriptive survey research design. The descriptive survey design was deemed suitable for this study because it enables the researcher to systematically collect, analyze, and interpret data about the current practices and perceptions surrounding the use of blended learning in teaching STEM at the University of Maiduguri. The design allows for the gathering of factual information from a sample of respondents through the use of structured instruments such as questionnaires and, where applicable, interviews or observations.

This design does not involve manipulating variables but rather seeks to assess and describe how blended learning is currently being utilized by lecturers and students in the Science Education Department. It also provides insight into the challenges and effectiveness of this instructional approach in a real-world academic setting.

According to Nworgu (2022), descriptive survey design is most appropriate when the aim is to describe and interpret existing conditions, attitudes, or practices. Thus, this design enabled the researcher to evaluate the extent of blended learning application, stakeholders' opinions, and the challenges faced in its implementation.

The population of this study comprises all STEM lecturers and undergraduate students in the Department of Science Education at the University of Maiduguri, Borno State. The target population includes lecturers who are involved in teaching STEM courses and students who are currently enrolled in STEM related programs across different academic levels (100–400 level). 32 academic staff (lecturers, assistant lecturers, and technologists), 850 undergraduate students enrolled in STEM and related courses

This population was selected because they are directly involved in the teaching and learning process where blended learning methods are likely to be adopted. Due to the large number of students and time constraints, a sample was drawn from the population using stratified random sampling for students and purposive sampling for lecturers. Stratified random sampling was used to ensure fair representation of students across all levels (100 to 400 levels). A proportionate number of students were selected from each level. Purposive sampling was used to select lecturers who are actively engaged in teaching STEM subjects and are knowledgeable about the blended learning approach. The sample size for this study comprises 200 undergraduate STEM students, with 50 students drawn from each academic level. In addition, 15 Science education lecturers were selected, specifically those actively engaged in teaching and involved with e-learning platforms.

The instrument for data collection in this study was a structured questionnaire developed by the researchers. The questionnaire was titled Experiences, Perceptions and Challenges Questionnaire (EPCQ). The questionnaire was designed to obtain relevant information from both science education lecturers and students regarding their experiences, perceptions, and challenges associated with the utilization of blended learning in

the teaching and learning of STEM. The questionnaire was divided into two versions one for lecturers and one for students to suit their different roles and experiences within the blended learning framework. The questionnaires were personally administered by the researchers to ensure accuracy and a high response rate. Separate versions of the questionnaire were designed for the two groups of respondents. For the lecturers, the questionnaires were distributed in their offices or during departmental meetings. For the students, copies were administered during lectures. In addition, for respondents who preferred digital participation or were unavailable to complete the questionnaire in person, a Google Form version was prepared and shared through WhatsApp and departmental groups. This ensured wider accessibility and inclusiveness in data collection.

The data collected from the respondents were carefully organized, coded, and analyzed using appropriate statistical tools in order to answer the research questions. Descriptive statistics such as frequencies, percentages were employed to summarize responses from the questionnaire. These measures were useful in assessing the extent of blended learning utilization, perceptions, and challenges. Frequency and percentage distributions were used to present respondents' opinion

5. Data Analysis and Results

Research Question 1: To what extent does blended learning provide flexible and accessible learning opportunities in the teaching and learning of STEM?

Table 4.1: Flexibility and Accessibility of Blended Learning

S/No.	Items	SA (4)	A (3)	D (2)	SD (1)
	Blended learning allows flexible access to STEM learning resources.	70 (34.83%)	85 (42.29%)	30 (14.93%)	16 (7.96%)
	Online platforms make it easier to revisit STEM lectures.	60 (29.85%)	90 (44.78%)	32 (15.92%)	19 (9.45%)
	Blended learning reduces barriers related to time and place of learning.	55 (27.36%)	88 (43.78%)	38 (18.91%)	20 (9.95%)
	Blended learning increases accessibility to STEM resources.	68 (33.83%)	80 (39.80%)	35 (17.41%)	18 (8.96%)

Source: (Field Survey, 2025)

The results in Table 4.2 show that blended learning provides considerable flexibility and accessibility in the teaching of STEM. A majority of respondents (77.12%) agreed that blended learning allows flexible access to STEM teaching and learning resources, while only 22.89% disagreed. Similarly, 74.63% of students agreed that online platforms make it easier to revisit STEM lectures, compared to 25.37% who disagreed. On whether blended learning reduces barriers related to time and place of learning, 71.14% were in agreement, while 28.86% disagreed. Furthermore, 73.63% of respondents confirmed that blended learning increases accessibility to STEM resources, whereas 26.37% expressed contrary views.

Research Question 2: How do multimedia tools used in blended learning enhance students' understanding of STEM concepts?

Table 4.3: Role of Multimedia in Enhancing Understanding

S/No.	Items	SA (4)	A (3)	D (2)	SD (1)
	Multimedia tools (videos, simulations, animations) improve my understanding of STEM.	72 (35.82%)	92 (45.77%)	25 (12.44%)	12 (5.97%)
	Visual and audio resources enhance retention of STEM concepts.	65 (32.34%)	89 (44.28%)	30 (14.93%)	17 (8.46%)
	Multimedia makes STEM lessons more engaging and interactive.	70 (34.83%)	85 (42.29%)	28 (13.93%)	18 (8.95%)
	Lecturers effectively apply multimedia tools in teaching and learning of STEM.	55 (27.36%)	80 (39.80%)	40 (19.90%)	26 (12.94%)

Source: (Field Survey, 2025)

The results in Table 4.3 indicate that multimedia tools play a significant role in enhancing students' understanding of STEM concepts. A large proportion of respondents (81.59%) agreed that multimedia resources such as videos, simulations, and animations improve their understanding of STEM, while only 18.41% disagreed. Similarly, 76.62% affirmed that visual and audio resources enhance their retention of STEM concepts, compared to 23.39% who disagreed. On the aspect of engagement, 77.12% of students agreed that multimedia makes STEM lessons more engaging and interactive, whereas 22.88% disagreed. However, when asked whether lecturers effectively applied multimedia tools in their teaching, the level of agreement dropped to 67.16%, while 32.84% of respondents expressed disagreement.

Research Question 3: In what ways does blended learning promote student-centred teaching approaches in STEM?

Table 4.4: Student-Centered Learning through Blended Approaches

S/No.	Items	SA (4)	A (3)	D (2)	SD (1)
	Blended learning encourages independent learning.	62 (30.85%)	90 (44.78%)	30 (14.93%)	19 (9.45%)
	Students are more actively involved in learning STEM through blended learning.	58 (28.86%)	92 (45.77%)	32 (15.92%)	19 (9.45%)
	Blended learning promotes problem-solving and critical thinking.	70 (34.83%)	80 (39.80%)	30 (14.93%)	21 (10.45%)
	Students control the pace of learning better in blended learning.	64 (31.84%)	86 (42.79%)	30 (14.93%)	21 (10.45%)

Source: (Field Survey, 2025)

The results presented in Table 4.4 show that blended learning significantly promotes student-centered approaches in the teaching and learning of STEM. A majority of respondents (75.63%) agreed that blended learning encourages independent learning, while 24.38% disagreed. Similarly, 74.63% of the students indicated that they were more actively involved in learning STEM through blended learning, compared to 25.37% who disagreed. In terms of problem-solving and critical thinking, 74.63% of the respondents agreed that blended learning enhances these skills, while 25.38% disagreed. Additionally, 74.63% affirmed that blended learning gives them better control over the pace of learning, while 25.38% expressed contrary views.

Research Question 4: How do interactive and collaborative components of blended learning influence STEM teaching and learning?

Table 4.5: Influence of Interactivity and Collaboration

S/No.	Item	SA (4)	A (3)	D (2)	SD (1)
	Blended learning promotes collaboration through group projects/discussions.	72 (35.82%)	88 (43.78%)	28 (13.93%)	13 (6.47%)
	Online platforms enhance student-lecturer interaction.	60 (29.85%)	95 (47.26%)	28 (13.93%)	18 (8.95%)
	Feedback from lecturers is faster in blended learning.	55 (27.36%)	89 (44.28%)	35 (17.41%)	22 (10.95%)
	Peer-to-peer learning is enhanced in blended learning.	65 (32.34%)	87 (43.28%)	30 (14.93%)	19 (9.45%)

Source: (Field Survey, 2025)

The results in Table 4.5 indicate that interactive and collaborative components of blended learning have a strong positive influence on Biology teaching and learning. A total of 79.60% of respondents agreed that blended learning promotes collaboration through group projects and discussions, while only 20.40% disagreed. Similarly, 77.11% of the students affirmed that online platforms enhance student-lecturer interaction, compared to 22.88% who

disagreed. In terms of lecturer feedback, 71.64% agreed that feedback is faster in blended learning, while 28.36% disagreed. Furthermore, 75.62% of respondents agreed that peer-to-peer learning is enhanced under blended learning approaches, while 24.38% did not share this view.

6. Findings

The study examined the influence of blended learning on the teaching and learning of STEM, focusing on four key dimensions: flexibility and accessibility, the role of multimedia, student-centered approaches, and interactivity and collaboration.

The findings revealed that blended learning provides significant flexibility and accessibility in STEM (Science education). A majority of respondents agreed that blended learning allows students to access resources at their convenience, revisit lectures online, and overcome barriers of time and location. This demonstrates that blended learning widens opportunities for learning beyond the traditional classroom setting.

With regard to the role of multimedia, the results indicated that the use of tools such as videos, animations, and simulations improves students' understanding of Biology concepts. Respondents also affirmed that multimedia enhances retention, makes lessons more engaging, and promotes interactive learning. However, a few students expressed concerns that lecturers do not always apply multimedia tools effectively.

The study further showed that blended learning strongly promotes student-centered approaches in STEM. Most students agreed that it encourages independent learning, enhances active participation, develops critical thinking and problem-solving skills, and gives learners greater control over the pace of their studies. This implies that blended learning shifts the focus from teacher-led instruction to a more learner-driven process.

Finally, the results highlighted the positive effect of interactivity and collaboration within blended learning environments. The majority of respondents affirmed that it encourages group projects, enhances peer-to-peer learning, strengthens student-lecturer interactions, and ensures faster feedback from lecturers. These findings suggest that blended learning fosters a more collaborative and supportive learning atmosphere, which is essential for effective STEM (Science education).

7. Discussion

The study examined the extent, role, and challenges of blended learning in STEM teaching and learning at the University of Maiduguri. The findings provide valuable insights into how blended learning influences the teaching and learning of STEM subjects. The discussion is presented in line with the four research questions.

The results indicated that blended learning significantly enhances flexibility and accessibility in the teaching of STEM. Students agreed that it enables them to access resources anytime, revisit lectures online, and overcome limitations of time and place. This finding aligns with Garrison and Vaughan (2008), who argue that blended learning expands opportunities for lifelong learning by allowing learners to engage with materials at their convenience. Similarly, Owston, York, and Murtha (2013) emphasize that flexibility is one of the most appealing features of blended learning, as it accommodates diverse student needs. In the context of STEM, this flexibility is particularly important, as it allows students to engage with complex scientific concepts repeatedly until mastery is achieved.

The study revealed that multimedia tools such as videos, simulations, and animations improve comprehension and retention of STEM concepts. Respondents noted that multimedia makes lessons more engaging and interactive. This supports the findings of Mayer (2009), whose Cognitive Theory of Multimedia Learning explains that learners understand better when information is presented through both visual and auditory channels. Similarly, Clark and Mayer (2016) highlight that multimedia creates richer learning experiences, which is crucial for subjects like STEM where abstract concepts often require visualization. However, the study also noted that some lecturers do not always utilize multimedia tools effectively, echoing findings by Bates and Sangrà (2011) that the success of blended learning largely depends on the instructor's ability to integrate technology meaningfully.

Another key finding is that blended learning encourages independent learning, active participation, problem-solving, and critical thinking. Students also reported that it gives them greater control over the pace of learning. This outcome is consistent with constructivist theories, which emphasize learner autonomy and active engagement in knowledge construction (Jonassen, 1999). Similar studies, such as those by Bonk and Graham (2012), suggest that blended learning shifts the focus from teacher-led instruction to student-centered approaches, thereby fostering deeper learning. In STEM, where analytical and problem-solving skills are essential, blended learning appears to provide an effective framework for nurturing these competencies.

The results further showed that blended learning enhances interactivity and collaboration among students and between students and lecturers. Students reported that it supports group projects, improves peer-to-peer learning, increases lecturer-student interaction, and allows for faster feedback.

These findings support the work of Hrastinski (2008), who notes that online components of blended learning encourage dialogue and collaboration, both of which are critical for effective learning. Moreover, this aligns with Vygotsky's (1978) social constructivist perspective, which highlights the role of social interaction in knowledge construction. In STEM education, collaborative projects and interactive feedback are vital for applying theoretical concepts to real-life problem-solving. Taken together, the findings of this study demonstrate that blended learning enhances flexibility, supports multimedia-based instruction, promotes student-centered learning, and strengthens collaboration in Biology education. These results corroborate the growing body of literature affirming that blended learning improves both teaching effectiveness and student learning outcomes when implemented effectively. However, the study also reveals that the effectiveness of blended learning depends on the commitment and technological competence of lecturers, which suggests the need for ongoing training and institutional support.

8. Conclusion

Based on the findings, the study concludes that blended learning significantly improves the teaching and learning of STEM in higher institutions. It provides learners with greater accessibility to resources, enriches understanding through multimedia, encourages independent and student-centered learning, and fosters interactivity and collaboration among students and lecturers. However, the study also concludes that the effectiveness of blended learning depends largely on the readiness and competence of lecturers to adopt and apply technological tools effectively. Without adequate training and institutional support, the full benefits of blended learning may not be realized.

9. Recommendations

In light of the findings and conclusions, the following recommendations were made:

Institutional Support: Universities and colleges should provide adequate technological infrastructure such as reliable internet access, learning management systems, and multimedia facilities to support blended learning.

Training for Lecturers: Regular training workshops and seminars should be organized to build lecturers' capacity in the effective use of multimedia tools and online teaching platforms.

Students Orientation: Students should be given orientation on how to effectively utilize blended learning platforms for independent and collaborative learning.

Curriculum Integration: Blended learning strategies should be integrated into the Science Education curriculum to ensure a balanced mix of face-to-face and online learning activities.

Continuous Assessment: Institutions should adopt continuous monitoring and evaluation mechanisms to assess the effectiveness of blended learning and make improvements where necessary.

Encouraging Collaboration: Lecturers should design activities that encourage group work, peer-to-peer learning, and student-lecturer interaction to maximize the collaborative benefits of blended learning.

References

- Adamu, A. & Obielodan, A. (2023). Blended Learning as an Instructional Strategy for Science Education in Nigeria Universities. *Journal of Educational Innovations*, 15(2), 44-58
- Adedoyin, O. B., & Soykan, E. (2020). COVID-19 Pandemic and Online Learning: The Challenges and Opportunities. *Interactive Learning Environment* 29(8), 1-13
- Ahmed, M. (2021). Adaptation of Higher Education in Conflict Zones: The Case-Study of University of Maiduguri. *African Journal of Education and Development Studies*, 18(4), 22-36
- Alammery, A. (2021). Blended Learning Models for Effective Teaching in Higher Education. *International Journal of Educational Technology in Higher Education*, 18(1), 1-20
- Bates, A. W., & Sangra, A. (2011). Managing Technology in Higher Education: Strategies for Transforming Teaching and Learning. Jossey-Bass
- Bawa, J. & Katcha, M. (2021). Multimedia and Virtual Learning Environments for Effective Science Instruction in Nigeria. *Journal of Science Education and Technology*, 10(3), 88-96
- Boelens, R., De wever, B., & Voet, M. (2020). Four key Challenges to the design of blended learning: A Systematic Literature Review. *Educational Research Review*. 22, 1-18.
- Bonk, C. J. & Graham, C. R. (2012). *The Handbook of Blended Learning: Global Perspectives local design*. Pfeiffer.
- Clark, R. C. & Mayer, R. E. (2016). *E-learning and the Science of Instruction: Proven Guidelines for consumers and designers of multimedia learning* (4th ed.). Wiley.
- Eze, B., Chinedu-Eze, V., & Bello, A. (2021). The Effect of Multimedia Instructional Tools on Students Achievement in Biology in Nigeria Universities. *Nigerian Journal of Science and Education*. 9(1), 52-64.

- Eze, C. (2023). Enhancing Science Learning through Visualisation and Interactivity: A Case for Blended Learning Instruction. *Nigeria Educational Review*, 18(2), 78-95
- Ezeanya, L., & Udo, E. (2023). Barriers to Effective use of Blended Learning among University lecturers in Nigeria. *Journal of Digital Learning in Africa*, 6(2), 11-23
- Garrison, D. R., & Vaughan, N. D. (2020). *Blended Learning in Higher Education: Framework Principles and Guidelines* (2nd ed.) Jossey-Bass
- Hrastinski, S. (2008). Asynchronous and Synchronous e-learning. *Education Quarterly*, 31(4), 51-55.
- Hrastinski, S. (2022). What do we Mean by Blended Learning? *TechTrends*. 66(5), 573-579
- Iro, G. O., Ugwu, C. A., & Abubakar, A. (2022). Post Pandemic Teaching Approaches in Nigeria Universities: The Case for Blended Learning. *Nigerian Journal of Educational Technology*, 14(3), 45-62.
- Jonassen, D. H. (1999). *Designing Constructivist learning Environments*. In C. M. Reigeluth (ed.)
- Instructional Design Theories and Models: A new Paradigm of Instructional Theory* (Vol. 2, pp.215-239). Lawrence Erlbaum Associates.
- Lo, C. K. & Hew, K. F. (2022). A critical Review of Flipped Classroom Research: Implications for Practice. *Educational Research Review*, 34, 100-434
- Mayer, R. E. (2009). *Multimedia learning* (2nd ed.) Cambridge University Press
- Mayer, R. E. (2021). *Multimedia learning* (3rd ed.) Cambridge University Press
- Nwachukwu, C., Agbo, A. & Oguche, A. (2023). Improving Science Education through Technology: An Assessment of Blended Learning Adoption in Nigeria Universities. *African Journal of Science and Education*, 11(2), 65-81
- Nworgu, B. G. (2022). *Educational Research: Basic Issues and Methodology* (5th ed.) University Trust Publishers.
- Oni, F., & Lawal, A. (2021). Post-COVID-19 Transformation in Nigerian Education: Prospects of Blended Learning. *Journal of African Educational Studies*, 17 (2), 102-119
- Owston, R., York, D., & Murtha, S. (2013). Students Perceptions and Achievement in a University Blended Learning Strategic Initiative. *The internet and Higher Education*, 18, 38-46
- Okebukola, P. (2021). *Reinvigorating Science Education in Nigeria: Towards Vision 2030*. Lagos: Macmillan Education.
- Salami, M., & James, F. (2022). Institutional Readiness for Blended Learning in Nigeria Universities. *Journal of Educational Management and Policy Studies*. 9(2) 88-102.
- Sweller, J., Van Morrienboer, J. J.G. & Paas, F. (2019). Cognitive Architecture and Instructional Design: 20 years later. *Educational Psychology Review*, 31(2), 261-292.
- Umar, A. & Goni, M. (2021). Challenges of Implementing ICT-based Instruction in Tertiary Institutions in Borno State. *Maiduguri Journal of Educational Research*, 12(1), 23-37.
- Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Harvard University Press.
- Yusuf, M. A., & Adigun, A. (2022). Traditional Teaching Methods and Students Performance in Nigerian Higher Institutions: The need for Innovation. *Journal of Educational Practice and Policy*, 14(1), 66-80