

Flipping STEM Classrooms in Nigeria: Enhancing Learning in Science, Technology, Engineering, and Mathematics Education

Lotachukwu Ernest Eze¹, Annabel Enu²

¹*Sismo Tutors, Enugu, Nigeria*

²*Independent Researcher Curriculum Design and Instructional Technology.*

ezelotachukwu91@gmail.com: enuanabel@gmail.com

Abstract

The current teaching methods used in Science, Technology, Engineering, and Mathematics (STEM) education in Nigerian classrooms often result in passive and disengaged learning, as educators primarily talk while students listen, with little to no active engagement. Students are often assigned homework afterward, which many struggle to complete, leading them to copy from one another without truly understanding the material. This paper advocates for the adoption of the flipped classroom model, where students engage with learning materials before class, allowing class time to be used for discussions, interactions, and collaboration. In this model, educators act as moderators, creating an engaging environment where initial assignments, typically done at home, are instead solved in class. This approach fosters better understanding, helps students collaborate, and addresses areas of weakness. The paper reviews studies where the flipped classroom model has been effectively implemented and highlights its benefits. It also examines the state of STEM education in Nigeria and suggests strategies for flipping classrooms using available resources, such as educators preparing materials with student participation. Additionally, the paper discusses the role of government, stakeholders, and NGOs in providing key resources like digital tools, electricity, and internet access to effectively implement this model in public schools.

Keywords: Flipped Classroom; STEM Education; Educational Technology; Student Engagement

Introduction

STEM education, an acronym for Science, Technology, Engineering, and Mathematics, emphasizes the development of problem-solving, critical thinking, creativity, and innovation skills. Since its inception by the United States National Science Foundation in 2001, STEM education has been globally integrated into the educational systems of many countries, including Nigeria (Odesomi, 2023). While mathematics and science are widely taught at the secondary school level in Nigeria, engineering and technology are less prevalent. Moreover,

even in institutions where STEM education is fully implemented, the teaching methods often result in inadequate and low-quality knowledge acquisition by students. The relevance of STEM education to economic development is undeniable. However, in Nigeria, realizing the full potential of STEM education is challenging due to numerous obstacles, including the need for greater investments, better training, innovative curriculum development, and updated educational policies (Fomunyan, 2019; Oluyemisi, 2023).

As the world evolves and embraces modern advancements across various sectors, education has also undergone significant transformations, aiming to foster a learning environment that is more efficient, flexible, and effective (Ayçiçek & Yelken, 2018). Over time, innovations in teaching and learning processes have been introduced, enriching the classroom experience and presenting new opportunities for development.

Globally, there is a growing recognition of the critical role that education plays in a nation's economic advancement. This has led to a continuous search for innovative ways to enhance teaching and learning experiences. The COVID-19 pandemic further accelerated the shift from traditional 'instructional discourse' to more hybrid and interactive teaching methods (Parker et al., 2022). Classrooms are increasingly moving away from passive learning models, embracing active participation through the integration of technology, both tangible (e.g., tablets, smartboards) and intangible (e.g., digital learning applications) (Samarraie, Shamsuddin & Alzahrani, 2019).

In the quest to create a more dynamic and student-centred learning environment, various pedagogical innovations have been introduced, such as project-based learning, cooperative learning, design thinking, and gamification. These methods not only leverage technology but also emphasize active learning and student engagement. Among these innovations, the flipped classroom model has gained significant attention from researchers and educators (Cabi, 2018).

The flipped classroom, also known as the inverted classroom (Samarraie, Shamsuddin & Alzahrani, 2019), reverses the traditional learning structure. In this model, students engage with digital resources and instructional materials at home, allowing classroom time to be dedicated to active, hands-on learning. Essentially, the "homework" is done in the classroom, with the teacher present to guide and assist, while the passive absorption of content happens outside the classroom. This model has been widely adopted in developed countries, but its implementation in Nigeria remains limited, with only 8 out of 123 federal university lecturers utilizing it, according to recent studies (Idhalama, Krubu & Etebu, 2023). Despite its

potential, the flipped classroom model is not yet mainstream in Nigeria, particularly in STEM education.

The relevance of STEM education to economic development is undeniable. However, in Nigeria, realizing the full potential of STEM education is challenging due to numerous obstacles, including the need for greater investments, better training, innovative curriculum development, and updated educational policies (Fomunyam, 2019; Oluyemisi, 2023). The adoption of flipped classrooms in Nigeria faces additional challenges, such as the need for above-average pedagogical expertise, significant time investment in teacher preparation, and the persistent use of digital technology, which may be met with resistance due to socio-cultural factors, especially among younger learners (Orlić, Marić & Petojević, 2023).

This paper focuses on the flipped classroom model and its potential significance for STEM education in Nigeria. It aims to explore the impact of flipping classrooms on learning outcomes, student engagement, and teacher effectiveness. By analysing the current state of STEM education in Nigeria, the challenges faced by educators and students, and the role of technology in facilitating flipped classrooms, this study seeks to offer insights into how this model can be effectively implemented in Nigeria's education system.

Global Perspectives and Insights on Flipped Classrooms

Numerous studies have explored the impact of the flipped classroom model on student performance, highlighting both its benefits and challenges. For instance, Nwosisi, Ferreira, Rosenberg, and Walsh (2016) investigated the effectiveness of flipping 30% of course content in a classroom setting. Their study demonstrates that incorporating the flipped classroom approach for a portion of the course content significantly benefits students, though some may initially struggle to adapt to this instructional style. The flipped classroom model facilitates greater interaction among students and between students and instructors, leading to improved learning outcomes. Qualitative results showed that 94% of students preferred this approach, with 72% indicating that it helped them learn the material better.

Chou, Chen, and Chia-Jen (2021) examined the impact of flipped learning on student motivation and attitude, particularly in language learning. Their study, which involved 386 high school students in Taiwan, found that students participating in flipped teaching models demonstrated better comprehension of the content. This improvement was linked to changes in learning style and attitude, enhancing overall learning effectiveness. The study suggested

that tailored instructional materials, such as films, could significantly support underachieving students by aligning with their individual abilities.

Nouri (2016) explored perceptions of the flipped classroom model in a university research methods course. The study used a questionnaire with 240 students and revealed a positive attitude towards the flipped classroom, video as a learning tool, and Moodle as a supporting tool. The positive attitude was correlated with increased motivation, engagement, and effective learning, with low achievers reporting more favourable outcomes regarding video use and perceived learning effectiveness.

Doğan, Batdı, and Yaşar (2021) conducted a meta-analysis of 30 studies on the effectiveness of the flipped classroom approach in science education. Their analysis revealed a positive medium effect ($g = 0.727$) on academic achievement, with the highest effect sizes observed in Physics and Chemistry and the lowest in Biology. The model was most effective in small-sized classes and at the Primary School level, providing valuable insights into its applicability across various science subjects and educational settings.

Tang, Abuhmaid, Olaimat, Oudat, Aldhaeabi, and Bamanger (2021) investigated the efficacy of online and combined online-flipped learning models during COVID-19. Their study found that students were generally dissatisfied with online learning, particularly with communication and Q&A modes. However, the combined model of online teaching with flipped learning significantly improved students' learning, attention, and course evaluation. This finding highlights the potential benefits of integrating flipped learning with online approaches, especially in challenging circumstances such as a global pandemic.

Divjak, Rienties, Iniesto, Vondra, and Žižak (2022) presented a systematic literature review of online flipped classroom approaches in higher education during the pandemic. Analyzing 205 publications, with 18 studied in detail, their research indicated that educators with prior experience in flipped classrooms adapted more successfully to online environments than those without. The review identified gaps in current research, such as the effectiveness of flipped classrooms in different courses and contexts, cognitive and emotional aspects of student engagement, and data protection. It emphasized the need for more comprehensive and rigorous examination of online flipped classroom delivery.

The growing body of research on flipped learning demonstrates its potential to enhance student engagement, improve academic performance, and foster deeper connections between educators and learners. Studies across different educational settings, from secondary

schools to universities, consistently reveal that the flipped classroom model leads to better comprehension, active participation, and skill development, especially in STEM education.

However, while studies across various countries demonstrate that the flipped classroom model can improve student engagement and academic achievement, its success is highly dependent on the context in which it is implemented. Factors such as access to technology, teacher preparedness, and cultural receptiveness play a significant role in shaping the outcomes of flipped classrooms. Therefore, it is crucial to evaluate the educational landscape of each country to determine the feasibility and potential impact of this approach. In the case of Nigeria, understanding the current state of STEM education and the unique challenges faced by educators and students will help identify the necessary adaptations to maximize the benefits of flipped learning.

Current State of STEM Education in Nigeria

To understand the current state of STEM education in Nigeria, it is essential to evaluate the progress made thus far and the approaches or policies in place to foster further advancement.

The introduction of Science, Technology, Engineering, and Mathematics (STEM) education in Nigeria stems from the government's recognition of its critical role in national technological and economic development. Drawing lessons from the impact of STEM education in advanced economies, Nigeria has worked to incorporate this educational innovation into its system. However, several challenges have hindered the full realization of its potential. As highlighted by Chisom et al. (2023), these challenges range from systemic issues such as poverty, inadequate school funding, poorly trained teachers, and limited learning resources, to more technical obstacles, including a shortage of specialized STEM instructors, limited integration of digital tools, inconsistent policy implementation, and a weak research and innovation ecosystem.

In response to these challenges, Nigeria has made efforts to promote STEM education through the establishment of specialized institutions, such as Yaba College of Technology and the Federal College of Arts, Science, and Technology (Ojetunde, 2021). Subsequently, the creation of universities like the Federal University of Technology, Minna (FUT Minna), the Federal University of Technology, Owerri (FUTO), and Ladoke Akintola University of Technology (LAUTECH) further reinforced these efforts. These institutions focus on STEM-

related courses with the goal of advancing technological and scientific innovation within the country.

Chisom et al. (2023) emphasized the need for legal and policy reforms in Nigeria's STEM education system. Key recommendations include the provision of free STEM education at the secondary and tertiary levels, gender equality in STEM fields, skill acquisition programs, improved employment opportunities for STEM educators, and the adoption of Fourth Industrial Revolution (4IR) technologies. According to Shonhe, Jain, and Akakandelwa (2023), students exposed to STEM education through 4IR technologies are better prepared for technical careers, such as coding, data analysis, and robotics. However, in Nigeria, many students graduate from STEM programs with only theoretical knowledge, lacking practical skills necessary for success in these fields (Aina, 2022).

A critical shortfall in the current state of STEM education in Nigeria is the insufficient focus on research output, which Umar (2019) argues is crucial for both academic and economic development. Areas requiring greater national investment include educational technology research, problem-solving methodologies, and comparative studies on STEM education models such as the flipped classroom system.

Moreover, Nigeria's STEM education policies are evolving slowly. While curricula reforms aimed at prioritizing science and technical education have gained attention, particularly in secondary education, challenges remain in policy implementation. Efforts to improve the teaching of core subjects such as mathematics, physics, chemistry, and biology continue, yet progress is hampered by inconsistent application of comparative analyses of global best practices in STEM education (Min, 2020; Aina, 2022).

Challenges Faced by Educators and Students in STEM Learning

The early integration of science into Nigeria's education system encountered significant challenges, particularly due to the lack of skilled teachers to instruct basic sciences such as arithmetic and algebra (Usman, 2020).

Inadequacy and Neglect of Teachers

A common misconception is that STEM education solely involves a teacher's ability to teach science in a classroom, regardless of practical expertise. In reality, STEM subjects are far more effective when taught with a strong emphasis on hands-on experimentation rather than traditional methods. This underscores the need for educators to possess both pedagogical and technical expertise to teach STEM effectively.

Without adequate training, orientation, and support, teachers are unable to fulfill the core objective of STEM education—preparing students for practical achievements and contributing to economic development (Chisom et al., 2023).

This inadequacy is exacerbated by the recruitment of unqualified individuals to teach STEM subjects. In some cases, teachers may feel it is unnecessary to pursue quality training since they can secure positions through connections or corrupt practices, especially in publicly funded schools with lax supervision. These practices compromise the delivery of quality education.

Inadequate Funding

Funding is critical to establishing and sustaining a successful educational system (Aina, 2022). The annual education budgets in many developed countries reflect the importance they place on education. By contrast, Nigeria has historically allocated insufficient resources to education, maintaining a pattern of underfunding that hinders progress. Since independence, Nigeria's education budget has consistently fallen short, both in comparison to other developing African nations and the UNESCO recommendation of 15–20% of the national budget (UNESCO, 2021; Premium Times, 2023; Ohaegbulem & Chijioke, 2023).

This funding shortfall extends beyond the national budget. It manifests in the lack of essential resources for STEM education, including inadequate laboratories, technical tools, and conducive learning environments. Moreover, there is a lack of investment in training more STEM educators and supporting students pursuing STEM fields (Aina, 2022; Ojetunde & Oluwatoyin, 2021).

According to Ohaegbulem and Chijioke (2023), the consequences of inadequate funding in Nigeria's education system are evident in the country's economy. Rather than using education to stimulate national economic growth, Nigeria contributes to the economies of countries that prioritize education and offer superior educational opportunities.

Low Rate of Research Output

Research is a key driver of development, but in Nigeria, much of the research relevant to education is derived from foreign sources. Aina (2022) highlights the low rate of educational research output in Nigeria, especially when compared to other African nations such as South Africa, Ghana, Zimbabwe, and Kenya.

While Nigeria has a tradition of facilitating final-year undergraduate research projects, these efforts are often limited in scope, lacking sufficient authenticity, funding, and credibility. As a result, they are frequently viewed as subpar research initiatives.

Inconsistency of Government Policy

Policies are designed to foster development and progress, yet in Nigeria, the challenge lies not in policy creation but in policy implementation. Although Nigeria frequently revises its educational policies, there is a persistent lag in educational development due to the inconsistent and often superficial enforcement of these policies (Eze, 2023).

Bello (2021) describes Nigeria's policy approach as a "out with the old, in with the new" system, in which leaders introduce new policies without conducting proper background research on the necessity of these changes or the credibility of the proposed policies. This inconsistent approach hinders long-term educational progress.

Building on these challenges, the next section will explore how flipped learning can be effectively implemented in Nigerian STEM classrooms. By addressing the challenges unique to the Nigerian context, we will outline a structured approach that leverages available resources, equipping educators and students with the necessary tools to thrive in a flipped learning environment.

Implementation of Flipped Learning in Nigerian STEM Education

Flipping STEM classrooms involves a structured process that can be grouped into five key areas:

1. Understanding the Importance of Flipping the Classroom
2. Teacher Training on the Use of Digital Tools.
3. Preparation of Learning Materials
4. Grading Strategies
5. Implementation of the Model

Understanding the Importance of Flipping the Classroom

It is essential for teachers, lecturers, and school management to recognize the significance of flipping the classroom. When the value of an initiative is understood, commitment to it naturally follows. The first step in implementing a flipped classroom in Nigeria's educational system is cultivating an awareness of its necessity and benefits. While numerous factors come into play during implementation, the foundational desire to embrace this model is paramount.

Benefits of the Flipped Classroom Model:

1. **Skill Development:** The preparation phase empowers students to acquire skills that extend beyond the classroom, such as creating presentation slides, video editing, teamwork, and effective communication. Involving students in the preparation process equips them with essential digital and soft skills.
2. **Enhanced Educator-Student Connection:** Collaborating with students during the flipping process fosters deeper relationships. This connection enhances the teaching experience, as students are more likely to engage when they feel a bond with their educator, ultimately leading to improved performance.
3. **Active Learning:** The flipped model encourages students to engage actively with the material during class. With prior knowledge, students can contribute meaningfully to discussions, making classes more enjoyable and dynamic.
4. **Identifying Struggles:** Class time becomes an opportunity to identify students struggling with specific concepts, as it focuses on problem-solving and discussions.
5. **Creating Open Educational Resources:** As educators develop materials, they contribute to a repository of open educational resources that can benefit learners worldwide. This not only enhances the educator's profile but also creates potential opportunities through platforms like YouTube.
6. **Skill Refinement for Educators:** Educators also benefit by sharpening their own skills, especially in digital technology, which is crucial for integrating tech into teaching.

Recognizing these numerous benefits is vital as we move to the next step of flipping the classroom.

Teacher Training on the Use of Digital Tools

To effectively implement the flipped classroom model, one critical area that requires attention is the training of teachers in using digital tools. While many educators have deep knowledge of the subjects they teach, they often lack proficiency in digital skills, which are crucial for creating and delivering flipped classroom materials. Organizations such as [Schoolinka](#) have already made strides in offering such training, but more comprehensive and widespread initiatives are needed.

Importance of Digital Literacy for Educators

STEM educators need to be proficient not only in their subject matter but also in essential digital tools to create a dynamic and interactive learning environment. When educators become adept with technology, they can equip their students not only with academic knowledge but also with the digital skills required in the modern world. This fusion of content expertise and digital literacy enhances student learning and engagement.

Key Skills for STEM Educators

- **Slide Preparation:** Teachers need to learn how to create well-organized and visually engaging slides for classroom instruction. Tools like Microsoft PowerPoint, Google Slides, [Nearpod](#) and [Canva](#) allow educators to create engaging and interactive slides. Nearpod, in particular, is a powerful tool that enables teachers to embed quizzes, polls, and collaborative activities directly into their presentations, making the learning experience more interactive and dynamic.
- **Video Editing:** With flipped learning, videos are a core component. Educators should be trained on how to record and edit instructional videos using software like Adobe Premiere, Camtasia, or Adobe Captivate. Educators can create instructional videos with these tools, giving students access to learning materials that can be reviewed anytime. Training in video editing ensures that teachers can produce high-quality videos that enhance students' understanding of complex topics.
- **Graphic Design:** Tools like [Canva](#) can help teachers design instructional materials, infographics, and visual aids that make lessons more engaging.
- **Basic Computer Knowledge:** This includes knowing how to troubleshoot simple technical issues, organize digital files, and use online platforms to share resources with students.

In addition to the above skills, educators should be familiar with online tools that make formative and summative assessments more interactive and engaging. Platforms such as [Kahoot](#), [Bamboozle](#), and [Quizizz](#) can be integrated into lessons to test students' understanding of materials in a fun, competitive way. These tools provide immediate feedback and help educators gauge student progress in real time.

Preparation of Learning Materials

Once the importance of flipping the classroom is understood and educators have acquired the necessary skills in using digital tools, the next step involves preparing the learning materials. This stage can be one of the most challenging aspects of the flipped classroom model,

requiring time and energy. While pre-existing resources can be utilized, materials created by educators are often more relatable and tailored to their students' needs.

By investing time in creating these resources—such as videos or articles—educators ensure they have valuable learning materials for future classes. This upfront effort pays off throughout the academic year, as these resources can be reused and shared. Moreover, hosting videos on platforms like YouTube allows educators to reach a broader audience while maintaining a focus on their students' comprehension.

For educators in higher institutions, a practical approach to material preparation involves:

1. Manuscript Preparation: Before the semester begins, take the time to prepare clear manuscripts of the topics you will be teaching. This foundational work sets the stage for effective teaching and ensures that your content is well-organized.

2. Collaborate with Course Representatives: Align with the course representatives of the various levels you teach to mobilize students willing to assist in creating PowerPoint slides based on your written documents. Overseeing this process not only helps you prepare instructional materials but also enhances the students' skills in content creation and presentation.

3. Skill Development: Engaging students in the preparation of learning materials sharpens their skills and provides them with valuable experience that will benefit them in their future careers. The collaborative effort fosters a sense of ownership and investment in their learning.

4. Video Narration and Editing: Once the slides are prepared, narrate the content and distribute the recordings to another group of students for video editing. While many students may lack editing skills, this presents an opportunity for them to gain relevant competencies that extend beyond the classroom. Consider investing in courses on video creation and editing for those interested, enabling skilled students to train their peers.

5. Hosting the Content: After successfully creating the videos, the next step is hosting them. Platforms like YouTube are ideal for sharing your content, especially if your institution lacks a dedicated Learning Management System (LMS). Hosting on YouTube allows you to reach a global audience while effectively flipping your classroom.

6. Focus on Student Comprehension: While it's important to create content that can serve a wider audience, remember that your primary focus should be on your students' comprehension. Tailoring the videos to meet their specific learning needs ensures that they can fully engage with the material.

By implementing these strategies, higher education educators can efficiently prepare learning materials while empowering their students with essential skills, thereby enhancing the overall educational experience.

For educators in secondary schools, flipping the classroom is not only possible but also an exciting opportunity for growth and innovation. While it may be easy to cite various challenges as reasons for not implementing this approach, the true limitation often lies within our own mindset. Recognizing the critical importance of flipping the classroom can empower educators to overcome obstacles and embrace this transformative method of teaching.

To effectively implement this strategy, secondary school educators can adopt a similar process to their higher education counterparts. Encourage your students to develop valuable skills by guiding them through the preparation of PowerPoint slides and video editing. Consider using school breaks as dedicated time for skill-building and resource preparation, rather than traditional summer lessons. This approach allows students to gain practical experience while fostering a sense of ownership and pride in the materials they help create.

By collaborating with students on these projects, educators not only enhance their connections with them but also make the learning process more engaging. When students are involved in the creation of educational resources, they are more likely to appreciate and actively participate in the learning experience when it is time to review the materials. Their involvement fosters a deeper connection to the content, making it more relevant and enjoyable for them.

Grading Strategies

In the context of secondary education, students tend to take their viewing and reading of materials seriously. However, this may not be the case for many students in higher education. To encourage them to actively engage with video content and reading materials, consider implementing the following grading model:

1. Pre-Class Quiz: At the beginning of each class, conduct a quiz based on the content of the videos watched. This quiz should contribute to the overall performance evaluation, accounting for approximately 10-15% of their final grade. This initial assessment serves as a motivator for students to engage with the material before coming to class.

2. Post-Class Quiz: To accommodate students who may watch the videos but struggle with comprehension, administer a second quiz after class discussions and explanations. This

quiz should carry more weight than the initial quiz, reinforcing the importance of understanding the material. By offering a second opportunity to demonstrate comprehension, you acknowledge varying levels of understanding while encouraging thorough engagement with the content.

3. Class Participation: In addition to the quizzes, consider grading students on their participation and engagement during class. This can include contributions to discussions, group activities, and interactions with peers. Students will be less inclined to risk their marks by failing to engage in the material, knowing that their participation will impact their overall performance.

4. Building Student Buy-In: While this method effectively addresses the needs of less motivated students, it's essential to communicate the benefits of the flipped classroom model during the preparation stages. By clearly articulating how this approach enhances learning and applies knowledge beyond the classroom, students may feel more inclined to comply.

5. Empowering Students: Ultimately, the goal is for students to not only pass the quizzes but also to be able to apply the knowledge gained in real-world scenarios. By fostering a sense of ownership over their learning, students can collectively decide on the consequences of failing to engage with the materials before class.

This grading structure incentivizes students to engage with the materials actively and participate in class, understanding that their performance is tied to their preparation. While this method effectively encourages compliance, building a strong rapport with students during the preparation phase can foster intrinsic motivation. Educators should aim for students to not only pass quizzes but also apply their knowledge beyond the classroom, aligning with the primary objective of the flipped classroom model.

Implementation

The successful implementation of a flipped classroom hinges on access to the necessary tools and resources. If educators lack adequate support, the preparation of learning materials may prove ineffective. Additionally, students must have access to the technology required for engaging with the materials. Therefore, the role of stakeholders, including government bodies, cannot be overstated.

Higher Institutions: For higher education institutions, the two fundamental resources that must be made available are **electricity** and **internet connectivity**. Many students report

prolonged periods without power, which hampers their ability to prepare for classes. Furthermore, the absence of stable internet access limits their ability to view online materials effectively (Tang et al., 2021).

To address these challenges, it is essential for stakeholders and government bodies to intervene by providing essential resources, such as:

- **Reliable Electricity:** Ensuring consistent power supply to facilitate the use of technological tools.
- **Stable Internet Connectivity:** Establishing dependable internet access on campuses and in communities to allow students to engage with online learning materials effectively.

By overcoming these barriers, higher education institutions can create an environment conducive to the successful implementation of the flipped classroom model, enhancing learning outcomes for students (Divjak et al., 2022).

Secondary/Primary Education: In secondary and primary schools, particularly in rural areas, access to resources is equally vital for effective implementation. Key needs include:

- **Projectors and Learning Devices:** Equipping classrooms with projectors and other teaching aids to facilitate group learning and discussions.
- **Reliable Electricity:** Similar to higher institutions, a stable power supply is necessary for the use of electronic resources.
- **Strong Internet Connections:** Providing access to the internet, even if it's limited to school facilities, allows students to engage with educational materials.

While it may not be feasible to provide devices to every student, equipping educators with laptops and projectors can significantly enhance the flipped classroom experience. Additionally, fostering a collaborative environment during material preparation can strengthen relationships between educators and students, further contributing to a successful flipped classroom model. By prioritizing these foundational resources, the flipped classroom model can be effectively implemented in STEM education across Nigeria, leading to improved learning outcomes for students.

Conclusion

While there are numerous challenges that might hinder the implementation of the flipped classroom model in Nigerian public schools, focusing on factors within our control can lead

to effective change. Prioritizing teacher training and involving students in the preparation of learning materials are essential steps. Additionally, government bodies, stakeholders, and NGOs must invest in providing digital tools in schools and work towards sustainable energy solutions to ensure that educational environments have reliable electricity, particularly in public higher institutions.

Enhancing internet connectivity should also be a priority for network providers, especially in remote areas, to prevent connectivity issues for students. Furthermore, creating a national body similar to the National Institute for Technical Education and Learning (NIPTTEL), which has successfully supported the flipping of STEM classrooms in India by providing resources, training, and infrastructure, could enhance educational delivery in Nigeria's technical schools and universities. By addressing these areas, we can effectively flip STEM classrooms in Nigeria, enhancing the learning experience for students and fostering meaningful knowledge transfer beyond the classroom.

References

- Aina, J. K. (2022). STEM education in Nigeria: Development and challenges. *Current Research in Language, Literature and Education*, 3, 53-60. <https://doi.org/10.9734/bpi/crll/v3/2258C>
- Abeyssekera, L., & Dawson, P. (2014). Motivation and cognitive load in the flipped classroom: Definition, rationale, and a call for research. *Higher Education Research & Development*. <https://doi.org/10.1080/07294360.2014.934336>
- Ayçiçek, B., & Yelken, T. Y. (2018). The effect of flipped classroom model on students' classroom engagement in teaching English. *International Journal of Instruction*, 11(2), 385-398.
- Bello, A. (2021). Policy inconsistency: Major bane to development in the educational sector in Nigeria. *Journal of Research and Development*, 8(1), 145-159.
- Cabi, E. (2018). The impact of the flipped classroom model on students' academic achievement. *International Review of Research in Open and Distributed Learning*, 19(3).<https://doi.org/10.19173/irrodl.v19i3.3482>

- Chisom, O. N., Unachukwu, C. C., & Osawaru, B. (2023). STEM education advancements in Nigeria: A comprehensive review. *International Journal of Applied Research in Social Sciences*, 5(10), 614-636.<https://doi.org/10.51594/ijarss.v5i10.724>
- Divjak, M., Rienties, B., Iniesto, F., Vondra, P., & Žižak, M. (2022). Online flipped classroom approaches in higher education during the pandemic: A systematic literature review. *Computers & Education*, 176, 104331. <https://doi.org/10.1016/j.compedu.2021.104331>
- Eze, K. U. (2023). Impact of policy inconsistency on the management of secondary education in Nigeria. *Augustinian Journal of Philosophy and Theology*, 5(1), 160-182.
- Fomunyan, K. G. (2019). Education and the Fourth Industrial Revolution: Challenges and possibilities for engineering education. *International Journal of Mechanical Engineering and Technology*, 10(8), 271-284.<http://www.iaeme.com/IJMET/index.asp>
- Hsieh, J. S. C., Wu, W.-C. V., & Marek, M. W. (2017). Using the flipped classroom to enhance EFL learning. *Computer Assisted Language Learning*, 30(1-2), 1-21. <https://doi.org/10.1080/09588221.2015.1111910>
- Idhalama, O. U., Krubu, D. E., & Etebu, A. T. (2023). Proficiency of university lecturers in the adoption of emerging instructional technologies in Nigeria. *East African Journal of Education and Social Sciences (EAJESS)*, 4(5), 101-108.<https://doi.org/10.46606/eajess2023v04i05.0324>
- Lakmal, A., Abeysekera, L., & Dawson, P. (2014). Motivation and cognitive load in the flipped classroom: Definition, rationale, and a call for research. *Higher Education Research & Development*. <https://doi.org/10.1080/07294360.2014.934336>
- Min, L., Jingpeng, L., & Yushun, L. (2020). A comparative analysis of STEM education research (2016-2020) based on CiteSpace. In *2020 Ninth International Conference of Educational Innovation through Technology (EITT)* (pp. 128-132). <https://doi.org/10.1109/EITT50754.2020.00029>
- Odesomi, O. (2023, November 16). The state of STEM education in Nigeria. *African Leadership Magazine*.<https://www.africanleadershipmagazine.co.uk/the-state-of-stem-education-in-nigeria/>
- Ohaegbulem, E. U., & Chijioke, S. C. (2023). On Nigeria's budgetary allocations to the education sector (1960–2023) in view of UNESCO's benchmarks. *International*

- Journal of Mathematics and Statistics Studies*, 11(4), 32-44.<https://doi.org/10.37745/ijmss.13/vol11n1119>
- Ojetunde, S. M., & Ajani, M. O. (2021). Effects of education budget and enrolment on science, technology, engineering, and mathematics (STEM) education in Nigeria. *International Journal of Educational Management*, 19(2).<https://www.ijem.org.ng/index.php/ijem/article/view/101>
- Oluyemisi, O. M. (2023). Impact of artificial intelligence in curriculum development in Nigerian tertiary education. *International Journal of Educational Research*, 12(2), 192-211.
- Orlić, S., Marić, M., & Petojević, A. (2023). Implementing the flipped classroom model in mathematics class teaching. *South African Journal of Education*, 43(4).<https://doi.org/10.15700/saje.v43n4a2223>
- Oyelere, S. S., Sanusi, I. T., Vatiainen, H., Shuhonen, J., & Tukiainen, M. (2023). Developing middle school students' understanding of machine learning in an African school. *Computers and Education: Artificial Intelligence*, 5.<https://doi.org/10.1016/j.caeai.2023.100155>
- Parker, A. S., Hill, K. A., Steffes, B. C., Mangaoang, D., & Bitta, C. (2022). Design of a novel online, modular, flipped-classroom surgical curriculum for East, Central, and Southern Africa. <https://doi.org/10.1097/AS9.0000000000000141>
- Samarraie, H. A., Shamsuddin, A., & Alzahrani, A. I. (2019). A flipped classroom model in higher education: A review of the evidence across disciplines. *Educational Technology Research and Development*, 68(3), 1017-1051.<https://doi.org/10.1007/s11423-019-09718-8>
- Shonhe, L., Jain, P., & Akakandelwa, A. (2023). Students' experiences with the utilisation of the 4IR technologies in online learning: A case study of institutions of higher learning in Botswana and Zambia. *Regional Journal of Information and Knowledge Management*, 8(2), 81-100.
- Tang, T., Abuhmaid, A. M., Olaimat, M., Oudat, D. M., Aldhaeabi, M., & Bamanger, E. (2020). Efficiency of flipped classroom with online-based teaching under COVID-19. *Interactive Learning Environments*. <https://doi.org/10.1080/10494820.2020.1817761>
- Umar, Y. (2019). STEM education as a catalyst for national development: Problems and prospects in Nigeria. *International Learning Science and Mathematics Journal*, 14, 48-59.

United Nations Educational, Scientific and Cultural Organization. (2021, November 10). UNESCO member states unite to increase investment in education.<https://www.unesco.org/en/articles/unesco-member-states-unite-increase-investment-education>

Usman, M. H. (2020). The usefulness of science, technology, engineering, and mathematics education (STEM) as an instrument for sustainable development in Nigeria. *Abacus (Mathematics Education Series)*, 45(1), 101-107.

Yunus, D., Batdı, V., & Yaşar, M. D. (2021). Effectiveness of flipped classroom practices in teaching of science: A mixed research synthesis. *Research in Science & Technological Education*, 41(1), 393–421.<https://doi.org/10.1080/02635143.2021.1909553>