ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26feb025

# Assessing the Impact of Emerging Technologies (VR, AR, AI) on Stem Teaching Practices and Students Learning Experiences in Federal College of Education Pankshin, Plateau State, Nigeria

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Publication Date: 2026/02/27

**Abstract: This study examined the impact of emerging technologies—Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI)—on STEM teaching practices and students' learning experiences at the Federal College of Education, Pankshin, Plateau State, Nigeria. A descriptive survey research design was adopted to generate empirical evidence on the level of technology integration, perceived instructional impact, and challenges associated with adoption. The population comprised 1,429 STEM students and 105 STEM lecturers, from which a sample of 374 students and 83 lecturers was selected using a stratified sampling technique. Data were collected using a structured questionnaire titled Emerging Technologies in STEM Teaching and Learning Questionnaire (ETSTLQ) and analysed using mean scores, standard deviations, and Chi-square tests of independence at the 0.05 level of significance. The findings revealed that the integration of VR, AR, and AI into STEM teaching practices at the institution was generally low, indicating a continued reliance on conventional instructional approaches. Despite this limited level of integration, the results showed a statistically significant positive impact of emerging technologies on students' learning experiences, particularly in terms of engagement, conceptual understanding, motivation, and knowledge retention. The study further identified significant challenges hindering adoption, including inadequate technological infrastructure, high costs of acquisition and maintenance, insufficient lecturer training, limited technical support, and resistance to change. The results of the hypotheses tests confirmed that both the impact of emerging technologies on learning experiences and the influence of identified challenges on adoption were statistically significant. The study concludes that while emerging technologies hold substantial potential for enhancing STEM education, deliberate institutional interventions are required to address structural and capacity-related barriers. Strategic investment in infrastructure, continuous professional development, and supportive institutional policies are recommended to promote effective integration and improve the quality of STEM teaching and learning.**

***Keywords:*** *Emerging Technologies, Virtual Reality, Augmented Reality, Artificial Intelligence, STEM Education, Teaching Practices, Learning Experiences.*

**How to Cite:** Dung, Mohammed Dauda; ILIYA, Godiya Bako (2026) Assessing the Impact of Emerging Technologies (VR, AR, AI) on Stem Teaching Practices and Students Learning Experiences in Federal College of Education Pankshin, Plateau State, Nigeria. *International Journal of Innovative Science and Research Technology*, 11(2), 1838-1845. https://doi.org/10.38124/ijisrt/26feb025

## I. INTRODUCTION

The global landscape of education is undergoing a profound transformation driven by rapid advances in digital and emerging technologies. In recent years, technologies such as Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI) have increasingly influenced how knowledge is constructed, delivered, and assessed, particularly within Science, Technology, Engineering, and Mathematics (STEM) education. These technologies have shifted instructional practices from predominantly teacher-centred approaches toward more interactive, learner-centred environments that

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26feb025

emphasize exploration, simulation, and problem-solving. In STEM disciplines, where abstract concepts and complex systems often challenge learners, the integration of immersive and intelligent technologies has been widely acknowledged as a pathway to improving conceptual understanding and deepening learning engagement.

Virtual Reality and Augmented Reality have emerged as powerful instructional tools capable of bridging the gap between theory and practice. VR allows learners to engage with fully immersive, computer-generated environments where abstract or hazardous scientific phenomena can be explored safely and repeatedly, while AR enhances real-world settings by overlaying digital information that supports contextual learning. Studies across different educational systems have shown that these technologies can significantly improve students' spatial reasoning, motivation, and retention of scientific concepts when appropriately integrated into instruction (Makransky and Petersen, 2019; Radianti, Majchrzak, Fromm, and Wohlgenannt, 2020). These affordances are particularly relevant to STEM education, where experiential learning and visualization play a critical role in knowledge construction.

Alongside VR and AR, Artificial Intelligence has introduced new possibilities for personalization and adaptive learning in education. AI-driven systems can analyse learners' behaviours, provide real-time feedback, recommend learning resources, and support instructors in monitoring students' progress more effectively. In STEM contexts, AI applications have been shown to support differentiated instruction and formative assessment by responding to individual learners' needs rather than relying solely on uniform instructional strategies (Zawacki-Richter, Marín, Bond, and Gouverneur, 2019). The pedagogical promise of AI lies not only in automation but in its capacity to augment teaching practices and enhance learning experiences when aligned with sound instructional design.

Despite the demonstrated potential of these emerging technologies, their adoption and effective integration remain uneven across regions and educational systems. While institutions in developed countries have increasingly embedded VR, AR, and AI into STEM curricula, many developing countries continue to face systemic constraints that limit meaningful technology integration. Challenges such as inadequate infrastructure, high costs of acquisition and maintenance, limited access to reliable internet connectivity, and insufficient professional development for educators have been widely reported in the literature (UNESCO, 2021). These constraints raise concerns about equity in access to innovative learning opportunities and the preparedness of graduates to function in technology-driven knowledge economies.

In Nigeria, efforts to integrate digital technologies into education have gained policy attention, particularly in relation to STEM education and national development goals. However, empirical evidence suggests that the actual use of advanced technologies such as VR, AR, and AI in higher education institutions remains relatively low and largely exploratory. Existing studies on educational technology in Nigeria have tended to focus on basic information and communication technologies, with limited attention given to immersive and intelligent systems and their pedagogical implications for STEM teaching and learning (Afolayan, 2020). This gap is more pronounced in teacher education institutions, which play a critical role in preparing future educators who will shape instructional practices at various levels of the education system.

The Federal College of Education, Pankshin, as a key teacher-training institution in Plateau State, occupies a strategic position in the development of STEM educators for the region and beyond. The quality of teaching practices and learning experiences within the College has direct implications not only for current students but also for the pupils they will eventually teach in primary and secondary schools. Understanding how emerging technologies are currently being utilized, perceived, or constrained within this institutional context is therefore essential. Without empirical evidence on the extent and impact of VR, AR, and AI integration in STEM teaching, institutional planning and policy decisions risk being based on assumptions rather than data-driven insights.

Against this backdrop, there is a compelling need for a systematic investigation into the impact of emerging technologies on STEM teaching practices and students' learning experiences at the Federal College of Education, Pankshin. Such a study is necessary to illuminate current levels of integration, examine perceived and actual pedagogical benefits, and identify the contextual challenges shaping technology adoption within the institution. By generating institution-specific empirical evidence, the study seeks to contribute to informed decision-making, guide capacity-building initiatives, and support the strategic integration of innovative technologies in STEM education, thereby addressing an important gap in both local practice and the broader body of educational research in Nigeria.

- *Statement of the Problem*

Emerging technologies such as Virtual Reality, Augmented Reality, and Artificial Intelligence have been widely recognized for their potential to transform STEM teaching and learning through immersive, interactive, and personalized instructional experiences. However, within many teacher education institutions in Nigeria, including the Federal College of Education, Pankshin, the extent to which these technologies are integrated into STEM teaching practices remains unclear and potentially limited. STEM instruction in such contexts continues to rely largely on conventional teaching methods, which often struggle to adequately support the visualization of abstract concepts, sustained student engagement, and the development of higher-order cognitive skills. This situation raises concerns about whether STEM students are being adequately exposed to innovative

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26feb025

instructional practices that align with contemporary global standards in science and technology education.

The persistence of limited integration of VR, AR, and AI in STEM teaching has far-reaching implications for both teaching effectiveness and students' learning experiences. Where these technologies are absent or underutilized, students may experience reduced engagement, shallow conceptual understanding, and limited opportunities for experiential and personalized learning, while lecturers may remain constrained in their ability to adopt innovative pedagogical approaches. If this problem is left unaddressed, it risks producing graduates who are insufficiently prepared for technology-driven educational environments and ill-equipped to transfer modern instructional practices to the schools they will eventually serve. Such an outcome could widen the gap between Nigerian teacher education institutions and global best practices in STEM education, undermining efforts to improve educational quality, technological relevance, and national development objectives.

➢ *Objectives of the Study*

The main objective of this study is to assess the impact of emerging technologies—Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI)—on STEM teaching practices and students' learning experiences at the Federal College of Education, Pankshin, Plateau State, Nigeria. Specifically, the study seeks to:

- Examine the extent to which Virtual Reality, Augmented Reality, and Artificial Intelligence are integrated into STEM teaching practices at the Federal College of Education, Pankshin.
- Determine the impact of Virtual Reality, Augmented Reality, and Artificial Intelligence on students' learning experiences in STEM subjects at the Federal College of Education, Pankshin.
- Identify the challenges affecting the adoption and effective use of Virtual Reality, Augmented Reality, and Artificial Intelligence in STEM teaching within the Federal College of Education, Pankshin.

➢ *Research Questions*

The following research questions will guide the study:

- To what extent are Virtual Reality, Augmented Reality, and Artificial Intelligence integrated into STEM teaching practices at the Federal College of Education, Pankshin?
- What impact do Virtual Reality, Augmented Reality, and Artificial Intelligence have on students' learning experiences in STEM subjects at the Federal College of Education, Pankshin?
- What challenges hinder the adoption and effective integration of Virtual Reality, Augmented Reality, and Artificial Intelligence in STEM teaching at the Federal College of Education, Pankshin?

➢ *Null Hypotheses*

The following null hypotheses were formulated to guide the study and were tested at the 0.05 level of significance:

- $H_{01}$: There is no significant level of integration of Virtual Reality, Augmented Reality, and Artificial Intelligence in STEM teaching practices at the Federal College of Education, Pankshin.
- $H_{02}$: There is no significant impact of Virtual Reality, Augmented Reality, and Artificial Intelligence on students' learning experiences in STEM subjects at the Federal College of Education, Pankshin.
- $H_{03}$: There is no significant relationship between identified institutional challenges and the adoption of Virtual Reality, Augmented Reality, and Artificial Intelligence in STEM teaching at the Federal College of Education, Pankshin.

➢ *Significance of the Study*

The findings of this study are expected to be significant to multiple stakeholders within the education sector, particularly teacher education institutions, policymakers, and curriculum developers. By providing empirical evidence on the extent and impact of Virtual Reality, Augmented Reality, and Artificial Intelligence in STEM teaching practices at the Federal College of Education, Pankshin, the study will offer valuable insights into how emerging technologies can enhance instructional delivery and students' learning experiences. For STEM lecturers, the results may serve as a practical guide for adopting innovative teaching strategies that promote engagement, conceptual understanding, and active learning. In addition, institutional administrators can use the findings to make informed decisions regarding investment in technological infrastructure, staff development programmes, and instructional resources that support effective technology integration.

Beyond the institutional level, the study holds broader significance for educational policy and research in Nigeria. By identifying context-specific challenges and opportunities associated with the adoption of emerging technologies in STEM education, the study will contribute evidence that can inform national policies on teacher preparation, digital transformation, and STEM capacity building. The insights generated are also expected to enrich the existing body of literature on educational technology by extending empirical knowledge to teacher education institutions in developing contexts, which remain underrepresented in global research. Ultimately, the study may support efforts to improve the quality and relevance of STEM education, enhance graduate preparedness for technologically driven learning environments, and promote sustainable educational development in Nigeria.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26feb025

## II. METHODOLOGY

The study adopted a descriptive survey research design to systematically examine the impact of emerging technologies—Virtual Reality, Augmented Reality, and Artificial Intelligence—on STEM teaching practices and students' learning experiences at the Federal College of Education, Pankshin, Plateau State, Nigeria. This design was considered appropriate because it allows for the collection of data from a relatively large population in order to describe existing conditions, practices, and perceptions as they naturally occur within the institution. The population of the study comprised all STEM lecturers and students in the College, estimated at approximately 1,429 students and 105 teachers drawn from STEM-related disciplines. From this population, a sample of 374 students and 83 teachers was selected using a stratified sampling technique to ensure proportional representation across the relevant STEM departments. This approach enhanced the representativeness of the sample by accounting for variations across disciplines and academic roles, thereby strengthening the generalizability of the findings within the institutional context.

Data for the study were collected using a structured questionnaire titled Emerging Technologies in STEM Teaching and Learning Questionnaire (ETSTLQ), designed to elicit information on the level of technology integration, perceived impact on learning experiences, and challenges associated with the use of VR, AR, and AI. The instrument was structured on a four-point Likert scale of Strongly Agree, Agree, Disagree, and Strongly Disagree. To ensure content and construct validity, the questionnaire was subjected to expert review by specialists in science education and educational measurement and evaluation, whose inputs guided necessary revisions. The reliability of the instrument was established through a pilot study, with internal consistency reliability coefficient of 0.84, determined using Cronbach's alpha coefficient. The validated questionnaire was administered to the sampled respondents through direct distribution with the support of trained research assistants, ensuring a high response rate and ethical compliance. Data analysis involved the use of descriptive statistics, specifically mean scores and standard deviations, to answer the research questions, while the hypotheses were tested using the Chi-square test of independence at the 0.05 level of significance.

## III. RESULTS

- *Research Question One*

To what extent are Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI) integrated into STEM teaching practices at the Federal College of Education, Pankshin?

Table 1: Mean and Standard Deviation of Responses on the Integration of Emerging Technologies in STEM Teaching Practices

| S/N | Items | Mean ($\bar{x}$) | SD | Decision |
|---|---|---|---|---|
| 1. | Virtual Reality tools are used during STEM lessons to demonstrate concepts that are difficult to visualize. | 2.18 | 0.87 | Disagree |
| 2. | Augmented Reality applications are incorporated into STEM instruction to enhance classroom demonstrations. | 2.11 | 0.91 | Disagree |
| 3. | Artificial Intelligence–based tools are used to support teaching activities such as assessment or feedback in STEM subjects. | 2.05 | 0.89 | Disagree |
| 4. | STEM lecturers regularly integrate emerging technologies into their instructional methods. | 2.23 | 0.84 | Disagree |
| 5. | Institutional facilities adequately support the use of VR, AR, and AI in STEM teaching practices. | 2.09 | 0.93 | Disagree |
| | **Cluster Mean** | **2.13** | **0.89** | **Low Integration** |

*Criterion Mean = 2.50*

As presented in Table 1, the mean scores for all five items measuring the integration of emerging technologies in STEM teaching practices fell below the criterion mean of 2.50. This indicates that respondents generally disagreed with statements suggesting regular or effective use of Virtual Reality, Augmented Reality, and Artificial Intelligence in STEM instruction at the Federal College of Education, Pankshin. The cluster mean of 2.13 further confirms that the overall level of integration of these technologies into teaching practices within the institution is low.

The relatively low standard deviation values associated with the items suggest a high degree of consistency in respondents' perceptions, indicating that both lecturers and students shared similar views regarding the limited presence of emerging technologies in STEM teaching. In particular, the lowest mean score recorded for the use of Artificial Intelligence–based tools highlight the near absence of intelligent systems for instructional support, assessment, or feedback. Collectively, these findings demonstrate that STEM teaching practices in the institution remain largely conventional, with minimal adoption of immersive and intelligent technologies. This outcome reinforces the need for targeted institutional interventions aimed at improving infrastructural provision, lecturer capacity development, and policy-driven integration of emerging technologies into STEM education.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26feb025

➢ *Research Question Two*

What impact do Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI) have on students' learning experiences in STEM subjects at the Federal College of Education, Pankshin?

Table 2: Mean and Standard Deviation of Responses on the Impact of Emerging Technologies on Students' Learning Experiences

| | Items | Mean ($\bar{x}$) | SD | Decision |
|---|---|---|---|---|
| 6. | The use of Virtual Reality improves students' understanding of complex STEM concepts. | 3.12 | 0.76 | Agree |
| 7. | Augmented Reality makes STEM lessons more engaging and interactive. | 3.18 | 0.71 | Agree |
| 8. | Artificial Intelligence–based tools support personalized learning in STEM subjects. | 3.05 | 0.79 | Agree |
| 9. | Learning with emerging technologies increases students' interest and motivation in STEM subjects. | 3.22 | 0.68 | Agree |
| 10. | The use of VR, AR, and AI enhances students' ability to retain and apply STEM knowledge. | 3.09 | 0.74 | Agree |
| | **Cluster Mean** | **3.13** | **0.74** | **High Positive Impact** |

*Criterion Mean = 2.50*

As presented in Table 2, the mean scores for all five items measuring the impact of emerging technologies on students' learning experiences were above the criterion mean of 2.50. This indicates that respondents generally agreed that Virtual Reality, Augmented Reality, and Artificial Intelligence positively influence learning experiences in STEM subjects at the Federal College of Education, Pankshin. The cluster mean score of 3.13 further confirms that the perceived impact of these technologies on students' learning experiences is high and positive.

The relatively low standard deviation values across the items suggest a reasonable level of consistency in respondents' views regarding the benefits of emerging technologies for learning. In particular, respondents acknowledged improvements in conceptual understanding, engagement, motivation, and knowledge retention when these technologies are applied in STEM instruction. These findings suggest that although the overall integration of VR, AR, and AI into teaching practices within the institution is limited, their pedagogical value is clearly recognized by both students and lecturers. This result highlights the potential gains that could be achieved if institutional barriers to adoption are addressed and emerging technologies are more systematically incorporated into STEM teaching and learning processes.

➢ *Research Question Three*

What challenges hinder the adoption of Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI) in STEM teaching at the Federal College of Education, Pankshin?

Table 3: Mean and Standard Deviation of Responses on Challenges Hindering the Adoption of Emerging Technologies in STEM Teaching

| | Items | Mean ($\bar{x}$) | SD | Decision |
|---|---|---|---|---|
| 11. | Inadequate availability of technological facilities limits the use of VR, AR, and AI in STEM teaching. | 3.31 | 0.65 | Agree |
| 12. | Lack of sufficient training prevents STEM lecturers from effectively using emerging technologies. | 3.27 | 0.69 | Agree |
| 13. | The high cost of acquiring and maintaining VR, AR, and AI tools hinders their adoption in STEM education. | 3.35 | 0.62 | Agree |
| 14. | Limited access to reliable internet and technical support affects the use of emerging technologies in STEM teaching. | 3.29 | 0.67 | Agree |
| 15. | Resistance to change among lecturers and students affects the adoption of VR, AR, and AI in STEM education. | 2.88 | 0.81 | Agree |
| | **Cluster Mean** | **3.22** | **0.69** | **High Level of Challenges** |

*Criterion Mean = 2.50*

As shown in Table 4, all items measuring challenges to the adoption of Virtual Reality, Augmented Reality, and Artificial Intelligence in STEM teaching recorded mean scores above the criterion mean of 2.50. This indicates that respondents generally agreed

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26feb025

that multiple factors significantly hinder the integration of emerging technologies into STEM teaching practices at the Federal College of Education, Pankshin. The cluster mean score of 3.22 further suggests that the overall level of challenges affecting adoption is high.

Among the identified challenges, the high cost of acquiring and maintaining technological tools and the inadequate availability of required facilities recorded the highest mean scores, indicating that financial and infrastructural constraints constitute the most critical barriers. Limited access to reliable internet services and insufficient technical support were also perceived as major impediments to effective integration. Although resistance to change among lecturers and students recorded a comparatively lower mean score, it still exceeded the criterion mean, suggesting that attitudinal factors also play a role in limiting adoption. Collectively, these findings demonstrate that the challenges hindering the use of emerging technologies in STEM education are multidimensional, reinforcing the need for comprehensive institutional strategies that address infrastructural, financial, technical, and human capacity constraints.

➢ *Test of Hypotheses*

The Chi-square ($\chi^2$) test of independence was employed to test the null hypotheses at 0.05 level of significance

- *Hypothesis One ($H_{01}$):*

There is no significant level of integration of Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI) in STEM teaching practices at the Federal College of Education, Pankshin.

Table 4: Chi-square Test of Integration of Emerging Technologies in STEM Teaching Practices

| Variable | $\chi^2$ Cal | df | $\chi^2$ Crit | Sig. Level | Decision |
|---|---|---|---|---|---|
| Integration of VR, AR, and AI in STEM Teaching Practices | 42.67 | 3 | 7.815 | 0.05 | Reject $H_{01}$ |

As shown in Table 4, the calculated Chi-square value of 42.67 is greater than the critical value of 7.815 at 3 degrees of freedom and 0.05 level of significance. This result indicates a statistically significant pattern in respondents' perceptions of the integration of emerging technologies in STEM teaching practices at the Federal College of Education, Pankshin. Consequently, the null hypothesis is rejected. This finding suggests that the observed low level of integration of VR, AR, and AI in STEM teaching practices is systematic rather than a result of chance.

- *Hypothesis Two ($H_{02}$):*

There is no significant impact of Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI) on students' learning experiences in STEM subjects at the Federal College of Education, Pankshin.

Table 6: Chi-square Test of the Impact of Emerging Technologies on Students' Learning Experiences

| Variable | $\chi^2$ Cal | df | $\chi^2$ Crit | Sig. Level | Decision |
|---|---|---|---|---|---|
| Impact of VR, AR, and AI on Students' Learning Experiences | 36.94 | 3 | 7.815 | 0.05 | Reject $H_{02}$ |

Table 6 shows that the calculated Chi-square value of 36.94 exceeds the critical value of 7.815 at 3 degrees of freedom and a 0.05 level of significance. This result indicates a statistically significant impact of Virtual Reality, Augmented Reality, and Artificial Intelligence on students' learning experiences in STEM subjects at the Federal College of Education, Pankshin. The null hypothesis is therefore rejected. This finding corroborates the descriptive results, which showed that respondents perceived emerging technologies as enhancing engagement, understanding, motivation, and knowledge retention in STEM learning.

- *Hypothesis Three ($H_{03}$):*

There is no significant relationship between identified challenges and the adoption of Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI) in STEM teaching at the Federal College of Education, Pankshin.

Table 7: Chi-square Test of Challenges Affecting the Adoption of Emerging Technologies in STEM Teaching

| Variable | $\chi^2$ Cal | df | $\chi^2$ Crit | Sig. Level | Decision |
|---|---|---|---|---|---|
| Challenges and Adoption of VR, AR, and AI in STEM Teaching | 39.28 | 3 | 7.815 | 0.05 | Reject $H_{03}$ |

As presented in Table 7, the calculated Chi-square value of 39.28 is greater than the critical Chi-square value of 7.815 at 3 degrees of freedom and a 0.05 level of significance. This result indicates a statistically significant relationship between identified institutional challenges and the adoption of emerging technologies in STEM teaching at the Federal College of Education, Pankshin. Accordingly, the null hypothesis is rejected. The finding implies that factors such as inadequate

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26feb025

facilities, insufficient training, high costs, limited technical support, and attitudinal resistance significantly influence the level of adoption of VR, AR, and AI in STEM teaching practices.

## IV. DISCUSSION OF FINDINGS

Research Question One (table 1), examined the extent of integration of Virtual Reality, Augmented Reality, and Artificial Intelligence in STEM teaching practices, the findings indicate a generally low level of integration of these emerging technologies at the Federal College of Education, Pankshin. The descriptive results revealed mean scores below the criterion mean for all items measuring instructional use and institutional support, suggesting that STEM teaching practices remain largely conventional. This outcome was further reinforced by the test of Hypothesis One, where the null hypothesis was rejected, indicating that the observed low level of integration is statistically significant and not due to chance. This finding aligns with earlier studies which have shown that while awareness of emerging technologies is increasing, their actual classroom use in many developing-country institutions remains limited due to infrastructural and institutional constraints. For instance, Afolayan (2020) reported that teacher education institutions in Nigeria often struggle to move beyond basic ICT tools, largely because advanced technologies such as VR, AR, and AI require specialized infrastructure and institutional commitment. The present finding therefore highlights a structural gap between technological potential and instructional practice within the institution.

The findings of Research Question Two (table 2) which focused on the impact of emerging technologies on students' learning experiences, revealed a high positive perceived impact of VR, AR, and AI on STEM learning. Mean scores for all related items exceeded the criterion mean, indicating agreement among respondents that these technologies enhance understanding of complex concepts, increase engagement and motivation, and support knowledge retention. The rejection of Hypothesis Two further confirms that the impact of emerging technologies on students' learning experiences is statistically significant. This result is consistent with existing literature that emphasizes the pedagogical benefits of immersive and intelligent technologies in STEM education. For example, Makransky and Petersen (2019) observed that immersive learning environments improve conceptual understanding and learner engagement, while Zawacki-Richter, Marín, Bond, and Gouverneur (2019) noted that AI-supported learning systems can enhance personalization and feedback in higher education. The contrast between the low level of integration and the high perceived impact observed in this study suggests that although these technologies are not widely used, their educational value is clearly recognized by both students and lecturers.

Research Question Three (table 3) investigated the challenges hindering the adoption of emerging technologies in STEM teaching, the findings revealed that multiple barriers significantly affect the use of VR, AR, and AI within the institution. High mean scores across all challenge-related items indicate that inadequate facilities, high cost of acquisition and maintenance, insufficient training, limited technical support, and resistance to change are major impediments to adoption. This result was substantiated by the rejection of Hypothesis Three, which confirmed a statistically significant relationship between identified challenges and the adoption of emerging technologies in STEM teaching. These findings are in line with prior research that has consistently identified infrastructural and capacity-related challenges as major obstacles to technology integration in developing contexts. UNESCO (2021) similarly reported that without sustained investment in infrastructure and professional development, advanced educational technologies are unlikely to be effectively adopted. The convergence of descriptive and inferential results in this study underscores the need for comprehensive institutional strategies that address both material and human capacity constraints if emerging technologies are to be meaningfully integrated into STEM education.

## V. CONCLUSION

This study assessed the impact of emerging technologies—Virtual Reality, Augmented Reality, and Artificial Intelligence—on STEM teaching practices and students' learning experiences at the Federal College of Education, Pankshin. The findings indicate that the integration of these technologies into STEM teaching practices within the institution remains low, with instructional activities still dominated by conventional methods. Despite this limited level of adoption, both descriptive and inferential results demonstrate that emerging technologies have a significant and positive influence on students' learning experiences, particularly in enhancing engagement, conceptual understanding, motivation, and knowledge retention. This contrast highlights a critical gap between the acknowledged pedagogical value of emerging technologies and their actual utilization in STEM instruction.

The study further reveals that the limited adoption of VR, AR, and AI in STEM teaching is shaped by a combination of infrastructural, financial, technical, and human capacity challenges. Inadequate facilities, high costs, insufficient training, limited technical support, and resistance to change collectively constrain effective integration. These findings suggest that improving STEM education within teacher training institutions requires more than awareness of technological benefits; it demands deliberate institutional planning, sustained investment, and targeted professional development. Addressing these challenges is essential for fostering innovative teaching practices and for preparing future STEM educators who can effectively respond to the demands of technology-driven educational environments.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26feb025

## RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proposed to improve the integration of emerging technologies in STEM teaching and learning at the Federal College of Education, Pankshin.

- The management of the College should invest in the provision and maintenance of relevant technological infrastructure, including VR, AR, and AI–supported facilities, to enable effective integration of emerging technologies into STEM teaching practices.
- Regular capacity-building programmes should be organized for STEM lecturers to enhance their skills and confidence in the pedagogical use of emerging technologies for instructional delivery and assessment.
- Institutional policies and support mechanisms should be strengthened through dedicated funding and strategic partnerships to address financial, technical, and attitudinal barriers to the sustainable adoption of emerging technologies in STEM education.

## ACKNOWLEDGEMENT

The researchers gratefully acknowledge the financial support provided by the Tertiary Education Trust Fund (TETFund), which made it possible to carry out and complete this study within the stipulated timeframe. The support received significantly contributed to the successful execution of the research activities.

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