# IMPLICATIONS OF EMERGING TECHNOLOGIES ON RESEARCH DEVELOPMENT IN TERTIARY INSTITUTIONS: A DEVELOPING COUNTRY PERSPECTIVE

**By**

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## ABSTRACT

*The purpose of this study is to investigate the implications of emerging technologies on research development in tertiary institutions, with a focus on the developing country perspective. The study thoroughly evaluated three key constructs; transparent use of Artificial Intelligence (AI), availability of high-speed internet, and capacity building and skill development that act as catalysts for research development in tertiary institutions. A quantitative research technique involving a descriptive survey was adopted for the study. A questionnaire was designed as the measurement instrument and deployed to a sample of 376 respondents from the selected tertiary institutions. Copies of questionnaire were conveniently distributed to employees of these institutions to gather data for the study. Confirmatory Factor Analysis (CFA) was used to validate the constructs in the measurement instrument. Structural Equation Modeling (SEM) was employed to estimate the structural relationships between emerging technology constructs and research development in tertiary institutions. The analysis was aided by the software, Analysis of Moment Structures (AMOS), version 23. The results showed that the transparent use of Artificial Intelligence (AI), the availability of high-speed internet, and capacity building and skill development have significant positive effects on research development in tertiary institutions. The study concluded that the adoption, integration, and ethical use of emerging technological tools are vital for enhancing research development in tertiary institutions in developing countries. Additionally, it is important for the management of tertiary institutions to invest in emerging technology infrastructure, such as high-speed internet, and in the capacity building and skill development of both academic and non-academic staff to further enhance research development within these institutions.*

**KEYWORDS: Emerging Technologies, Research Development, Transparent use of AI, High Speed Internet, and Capacity Building and Skill Development.**

## INTRODUCTION

Emerging technologies, such as Artificial Intelligence (AI), and high-speed internet hold significant potential to transform research development in Nigerian tertiary institutions. However, their adoption faces considerable challenges that limit their impact on research outputs, especially in developing countries like Nigeria (Bala, 2024). Artificial Intelligence, in particular, offers tremendous promise by enhancing data analysis, predictive modeling, and

decision-making processes in research (Adeyeye & Oladokun, 2023). When used transparently and ethically, AI has the potential to revolutionize research activities by automating time-consuming tasks and optimizing data-driven decision-making (Abayomi et al., 2021). However, Nigerian institutions face barriers to adopting AI, including limited access to AI tools, inadequate funding for technology procurement, and the lack of skilled personnel to implement and manage AI systems (Adeoye et al., 2022). Additionally, ethical concerns around AI transparency, such as data privacy and biases in AI algorithms, further complicate its integration into research environments. Many institutions lack a framework to manage these concerns, leading to hesitancy in fully embracing AI technologies, which is a major setback for research development in Nigeria.

Similarly, the availability of high-speed internet plays a crucial role in research development. Access to global academic databases, online collaboration platforms, and real-time communication tools depends on robust internet infrastructure. However, in Nigeria, internet access, particularly high-speed connectivity, is inconsistent and generally inadequate in most institutions. While some universities have made strides in improving their digital infrastructure, others remain hampered by poor internet access. This digital divide between institutions creates unequal opportunities for research advancement, reducing the potential for collaborative research, access to international funding, and the sharing of research outputs. The overall result is a slow research productivity across the country, despite the increasing global reliance on digital resources for academic work (Agbetuyi & Isah, 2021).

Furthermore, capacity building and skill development represent another critical area where Nigerian institutions face challenges. Even where AI and high-speed internet infrastructure exist, many researchers and academic staff lack the necessary skills to fully leverage these technologies for research purposes. This gap in technical expertise is largely due to the absence of structured professional development programmes focused on emerging technologies. While developed countries are making significant investments in training their researchers in advanced technology use, Nigeria lags behind, with many researchers being unable to incorporate new tools into their methodologies. The lack of capacity-building programmes stifles innovation and reduces the overall quality of research output, contributing to Nigeria's lower standing in global research rankings (Akande & Popoola, 2022).

Despite the growing recognition of the importance of emerging technologies in improving research development in Nigerian tertiary institutions, there remains a significant gap in the literature concerning their practical implications. While studies have explored the challenges of technology integration in higher education, few have specifically addressed how technologies like Artificial Intelligence (AI), high-speed internet, and capacity-building initiatives influence research development in a developing country context, particularly Nigeria. Therefore, this study will bridge this gap and contribute to current knowledge.

## LITERATURE REVIEW

### Emerging technologies

Emerging technologies are novel and evolving tools, systems, or methodologies that significantly impact industries, including education and research (Bakare, 2023). These technologies often bring innovation and transformation, driving efficiency, scalability, and

access to new resources. Examples of emerging technologies include Artificial Intelligence (AI), Machine Learning (ML), Virtual Reality (VR), Augmented Reality (AR), Blockchain, and high-speed internet. These technologies hold the potential to fundamentally change how research is conducted in tertiary institutions, especially in developing countries like Nigeria.

AI, for instance, can automate complex data analysis, allowing researchers to process vast datasets with greater speed and precision (Opele, 2023). High-speed internet facilitates collaboration between global research institutions, enabling real-time communication and access to international databases. However, in many Nigerian tertiary institutions, the adoption of these technologies is still nascent due to infrastructure, cost, and skill limitations.

The relationship between emerging technologies and research development in tertiary institutions is becoming increasingly significant. As educational institutions integrate digital tools, their ability to contribute to global research efforts is enhanced. Emerging technologies enable researchers to access and analyze data more efficiently, improve collaboration through cloud computing, and engage in interdisciplinary research (Edeh et al., 2020). In Nigeria, where research productivity has been limited by underfunding and lack of modern infrastructure, emerging technologies could bridge these gaps by providing scalable and cost-effective research tools. However, the implementation is often hindered by a lack of technical expertise and insufficient access to these technologies, which are more readily available in developed countries.

Current research highlights how these technologies can boost student engagement, learning outcomes, and employability. For example, the use of AI in Built Environment (BE) education has shown that students who engage with immersive technologies, such as VR and AR, gain a deeper understanding of complex concepts and develop skills critical for modern research and industry demands (Onyema, 2019). Similarly, digital platforms can create new pathways for research in traditionally underfunded areas by offering affordable tools that democratize access to advanced resources (Badaru & Mphahlele, 2023). For Nigerian tertiary institutions to capitalize on these benefits, significant investment in infrastructure and capacity building is necessary. This includes providing training for academic staff to effectively use these tools and ensuring equitable access to digital technologies across institutions.

**Research development in tertiary institutions**

Research development in tertiary institutions is the organized efforts within universities and higher education institutions to enhance the research capabilities, outputs, and overall contribution to knowledge and innovation (Alyoshina, 2020). It encompasses several activities, such as fostering a research culture, providing necessary infrastructure and tools, facilitating interdisciplinary collaboration, and securing funding for research projects. In developing countries like Nigeria, research development is critical for addressing socio-economic challenges through evidence-based solutions and innovations. However, many tertiary institutions face limitations in terms of technological infrastructure, funding, and skilled personnel, which hinder their research potential.

Emerging technologies, such as Artificial Intelligence (AI), high-speed internet, and cloud computing, have revolutionized the way research is conducted in universities globally.

These technologies offer powerful tools for data analysis, real-time collaboration, and simulation, which can accelerate the research process and enhance the quality of findings (Fahimirad & Kotamjani, 2018). In Nigerian tertiary institutions, however, the integration of these technologies into research is uneven due to various challenges, such as infrastructural deficits, limited funding, and a lack of training and capacity building for staff (Rosak-Szyrocka et al., 2022). AI, for instance, plays a crucial role in automating complex tasks, such as data processing and predictive modeling, which are integral to advanced research. In many developed countries, AI has been adopted to streamline research activities, enabling faster and more accurate results (Enang, 2022). However, in Nigeria, many institutions struggle to adopt AI due to ethical concerns around data privacy, lack of transparency, and limited access to necessary AI tools (Oliveira et al., 2019). The absence of proper frameworks for managing AI-related challenges further hinders its effective use in research settings.

The availability of high-speed internet is another cornerstone for research development, as it facilitates access to global academic databases, virtual collaborations, and the use of cloud-based research platforms. Unfortunately, in Nigeria, there is a significant digital divide, with many institutions lacking reliable internet infrastructure. This limits their ability to engage in cutting-edge research and collaborate internationally, which are essential for advancing research quality and visibility (Okolo et al., 2023).

Furthermore, capacity building and skill development are essential components of research development, as they equip researchers and academic staff with the knowledge and expertise needed to leverage emerging technologies. In Nigerian institutions, there is often a gap in technical skills required to integrate digital tools into research. Without targeted training programmes, researchers are unable to fully utilize AI, advanced statistical tools, or even basic research software. This lack of capacity building limits the potential of emerging technologies to improve research outcomes (Wu & Liu, 2021). The relationship between research development and emerging technologies is clear. As universities increasingly rely on digital tools and platforms to conduct research, the ability to adopt and effectively use these technologies becomes a determinant of research success. The lack of adequate infrastructure, training, and ethical frameworks in Nigerian tertiary institutions creates a gap in research capabilities, making it difficult for these institutions to compete globally and contribute significantly to national development.

**Transparent use of Artificial Intelligence (AI)**

The transparent use of Artificial Intelligence (AI) is ensuring that the processes, decisions, and mechanisms of AI systems are open and understandable to users and stakeholders. It emphasizes explain ability, allowing individuals to comprehend how AI models arrive at their conclusions and ensuring accountability in the deployment of these technologies (Victor et al., 2024). Transparency in AI is critical, especially in higher education and research, where the ethical implications of AI's role in decision-making and automation must be carefully managed. However, in tertiary institutions, AI plays a transformative role in research development by streamlining processes like data analysis, literature review, and experimental simulations. However, for these benefits to be fully realized in a developing country context, transparency in AI's usage is crucial (Edeh et al., 2020). Transparent AI enables researchers to verify the reliability of AI-generated results and fosters collaboration

by making AI-driven research more comprehensible across disciplines. This is especially important as AI becomes integrated into various fields, from the natural sciences to the social sciences, where interpretation and critical understanding of data are essential.

Recent studies highlight the importance of transparency in AI for educational and research settings, underscoring the need for explain ability to avoid biases and inaccuracies. As AI systems are increasingly used in higher education, from grading to research assistance, ensuring their decisions are transparent is essential to maintaining academic integrity and trust (Chugh et al., 2023). A study by Liao and Vaughan (2024). explores how transparency can be integrated into AI systems through various approaches such as publishing evaluation results and communicating uncertainties, all aimed at improving trustworthiness in AI applications.

*H1: Transparent use of Artificial Intelligence (AI) has a significant effect on research development in tertiary institutions*

**Availability of high-speed internet**

High-speed internet are internet services that offer fast data transfer rates, generally through broadband technologies, including fiber-optic, cable, or wireless connections (Al-araibi et al., 2019). Its availability is crucial in enabling access to large amounts of data, streaming content, and conducting real-time collaboration across vast distances. In tertiary institutions in developing countries, the accessibility of high-speed internet plays a pivotal role in the digitalization of education, enabling the use of advanced technologies for research and learning.

The availability of high-speed internet is directly linked to the enhancement of research development in tertiary institutions. For academic institutions, access to reliable and fast internet facilitates research by providing access to digital libraries, databases, and other academic resources. It enables collaboration between researchers across different geographical regions, making the sharing of knowledge and data more seamless (Mirata et al., 2022). Research institutions that have access to robust internet infrastructure can utilize cutting-edge technologies such as data analytics, cloud computing, and AI-based tools, which require substantial bandwidth. Study have shown that students and researchers in Nigerian universities reported that high-speed internet helped them access online journals, databases, and e-books, significantly improving their academic performance and research output (Ivwighreghweta & Igere, 2016). However, many institutions in developing nations face challenges such as slow internet speeds and inadequate computer terminals, limiting the full potential of digital resources for research development.

Moreover, the introduction of mobile broadband in many developing countries is accelerating human development by enhancing education outcomes, allowing for greater digital inclusion among students and faculty members. This leapfrogging effect is especially evident in countries with less reliance on traditional broadband infrastructure, where mobile broadband acts as a crucial tool for accessing academic resources (Bala, 2024).

*H2: Availability of high-speed internet has a significant effect on research development in tertiary institutions.*

**Capacity building and skill development**

Capacity building is the process of developing and strengthening the abilities, skills, resources, and institutions necessary for individuals, organizations, and societies to effectively perform functions, solve problems, and achieve objectives (Ghanbaripour et al., 2024). In tertiary institutions, capacity building involves enhancing research capabilities through infrastructure, faculty development, and access to knowledge resources. Skill development, on the other hand, focuses on the acquisition of specific competencies, such as technical and analytical skills necessary for conducting and advancing research (Criollo-C, 2024). Together, capacity building and skill development form the foundation for strengthening research output, innovation, and overall academic growth in tertiary institutions (Rahmadi, 2024).

Emerging technologies, such as artificial intelligence (AI), virtual reality (VR), and data analytics, are transforming research development in tertiary institutions, particularly in developing countries. These technologies demand new skills and capacities among researchers and educators. The rapid adoption of digital tools necessitates not only the technical upskilling of faculty but also the expansion of institutional capacity to integrate these technologies into the research ecosystem.

In developing countries, capacity building directly impacts research development by fostering an environment conducive to innovation and knowledge creation (Slimi & Carballido, 2023). Institutions need robust infrastructures, such as research centers, high-quality laboratories, and access to global research networks. Emerging technologies can accelerate this process, but without adequate capacity building, institutions risk falling behind in global research competitiveness (Slimi & Carballido, 2023). Effective capacity building, therefore, involves training researchers in new technologies and providing access to tools and platforms that enhance research capabilities.

*H3: Capacity building and skill development has a significant effect on research development in tertiary institutions.*

**METHOD**

The research employed the quantitative approach involving a descriptive survey design. A sample size of 376 academic staff were randomly selected from two federal universities in South-South Nigeria. A questionnaire instrument was developed and used in gathering primary data for the study. The instrument covers the constructs of the study (transparent use of Artificial Intelligence (AI), availability of high-speed internet, and capacity building and skill development). However, to validate the measurement instrument, Confirmatory Factor Analysis (CFA) was used. After data screening, identification, and replacement of missing values using serial mean substitution and outliers analysis using Mahalanobis Distance D2 (Hair et al., 2010). The analysis revealed a D2 probability above 0.001 for 26 values, which indicated 26 outliers from the data set. The 26 identified outliers were deleted to ensure that the data set was free from outliers. The remaining 350 values were retained and used for

further analysis in the research. To examine the implications of transparent use of artificial intelligence, the availability of high-speed internet, and capacity building and skill development on research development in tertiary institutions, and to ensure that the assumptions of the analysis were satisfactorily meet, several inferential statistics were performed, including normality, multicollinearity, and heteroscedasticity tests. Structural Equation Model (SEM) was used to estimate structural/causal relationships between emerging technologies on research development in tertiary institutions.

## RESULTS

Confirmatory Factor Analysis (CFA)

To ascertain if the measures of the constructs are consistent and the data fit the measurement model, CFA was used to validate the instrument. In CFA, items with factor loading less than (<0.50) were deleted from the model. In CFA analysis, it is important to report the Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), Chi-Square test ($\chi 2$), and Standardized Root Mean Square Residual (SRMR) to determine the goodness of fit of the measurement model (Kline, 2015; Brown, 2015). After the CFA analysis, all the indices retain the CFA revealed that the model achieve goodness of fit ($\chi 2$/ df = 2.39, RMSEA = 0.071, CFI = 0.922 and SRMR = 0.073). All the indices meet the recommended cut-off marks and were acceptable ($\chi 2$/df< 3, RMSEA < 0.08, CFI > 0.9 SRMR< .08) (Kline, 2015). All the retained factor loading items exceeded the acceptable threshold of (>0.50). The Cronbach's alpha values ranged from 0.786-0.923 and were acceptable since the alpha values meet the recommended internal consistency value of (>0.60) (Hair et al., 2010). The Composite Reliability (CR) values ranged from 0.756-0.899, and the Average Variance Extracted (AVE) ranged from 0.542-0.686 and were all acceptable as the obtained values exceeded the recommended values of (>0.60 and >0.50) respectively in all the constructs, indicating that the model satisfactorily meets the recommended threshold. The summary of CFA result for all the constructs is presented in Table 1.

**Table1. Summary of confirmatory factor analysis result**

| Constructs | Item | Factor loading | Cronbach alpha | CR | AVE |
|---|---|---|---|---|---|
| Transparent Use of Artificial Intelligence (TUAI) | TUAI | 0.832 | 0.923 | 0.899 | 0.686 |
| | TUAI 2 | 0.773 | | | |
| | TUAI 3 | 0.843 | | | |
| | TUAI 4 | Deleted | | | |
| | TUAI 5 | 0.883 | 0.786 | 0.756 | 0.522 |
| Availability of High-Speed Internet (AHSI) | AHSI 6 | 0.783 | | | |
| | AHSI 7 | 0.832 | | | |
| | AHSI 8 | Deleted | | | |
| | AHSI 9 | 0.873 | | | |
| | AHSI 10 | 0.892 | 0.853 | 0.810 | 0.579 |
| Capacity Building and Skill Development (CBSD) | CBSD 11 | 0.833 | | | |
| | CBSD 12 | Deleted | | | |
| | CBSD 13 | 0.899 | | | |
| | CBSD 14 | 0.821 | | | |
| | CBSD 15 | Deleted | | | |
| | CBSD 16 | 0.884 | 0.828 | 0.732 | 0.536 |
| Research Development (RD) | RD 1 | 0.833 | 0.845 | 0.801 | 0.622 |
| | RD 2 | 0.843 | | | |
| | RD 3 | 0.877 | | | |
| | RD 4 | 0.882 | | | |
| | RD 5 | 0.89 | | | |
| | RD 6 | Deleted | | | |

$\chi 2$/ df = 2.39, RMSEA = 0.071, CFI = 0.922 and SRMR = 0.073

Table 2 presents the result of descriptive statistics. The analysis revealed a sample of (N) 350 in all constructs. The emerging technologies constructs had a minimum and maximum values of 1 and 5. The constructs had a mean average value ranging between 4.561 to 4.832, with standard deviation and variance values ranging between 0.921 to 1.150 and 1.432 to 2.332 respectively.

**Table 2. Result of descriptive statistics**

| Constructs | N | Minimum | Maximum | Mean | Std. Deviation | Variance |
|---|---|---|---|---|---|---|
| TUAI | 350 | 1 | 5 | 4.561 | 0.921 | 1.432 |
| AHSI | 350 | 1 | 5 | 4.644 | 1.392 | 2.332 |
| CBSD | 350 | 1 | 5 | 4.732 | 1.204 | 2.123 |
| RD | 350 | 1 | 5 | 4.832 | 1.150 | 2.234 |
| Valid N (listwise) | 350 | | | | | |

**Normality test**

To determine the normality of the distribution, the Kolmogorov-Smirnov and Shapiro-Wilk tests were used to determine whether the sample population is normally distributed. As a rule of thumb, if the significant values of Kolmogorov-Smirnov and Shapiro-Wilk tests are greater than 0.05, the data is normally distributed but if below 0.05, it indicates that the data significantly deviated from a normal distribution (Hair *et al.,* 2010). Also, the absolute values of skewness and kurtosis of the distribution should not exceed 1.00 and 2.00 respectively. Table 3 presents the result of the normality test.

**Table 3. Summary of normality test result**

| | | Kolmogorov-Smirnov | | | Shapiro-Wilk | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Constructs | Statistic | Df | Sig. | Statistic | df | Sig. | skewness | Kurtosis |
| | TUAI | .183 | 347 | .0731 | .932 | 347 | .083 | -.105 | -.197 |
| RD | AHSI | .181 | 347 | .0643 | .932 | 347 | .072 | -.126 | -.182 |
| | CBSD | .211 | 347 | .0571 | .941 | 347 | .054 | -.105 | -.248 |

a. Lilliefors Significance Correction

*. This is the lower bound of the true significance

**Multicolinearity test**

To determine the intercorrelation between the variables, a multicollinearity test was executed using tolerance and Variance Inflation Factor (VIF) to see if there were very high intercorrelations among the predictor variables. The rule of thumb is that tolerance should be greater than 0.2 and VIF should be less than 5.0 (Hair *et al.,* 2010). Table 4 presents the result of the multicollinearity test. Also, the Eigenvalues of (.151, .148, and .153) were not close to zero across all variables and the Condition Index Values (CIV) of (6.231, 7.032, and 8.421) were all less than the cut of mark of 15 which further confirm that there were no multicollinearity issues among the independent variables.

**Table 4. Summary of multicollinearity test result**

Coefficients[a]

| Model | | Unstandardized Coefficients | | Standardized Coefficients | | | Collinearity Statistics | | Eigen | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | t | Sig. | Tolerance | VIF | Values | CIV |
| 1 | (Constant) | 8.164 | 1.132 | | 6.522 | .000 | | | | |
| | TUAI | 0.432 | 0.054 | 0.232 | 7.153 | .000 | .342 | 1.421 | .151 | 6.231 |
| | AHSI | 0.363 | 0.077 | 0.211 | 4.854 | .000 | .421 | 1.542 | .148 | 7.032 |
| | CBSD | 0.855 | 0.055 | 0.531 | 5.543 | .000 | .541 | 1.332 | .153 | 8.421 |

a. Dependent Variable: RD

**Heteroscedasticity test**

To determine whether there is a variance inequality of the residual among the observation's periods, the heteroscedasticity test was performed. In particular, the Glejser test was used to determine the presence or absence of heteroscedasticities. As a rule of thumb in heteroscedasticity with test Glejser, if the significant values are greater than 0.05, then there are no heteroscedasticity issues, but if the significant value is less than 0.05 there are heteroscedasticity problems. Table 5 present the result of the heteroscedasticity test. The result indicated that the obtained values of significance for TUAI, AHSI and CBSD constructs were (0.198, 0.274, and 0.264) respectively which were all greater than 0.05. Based on this result it was concluded that there are no heteroscedasticity issues.

**Table 5. Heteroscedasticity test result**

| Coefficients[a] | | | | | | |
|---|---|---|---|---|---|---|
| | | Unstandardized Coefficients | | Standardized Coefficients | | |
| Model | | B | Std. Error | Beta | T | Sig. |
| 1 | (Constant) | -3.154 | 1.221 | | -2.431 | .187 |
| | Health and safety training | .253 | .562 | .071 | .423 | .198 |
| | Safety monitoring | .145 | .454 | .071 | .272 | .274 |
| | Enforcement of compliance | .137 | .332 | .081 | .373 | .264 |

a. Dependent Variable: Absolute R

**Structural Modelling**

To examine the relationship between Transparent Use of Artificial Intelligence (TUAI), Availability of High-Speed Internet (AHSI), and Capacity Building and Skill Development (CBSD) on research development, Structural Equation Modelling (SEM) was used. Table 6 presents the summary of the direct influence of Transparent Use of Artificial Intelligence (TUAI), Availability of High-Speed Internet (AHSI), and Capacity Building and Skill Development (CBSD) on research development. Table 6 revealed that the direct effect of transparent use of artificial intelligence on research development was significant at 0.463 (p=0.00). This implies that a 1% increase in transparent use of artificial intelligence, will result in a 0.463 % increase in research development. Therefore, hypotheses (H1) was supported that transparent use of artificial intelligence has a significant positive effect on research development in tertiary institutions. Second, the direct effect of availability of high-speed internet was significant at 0.372 (p=0.00). This implies that when availability of high-speed internet increase by 1%, research development increases by 0.372. Based on the result, hypotheses (H2) was supported that availability of high-speed internet has a significant positive effect on research development in tertiary institutions. Third, the direct effect of capacity building and skill development on research development was significant at 0.896 (p=0.00). This implies that when enforcement of compliance increases by 1%, employee efficiency increases by 0.516 %. Based on this result, hypotheses (H3) was supported that capacity building and skill development has a significant positive effect on research development in tertiary institutions. Therefore, transparent use of artificial intelligence, availability of high-speed internet, and capacity building and skill development has a significant positive effect on research development in tertiary institutions.

**Table 6. Summary of direct influence of emerging technologies constructs on research development**

| Hypotheses | Constructs | Path | Constructs | Estimate | S.E. | C.R. | P-value | Result |
|---|---|---|---|---|---|---|---|---|
| $H_1$ | RD | <--- | TUAI | .463 | .037 | 11.434 | 0.00 | Significant |
| $H_2$ | RD | <--- | AHSI | .372 | .043 | 8.182 | 0.00 | Significant |
| $H_3$ | RD | <--- | CBSD | .516 | .043 | 21.047 | 0.00 | Significant |

Table 7 presents a summary of the goodness of fit indexes of the measurement model for transparent use of artificial intelligence, availability of high-speed internet, and capacity building and skill development on research development. The indices from Table 7 indicated that the measurement model achieved the overall goodness of fit.

**Table 7. Summary of goodness of fit indexes of the measurement model**

| Model | Chisq/df | RMSEA | CFI | GFI | AGFI | p-value |
|---|---|---|---|---|---|---|
| Direct effect of the constructs | 2.482 | 0.079 | 0.932 | 0.947 | 0.974 | .000 |

Table 7 revealed Chi-square df value of ($\chi 2/df = 2.482$), root mean square error of approximation value of (RMSEA = 0.079), comparative fit index value of (CFI = 0.932), goodness of fit index value of (GFI = 0.947), adjusted goodness of fit index values of (AGFI = 0.974) and a Probability value of (p = 0.000), which achieve the acceptable cut-off values and were all satisfactory as recommended ($\chi 2/df<3$, RMSEA <0.08, CFI >0.9, GFI >0.9, AGFI >0.9 and p-value<0.05) (Hair et al., 2010). This result supported the hypotheses of the study and affirm that transparent use of artificial intelligence, availability of high-speed internet, and capacity building and skill development has a significant positive effect on research and development in tertiary institutions.

## DISCUSSION

*Transparent use of Artificial Intelligence (AI) has a significant effect on research development in tertiary institutions.*

The study found that transparent use of AI has a significant positive effect on research development in tertiary institutions. AI tools facilitate data analysis, optimize research workflows, and enhance educational experiences, thus playing a transformative role. According to Alyoshina (2020), AI's integration into research workflows streamlines decision-making processes and fosters deeper analytical insights. Fahimirad and Kotamjani (2018) further support this, noting how AI applications in education improve efficiency and enable researchers to analyze complex data more accurately. Additionally, Slimi and Carballido (2023) discuss the importance of ethical AI usage, emphasizing transparency to prevent biases in research outcomes. The implications of these findings suggest that, as AI tools become more pervasive, their ethical and transparent use will be vital in ensuring that research remains objective and credible.

*Availability of high-speed internet has a significant effect on research development in tertiary institutions.*

Availability of high-speed internet has a significant positive effect on research development in tertiary institutions. High-speed internet availability is a critical factor that significantly impacts research development. Fast and reliable internet access allows for the swift exchange of knowledge and collaboration, both of which are crucial for modern research. According to Edeh et al. (2020), the availability of broadband infrastructure significantly improves access to digital libraries and remote learning tools, directly enhancing research output. Similarly, Bala (2024) emphasizes the importance of mobile broadband in increasing research productivity, particularly in developing countries. Ivwighreghweta and Igere (2016) found that reliable internet access enables students and researchers to access the latest research materials, thus improving the overall quality of research. The implication here is clear: expanding high-speed internet access in tertiary institutions is essential for driving global competitiveness in research.

*Capacity building and skill development has a significant effect on research development in tertiary institutions.*

Capacity building and skill development also have a significant positive effect on research development in tertiary institutions. Research from Okolo et al. (2023) indicates that investments in skill development programs lead to more innovative research outputs by enhancing the capabilities of both students and faculty. Enang (2022) corroborates this, suggesting that continuous training in emerging technologies not only improves research quality but also fosters innovation in teaching methods. Chugh et al. (2023) argue that capacity-building efforts that focus on technology training create a skilled academic workforce, which is crucial for sustaining long-term research initiatives. The implication here is that tertiary institutions need to prioritize capacity building, especially in technological competencies, to remain competitive in a rapidly evolving academic environment.

## CONCLUSIONS

The integration of AI, high-speed internet, and capacity-building programs into tertiary institutions presents several implications for the future of research development. AI-driven tools must be implemented transparently to ensure the integrity of research, while the expansion of high-speed internet access is necessary for fostering global collaboration. Capacity building, particularly in emerging technologies, will remain pivotal in sustaining and advancing research activities. As these technologies evolve, the role of ethical considerations and equitable access will be increasingly important, especially in regions with limited technological infrastructure. Institutions that invest in these areas are likely to see significant advancements in research output, positioning themselves as leaders in academic innovation.

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