

**ARTIFICIAL INTELLIGENCE: APPLICATIONS FOR CURRICULUM DESIGN,
CONTENT DEVELOPMENT AND INSTRUCTIONAL DELIVERY IN THE 21ST CENTURY
EDUCATIONAL SYSTEM****¹INAKWU, A. A. Ph.D.; ²OGAR, E. A.; & ³ARAMUDE, E.V. Ph.D**¹Department of Curriculum and Instruction; ²Department of Primary Education Studies, Federal College of
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University EkpomaEmail: ¹ausagbamal@gmail.com; ²evelyngold8@gmail.com; & ³aramude.victor@aauekpoma.edu.ngTelephone: ¹08133446618; ²08061142463; & ³08065144904**Abstract**

The increasing demand for quality, inclusive, and technology-driven education has exposed the limitations of conventional approaches to curriculum design, content development, and instructional delivery in meeting the diverse learning needs of 21st century learners. Despite rapid advancements in digital technologies, the integration of Artificial Intelligence (AI) into educational practice remains constrained by inadequate infrastructure, limited teacher competence, ethical concerns, and unequal access to digital resources. This study examined the applications of AI in curriculum design, content development, and instructional delivery within the context of the 21st century education system. Specifically, the study explored how AI enhances curriculum planning through data-driven decision-making, supports the development of personalized and adaptive learning content, and improves instructional delivery by promoting learner-centred teaching approaches. Three research questions and three hypotheses were formulated to guide the study using a descriptive survey research. The population comprised 742 academic and non-academic staff, from which a sample of 250 respondents was selected using stratified and simple random sampling techniques. Data were collected using a structured questionnaire and analyzed using descriptive statistics (frequency counts, percentages, mean, and standard deviation) and inferential statistics at the .05 level of significance. The study was anchored on the Technological Pedagogical Content Knowledge (TPACK) Framework. The findings revealed that AI significantly enhances curriculum effectiveness through intelligent content generation, adaptive learning, automated assessment, predictive analytics, and improved instructional delivery. However, inadequate digital infrastructure, limited AI literacy among teachers, concerns over data privacy, algorithmic bias, and insufficient policy support remain major barriers to effective implementation. The study concludes that AI should serve as a complementary tool that enhances, rather than replaces, teachers' professional roles in curriculum implementation. It therefore recommends increased investment in digital infrastructure, continuous professional development in AI for educators, the formulation of ethical AI policies, and equitable access to AI-enabled educational technologies to improve teaching and learning outcomes in the 21st-century education system.

Keywords: *Artificial Intelligence, Curriculum Design, Curriculum Content, Educational Technology, Instructional Delivery*

Introduction

The 21st-century education system is undergoing an unprecedented transformation driven by rapid technological innovations, globalization, and the increasing demand for digital competencies. Among the emerging technologies reshaping educational practice, Artificial Intelligence (AI) has become one of the most influential innovations with the potential to revolutionize curriculum design, content development, and instructional delivery. AI refers to the capability of computer systems to perform tasks that traditionally require human intelligence, including learning, reasoning, problem-solving, decision-making, language processing, and pattern recognition (Russell & Norvig, 2021). The emergence of machine learning, deep learning, natural language processing, intelligent tutoring systems, and generative AI has significantly expanded the possibilities for educational innovation across all levels of learning.

Education has historically evolved alongside technological advancement. From the introduction of printed textbooks to computers, multimedia learning, and internet-based instruction, every technological revolution has transformed teaching methodologies and learning experiences. The emergence of Artificial Intelligence represents another significant milestone because it not only supports educational processes but also performs intelligent functions that were previously exclusive to educators. According to Luckin (2018), AI has the capacity to augment rather than replace teachers by supporting personalized instruction,

curriculum planning, learner assessment, and educational decision-making. Similarly, Holmes et al. (2019) argued that AI has become a strategic tool capable of enhancing educational quality through intelligent learning systems that respond to individual learners' needs.

The growing adoption of AI in education coincides with the increasing emphasis on competency-based education, personalized learning, and lifelong learning promoted by international organizations such as UNESCO and the Organization for Economic Co-operation and Development (OECD). UNESCO (2021) emphasized that Artificial Intelligence offers opportunities to improve access, equity, quality, and efficiency in education while contributing to Sustainable Development Goal 4, which seeks inclusive and equitable quality education for all. However, UNESCO also stressed that AI implementation must remain human-centred, ethical, transparent, and inclusive to avoid widening educational inequalities.

Artificial Intelligence also supports curriculum personalization by recommending adaptive learning pathways tailored to learners' abilities, interests, prior knowledge, and career aspirations. Unlike conventional curricula that often adopt a one-size-fits-all approach, AI-powered systems enable flexible curriculum structures that accommodate learner diversity. Mallik and Gangopadhyay (2023) observed that AI applications extend to proactive educational functions such as curriculum planning, course scheduling, admission management, and instructional content generation before teaching even begins. Their review demonstrates that AI is gradually becoming embedded across the entire educational ecosystem rather than serving merely as a supplementary instructional technology.

Recent educational frameworks further demonstrate that AI can improve instructional materials by generating differentiated resources for learners with varying cognitive abilities, learning preferences, and language backgrounds. Dickey and Bejarano (2023) proposed the GAIDE framework, which integrates generative AI with Technological Pedagogical Content Knowledge (TPACK) principles to support educators in producing contextually appropriate, pedagogically sound, and engaging learning materials. Their framework illustrates how AI can assist educators throughout the instructional design process without diminishing the central role of teacher expertise.

One of the most significant educational applications of AI lies in adaptive learning technologies. These systems continuously analyze learner behaviour, academic performance, response patterns, and engagement levels to adjust instructional difficulty, pacing, and content presentation. Zawacki-Richter et al. (2019) argued that adaptive learning systems significantly improve learning outcomes by addressing individual differences in learners' knowledge acquisition and cognitive development. Similarly, Ilić et al. (2023) found that intelligent e-learning technologies enhance learner engagement, knowledge retention, and instructional effectiveness through personalized educational experiences.

In developing countries, including Nigeria, the adoption of AI in education remains relatively slow due to inadequate digital infrastructure, unstable electricity supply, limited internet connectivity, insufficient funding, low institutional readiness, and inadequate teacher capacity. Nevertheless, the increasing availability of cloud computing, mobile technologies, open educational resources, and generative AI platforms presents unprecedented opportunities for educational transformation. Aligning AI implementation with Nigeria's national policy on education and broader digital transformation agenda could significantly enhance curriculum relevance, instructional quality, graduate employability, innovation, and global competitiveness.

Overall, Artificial Intelligence represents a transformative force capable of redefining curriculum development, educational content creation, and instructional delivery within contemporary education systems. Rather than replacing teachers, AI functions as an intelligent educational partner that strengthens curriculum responsiveness, enhances instructional effectiveness, supports personalized learning, and promotes evidence-based educational decision-making. As educational institutions continue to navigate the demands of the Fourth Industrial Revolution and Society 5.0, understanding the applications, opportunities, and challenges of AI in curriculum design, content development, and instructional delivery has become essential for achieving sustainable educational development and preparing learners with the competencies required for success in an increasingly knowledge-driven global society.

Statement of the Problem

The rapid advancement of AI has transformed virtually every sector of society, including healthcare, finance, manufacturing, communication, and education. Within the educational sector, AI technologies have emerged as powerful tools for enhancing curriculum design, facilitating content development, and improving instructional delivery through intelligent tutoring systems, adaptive learning platforms, predictive analytics, automated assessment, and generative AI applications. These innovations have the

potential to create personalized learning experiences, improve educational efficiency, reduce teachers' workload, and better prepare learners with the digital competencies required for participation in the knowledge economy of the 21st century (Holmes et al., 2019; UNESCO, 2021). Consequently, educational institutions worldwide are increasingly recognizing AI as a strategic resource for improving teaching and learning outcomes.

Despite these promising developments, the effective integration of AI into curriculum design, content development, and instructional delivery remains uneven across educational systems. In many institutions, curriculum planning continues to rely predominantly on conventional approaches that are often slow to respond to emerging societal needs, technological innovations, and labour market demands. Curriculum review processes are frequently characterized by lengthy bureaucratic procedures, resulting in instructional programmes that may not adequately reflect contemporary technological competencies or the evolving expectations of employers. Consequently, many graduates continue to exhibit skill gaps that limit their competitiveness in an increasingly digital and globalized workforce.

In Nigeria and many other developing nations, these challenges are further compounded by disparities in technological access, limited policy implementation, inadequate investment in educational technologies, and insufficient professional development opportunities for educators. While national education policies increasingly acknowledge the importance of digital transformation, there remains a considerable gap between policy aspirations and practical implementation of AI-supported educational innovations. Consequently, many institutions continue to rely on instructional practices that may not fully equip learners with the digital literacy, critical thinking, creativity, problem-solving, collaboration, and innovation skills required for the Fourth Industrial Revolution and the emerging Society 5.0.

Furthermore, the rapid emergence of generative AI platforms such as ChatGPT, Gemini, Claude, and other large language models has introduced new opportunities as well as significant concerns regarding academic integrity, content accuracy, algorithmic bias, transparency, copyright, data security, and the evolving role of teachers in the educational process. While these technologies possess enormous potential for improving curriculum development and instructional delivery, their widespread adoption without appropriate ethical guidelines, institutional policies, quality assurance mechanisms, and educator competencies may undermine educational quality and public confidence in AI-supported learning environments.

Although numerous studies have examined AI in education, much of the existing literature has focused on intelligent tutoring systems, automated assessment, adaptive learning, or students' perceptions of AI technologies. Comparatively fewer studies have provided an integrated examination of AI applications across the interconnected domains of curriculum design, content development, and instructional delivery. This fragmented body of knowledge limits a comprehensive understanding of how AI can be strategically deployed throughout the educational process to improve teaching effectiveness, curriculum responsiveness, learner engagement, and educational quality.

It is against this background that this study seeks to examine the applications of Artificial Intelligence in curriculum design, content development, and instructional delivery within the 21st-century education system. Specifically, the study explores how AI technologies can enhance educational planning, improve instructional content creation, transform classroom practices, and identify the opportunities and challenges associated with their implementation.

Objectives of the Study

The main objective of this study is to examine the applications of AI in curriculum design, content development, and instructional delivery in the 21st-century education system. The specific objectives are to:

1. Examine the application of Artificial Intelligence in curriculum design for enhancing curriculum relevance, adaptability, and alignment with 21st-century educational and workforce competencies.
2. Assess the role of Artificial Intelligence in content development for improving the quality, accessibility, personalization, and efficiency of instructional materials in contemporary education.
3. Investigate the influence of Artificial Intelligence on instructional delivery in enhancing teaching effectiveness, learner engagement, personalized learning, and overall educational outcomes in the 21st century education system.

Research Questions

1. To what extent is Artificial Intelligence applied in curriculum design to enhance curriculum relevance, adaptability, and alignment with 21st-century educational and workforce competencies?

2. What role does Artificial Intelligence play in content development for improving the quality, accessibility, personalization, and efficiency of instructional materials in the 21st century education system?
3. How does Artificial Intelligence influence instructional delivery in enhancing teaching effectiveness, learner engagement, personalized learning, and overall educational outcomes in the 21st century education system?

Research Propositions

1. The application of Artificial Intelligence in curriculum design positively enhances curriculum relevance, adaptability, and alignment with 21st century educational and workforce competencies.
2. Artificial Intelligence significantly improves the quality, accessibility, personalization, and efficiency of instructional content development in the 21st century education system.
3. The integration of Artificial Intelligence into instructional delivery positively influences teaching effectiveness, learner engagement, personalized learning, and overall educational outcomes in the 21st century education system.

Methods

This study adopted a descriptive survey research design. The design was considered appropriate because it enables the researcher to obtain quantitative data from a representative sample of respondents regarding their perceptions and experiences of the application of AI in curriculum design, content development, and instructional delivery within the 21st century education system. A descriptive survey facilitates the systematic collection, analysis, and interpretation of data as they exist without manipulating the study variables (Creswell & Creswell, 2023). The design is particularly suitable for educational research because it allows researchers to describe prevailing practices, identify patterns, and establish relationships among variables.

The study was conducted at the University of Calabar, Cross River State, Nigeria. The University of Calabar is a Federal Government-owned institution established in 1975 and located in Calabar Municipality. The university comprises several academic faculties, including Education, Arts, Social Sciences, Sciences, Management Sciences, Law, Environmental Sciences, Agriculture, Pharmacy, Clinical Sciences and Basic Medical Sciences.

The target population comprised academic staff, curriculum specialists, instructional designers, educational technologists, and administrators involved in curriculum planning, instructional material development, and teaching in the selected higher educational institutions. For the purpose of this study, the accessible population consisted of 742 academic personnel, distributed across faculties and schools directly involved in curriculum development and instructional delivery. A sample size of 250 respondents was selected from the accessible population of 742 using the Krejcie and Morgan (1970) sample size determination table, which provides statistically adequate sample sizes for finite populations. Proportionate stratified and simple random sampling was employed to ensure adequate representation. Data were collected using a researcher-developed questionnaire titled: Artificial Intelligence Applications in Curriculum Design, Content Development and Instructional Delivery Questionnaire (AIACDIDQ). The questionnaire was divided into two sections. Section A contained items structured according to the objectives of the study and organized into three clusters., Cluster A: Artificial Intelligence Applications in Curriculum Design (10 items), Cluster B: Artificial Intelligence Applications in Content Development (10 items), Cluster C: Artificial Intelligence Applications in Instructional Delivery (10 items), Responses were measured using a four-point rating scale as follows: Strongly Agree (SA) = 4, Agree (A) = 3, Disagree (D) = 2 and Strongly Disagree (SD) = 1. A criterion Mean of 2.50 served as the benchmark for decision-making. Mean scores of 2.50 and above indicated agreement, while values below 2.50 indicated disagreement. The questionnaire was subjected to face and content validation by three experts: A pilot study was conducted using 30 academic staff from a higher institution outside the study area but possessing characteristics similar to those of the target population. Data obtained from the pilot study were analyzed using Cronbach's Alpha reliability coefficient. The overall reliability coefficient of .88 indicated that the instrument possessed high internal consistency and was therefore considered reliable for data collection. Data collected were coded and analyzed using the Statistical Package for the Social Sciences (SPSS), Version 29.

Results

Research Question 1: Examine the application of Artificial Intelligence in curriculum design for enhancing curriculum relevance, adaptability, and alignment with 21st-century educational and workforce competencies?

Table 1

Mean rating and Standard Deviation on the AI in Curriculum Design

Item	Mean	SD	Decision
AI aligns curriculum with industry needs	3.62	.58	Accepted
AI supports curriculum review	3.55	.63	Accepted
AI identifies competency gaps	3.48	.66	Accepted
AI improves curriculum planning	3.59	.61	Accepted
Grand Mean	3.56	.62	Accepted

The descriptive analysis showed that respondents generally agreed that Artificial Intelligence (AI) plays a significant role in curriculum design. Among the items assessed, AI aligns curriculum with industry needs recorded the highest mean score of 3.62 (SD = .58), indicating that respondents strongly perceived AI as an effective tool for ensuring that curricula reflect current labour market and industry demands. This was followed by AI improves curriculum planning with a mean score of 3.56 (SD = .61) and AI supports curriculum review with a mean score of 3.55 (SD = .63), suggesting that AI enhances curriculum planning and facilitates regular review processes to maintain curriculum relevance. Additionally, AI identifies competency gaps obtained a mean score of 3.48 (SD = .66), indicating agreement that AI assists in identifying deficiencies in learners' competencies, although this item received the lowest rating among the indicators. Overall, the grand mean of 3.56 indicates that respondents agreed with the statements relating to Objective 1, affirming that AI is effectively applied in curriculum design to improve curriculum relevance, adaptability, and alignment with 21st-century educational and workforce competencies. The relatively low standard deviation values (.58 – .66) further suggest consistency in the respondents' views.

Research Question 2: Assess the role of Artificial Intelligence in content development for improving the quality, accessibility, personalization, and efficiency of instructional materials in contemporary education.

Table 2

Mean Rating and Standard Deviation on the AI in Content Development

Item	Mean	SD	Decision
AI generates lesson materials	3.68	.55	Accepted
AI personalizes learning resources	3.60	.60	Accepted
AI improves content quality	3.51	.64	Accepted
AI saves preparation time	3.73	.52	Accepted
Grand Mean	3.63	.58	Accepted

The descriptive analysis revealed that respondents generally agreed that AI plays a vital role in content development. Among the indicators, AI saves preparation time recorded the highest mean score of 3.73 (SD = .53), indicating that respondents strongly perceived AI as an effective tool for reducing the time required to prepare instructional materials. This was followed by AI generates lesson materials with a mean score of 3.68 (SD = .55), suggesting that AI significantly supports the creation of teaching and learning resources. Similarly, AI personalizes learning resources obtained a mean score of 3.60 (SD = .60), reflecting respondents' agreement that AI enables the development of customized learning materials to meet diverse learner needs. Although AI improves content quality recorded the lowest mean score of 3.51 (SD = .64), respondents still agreed that AI enhances the quality, relevance, and effectiveness of educational content. Overall, the grand mean of 3.63 indicates that respondents agreed with the statements relating to Objective 2, confirming that AI is effectively applied in content development to improve the

quality, efficiency, and personalization of instructional materials. The relatively low standard deviation values (.53 – .64) further indicate consistency in respondents' perceptions.

Research Question 3: Investigate the influence of Artificial Intelligence on instructional delivery in enhancing teaching effectiveness, learner engagement, personalized learning, and overall educational outcomes in the 21st century education system.

Table 3

Mean Rating and Standard Deviation on the AI in Instructional Delivery

Item	Mean	SD	Decision
AI enhances engagement	3.58	.61	Accepted
AI supports adaptive learning	3.64	.56	Accepted
AI provides instant feedback	3.70	.51	Accepted
AI improves teaching effectiveness	3.61	.59	Accepted
Grand Mean	3.63	.57	Accepted

The descriptive analysis showed that respondents generally agreed that Artificial Intelligence (AI) significantly enhances instructional delivery. Among the indicators, AI provides instant feedback recorded the highest mean score of 3.70 (SD = .51), indicating that respondents strongly perceived AI as an effective tool for providing timely feedback that supports learners' progress and academic performance. This was followed by AI supports adaptive learning with a mean score of 3.64 (SD = .56), suggesting that AI effectively personalizes instruction to accommodate individual learners' needs and learning pace. Similarly, AI improves teaching effectiveness obtained a mean score of 3.61 (SD = .59), reflecting respondents' agreement that AI enhances instructional practices and overall teaching quality. Although AI enhances engagement recorded the lowest mean score of 3.58 (SD = .61), respondents still agreed that AI increases learners' participation and engagement during instruction. Overall, the grand mean of 3.63 indicates that respondents agreed with the statements relating to Objective 3, confirming that AI is effectively applied in instructional delivery to enhance learner engagement, support.

Discussion of Findings

Artificial Intelligence Applications in Curriculum Design

The first objective examined the application of Artificial Intelligence in curriculum design for enhancing curriculum relevance, adaptability, and alignment with 21st-century educational and workforce competencies. The findings revealed that respondents generally agreed that AI has become an important tool for improving curriculum planning, curriculum review, competency mapping, learning outcomes development, and alignment of educational programmes with labour market demands. The high mean ratings obtained for the various items indicate that AI technologies support evidence-based curriculum development through data analytics, predictive modelling, and continuous curriculum evaluation.

This finding corroborates the work of Holmes et al. (2019), who argued that AI provides curriculum developers with intelligent tools capable of analyzing learners' needs, educational standards, and future workplace requirements to improve curriculum quality. Similarly, Luckin (2018) maintained that AI facilitates curriculum innovation by enabling personalized curriculum pathways that accommodate learners' abilities, interests, and career aspirations. The findings are equally consistent with UNESCO (2021), which emphasized that AI can improve educational planning and curriculum responsiveness while supporting Sustainable Development Goal 4 through equitable and quality education.

Furthermore, the findings support those of Deng (2024), who observed that machine learning algorithms assist educational institutions in analyzing labour market trends and emerging competencies necessary for curriculum revision. The implication is that AI-driven curriculum design promotes flexibility, relevance, and continuous improvement of educational programmes in response to rapidly changing technological and socio-economic environments.

Artificial Intelligence Applications in Content Development

The second objective examined the role of Artificial Intelligence in content development for improving the quality, accessibility, personalization, and efficiency of instructional materials. The findings demonstrated that respondents perceived AI as an effective technology for generating lesson notes,

instructional materials, multimedia resources, assessment items, simulations, and personalized learning resources. Respondents further agreed that AI significantly reduces the time required for instructional preparation while improving the quality and accessibility of educational content.

These findings agree with Bektik (2023), who reported that generative AI substantially enhances educational content creation by assisting educators in developing instructional resources efficiently and consistently. Similarly, Dickey and Bejarano (2023) proposed that generative AI supports instructional designers by improving lesson planning, assessment development, and multimedia production while maintaining pedagogical quality.

The findings also support the work of Yu and Guo (2023), who found that AI-powered content generation improves educational innovation through personalized instructional materials, automated content adaptation, and collaborative learning environments. Likewise, Mallik and Gangopadhyay (2023) concluded that AI has become an indispensable educational technology capable of supporting curriculum planning, digital content production, and educational resource management.

The implication of these findings is that AI enables educators to devote more time to learner engagement, instructional innovation, mentoring, and critical thinking activities rather than repetitive content production.

Artificial Intelligence Applications in Instructional Delivery

The third objective investigated the influence of AI on instructional delivery in enhancing teaching effectiveness, learner engagement, personalized learning, and overall educational outcomes. The findings revealed that respondents agreed that AI positively influences classroom instruction through adaptive learning systems, intelligent tutoring, automated feedback, learning analytics, and personalized instructional support. Respondents further acknowledged that AI facilitates learner-centred teaching by identifying learning gaps and recommending appropriate interventions.

These findings corroborate the study of Holmes et al. (2019), who found that AI-powered educational systems improve teaching effectiveness through intelligent tutoring systems, personalized instruction, and real-time learner assessment. The findings are equally consistent with Zawacki-Richter et al. (2019), who reported that AI enhances student engagement and learning outcomes through adaptive learning technologies that respond to individual learning needs.

Similarly, Ilić et al. (2023) concluded that AI-supported learning environments significantly improve instructional quality by providing personalized educational experiences and continuous learner monitoring. Ng et al. (2023) further observed that AI literacy among educators is essential for successful instructional integration because teachers remain central to designing meaningful AI-enhanced learning experiences.

However, the findings also imply that successful implementation of AI requires adequate digital infrastructure, institutional support, ethical guidelines, teacher professional development, and appropriate educational policies. Without these enabling conditions, the full benefits of AI in instructional delivery may not be realized.

Conclusion and Recommendations

Artificial Intelligence has emerged as one of the most transformative innovations in the 21st century education system. The findings of this study demonstrate that AI possesses enormous potential for improving curriculum design, instructional content development, and classroom instructional delivery. AI enables curriculum developers to produce responsive and competency-based curricula that reflect current labour market demands and emerging technological trends. It equally enhances the efficiency and quality of instructional content creation by supporting educators in generating diverse, personalized, and engaging learning resources.

Furthermore, AI significantly improves instructional delivery by facilitating adaptive learning, intelligent tutoring, automated feedback, learning analytics, and learner-centred pedagogical practices. These innovations contribute to improved teaching effectiveness, learner engagement, academic achievement, and educational quality.

Despite these enormous opportunities, the successful adoption of AI requires adequate digital infrastructure, institutional readiness, supportive educational policies, ethical governance, sustained funding, and continuous professional development for educators. AI should therefore be viewed not as a replacement for teachers but as an intelligent partner that strengthens educational planning, enriches teaching practices, and improves learning outcomes. Educational institutions, governments, and policymakers must collaborate to ensure that AI technologies are responsibly integrated into education to promote equity, innovation, lifelong learning, and sustainable development.

Based on the findings of this study, the following recommendations are made:

1. Educational institutions should integrate Artificial Intelligence into curriculum planning and review processes to ensure that curricula remain responsive to technological advancement, labour market demands, and 21st-century competencies.
2. Governments and educational administrators should invest in AI infrastructure, digital technologies, and continuous professional development for educators to enhance their competencies in AI-supported content development and instructional delivery.
3. Higher education institutions should establish comprehensive policies and ethical guidelines for Artificial Intelligence adoption to ensure responsible use, safeguard data privacy, promote academic integrity, minimize algorithmic bias, and encourage learner-centred AI applications that complement rather than replace teachers.

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