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From BMAS to CCMAS: Assessing Curriculum Reforms in Mathematics Education for AI Competence and 21st-Century Skills Development

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Abstract

This study investigated the evidence of Artificial Intelligence (AI) related content and 21st-century skills in the Benchmark Minimum Academic Standard (BMAS) and Core Curriculum Minimum Academic Standard (CCMAS). Two research questions were raised and answered in this research. The research adopted a qualitative content analysis design. This was done through the use of an adapted instrument. The instrument was validated by three experts. The reliability of the instrument was established through an inter-rater approach. Two experts rated the instrument, and their ratings were calculated using Cohen's Kappa (K), in which the coefficient was found to be 0.75. This is substantial and reliable. The study investigated the BMAS and CCMAS courses of three Universities to check the evidence of AI-related content and 21st-century skills in 30% of the courses developed by the universities. The findings indicated that there's no evidence of AI-related content in the BMAS, and even in the CCMAS is not explicitly mentioned. Furthermore, even though BMAS advocated for the acquisition of some skills, which are similar to the 21st-century skills, no provision was made for the inculcation of the skills. In the CCMAS, the curriculum categorically stated and advocated for the acquisition of 21st-century skills, while only a few courses seem to be promising to reach the promised land. It was recommended that universities should generate courses with 30% AI-related content and that may help students in acquiring the 21st century skills.

Keywords: BMAS, CCMAS, AI competence, 21st century skills, mathematics education

1 Introduction

The rapid advancement of digital technologies, artificial intelligence (AI), automation, and data-driven systems has transformed the nature of work, learning, and societal interactions across the globe (Owojipu et al., 2024). Consequently, higher education institutions are under increasing pressure to redesign their curricula to produce graduates who possess not only disciplinary knowledge but also digital competence, AI literacy, critical thinking, problem-solving abilities, creativity, collaboration skills, communication skills, and lifelong learning capabilities. These competencies, commonly referred to as 21st-century skills, have become essential for effective participation in the contemporary knowledge economy and the emerging digital society (Albay, 2020; OECD, 2012; Ruettgers, 2013; Valtonen et al., 2017).

In Nigeria, the need to align university education with global educational and technological developments prompted the reform of the existing Benchmark Minimum Academic Standards (BMAS), which had guided academic programmes in Nigerian universities for several years. Recognizing the changing demands of the twenty-first century, the National Universities Commission (NUC) initiated a comprehensive curriculum review process that culminated in the introduction of the Core Curriculum and Minimum Academic Standards (CCMAS). The CCMAS was designed to replace the BMAS and provide a more flexible, innovative, and future-oriented curriculum framework capable of responding to contemporary societal, technological, and labour market needs. The new curriculum officially commenced implementation in Nigerian universities in the 2023/2024 academic session (Vanguard News, August 23, 2023). CCMAS is an improved curriculum designed to be implemented through blended learning and developed for the training and development of graduates who are fit to solve the problems confronting the nation and contribute to national and international development (Ayeni, et al, 2024).

A major feature of the CCMAS is its emphasis on 21st-century competencies, innovation, entrepreneurship, digital technologies, blended learning, and institutional flexibility. Unlike the BMAS, which largely prescribed programme content

through centrally defined benchmarks, the CCMAS allocates 70 percent of programme content as core requirements while allowing universities to develop the remaining 30 percent based on institutional strengths, emerging trends, and local needs. This flexibility is intended to encourage innovation, interdisciplinarity, technology integration, and responsiveness to the rapidly evolving global environment (Owojipu et al., 2024). For Mathematics Education programmes, the transition from BMAS to CCMAS is particularly significant. Mathematics educators are expected to prepare learners for a world increasingly influenced by computational thinking, data analytics, artificial intelligence, educational technologies, and digital problem-solving tools. Consequently, mathematics teacher education programmes must equip prospective teachers with the competencies required to integrate digital technologies and AI-driven tools into teaching and learning while fostering critical thinking, creativity, collaboration, and innovation among students. The effectiveness of curriculum reforms in achieving these objectives becomes a critical area of inquiry.

The curriculum is derived based on the norms, values, and needs of society. Derive from either national, state, or local demands of the society. It is through this process that every curriculum is developed, including Mathematics education curriculum. But human beings and nature are dynamic. There's always an incessant need to improve life and living conditions, whether posed by natural phenomena such as climate change or created artificially due to human activities. These always call for a review of the curriculum to meet the current trends in society. After several years of using BMAS, National Universities Commission (NUC) found it deemed necessary to review the whole university curriculum. The essence is to meet the current demands of society, industries, private organizations, all other stakeholders involved, and even personal development. The current curriculum delivered to the Universities known as CCMAS advocates for the inculcation of digital literacy, AI integration, and development of 21st century skills in the learners. For this to be achieved, adequate provision should be made from the design to the evaluation stage. Putting this curriculum on the ADDIE model, one can observe that analysis, design, and development were done partially. But the most critical aspect of this model is implementation. It is imperative to assess whether CCMAS makes adequate provision to achieve digital literacy, AI integration, and development of 21st century skills in the learners.

Despite the widespread implementation of the CCMAS, there is limited empirical evidence regarding the extent to which the new curriculum has strengthened provisions for digital transformation, AI competence, and 21st-century skills development within the Mathematics Education programme. Questions remain as to whether the curriculum reforms represent a substantial shift towards future-ready teacher preparation or merely a modification of existing curricular structures. Against this backdrop, this study examines the transition from BMAS to CCMAS in Mathematics Education by assessing the nature and extent of curriculum reforms introduced under the CCMAS. Specifically, the study investigates how the reforms address digital literacy, artificial intelligence competence, and the development of 21st-century skills in the CCMAS content. The findings are expected to provide valuable insights for curriculum developers, policymakers, teacher educators, and other stakeholders seeking to strengthen Mathematics Education for the demands of the digital age and the Fourth Industrial Revolution.

1.1 Objectives of the Study

Generally, this study aims to evaluate changes introduced by CCMAS and their potential impact on producing digitally competent and AI-literate mathematics educators. In specific terms, this study aims to:-

1. Examine the changes introduced in CCMAS compared to BMAS regarding digital literacy and AI integration in Mathematics Education programmes
2. To evaluate the potential of CCMAS in enhancing 21st-century skills available in the content compared to BMAS.

1.2 Research Questions

The following research questions were developed in line with the stated objectives to guide this study:

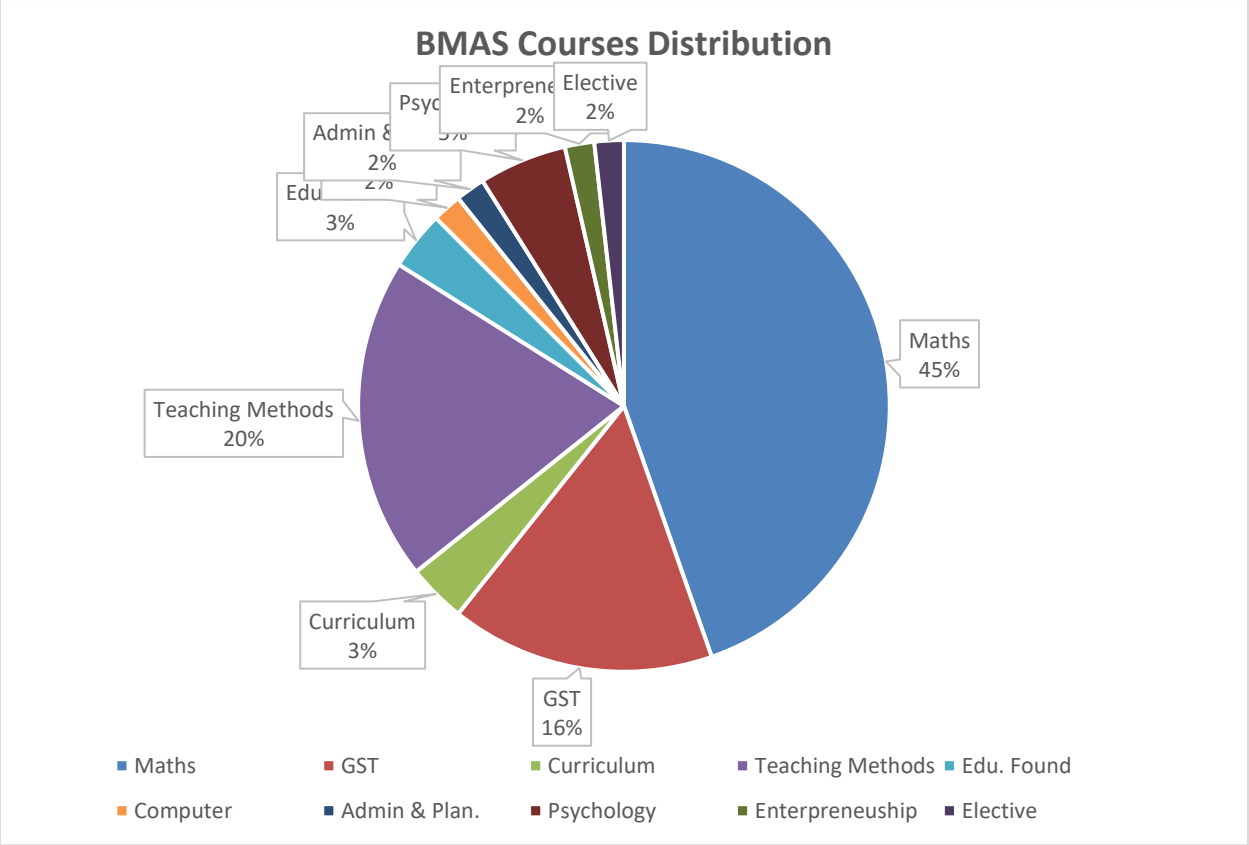
1. What changes have been introduced in CCMAS content compared to BMAS regarding AI-related content in Mathematics Education programmes?
2. How does CCMAS content provide room to enhance the development of 21st-century skills among mathematics educators compared to BMAS?

2 Literature Review/Theoretical Framework

CCMAS documents will serve as a guide to Nigerian Universities in the design of curricula for their programmes concerning the minimum acceptable standards of input and process, as well as a measurable benchmark of knowledge, 21st-century skills, and competencies expected to be acquired by an average graduate of each of the academic programmes, for self, national, and global relevance (Nuhu & Imoukhuede, 2025). The CCMAS is designed to be implemented by both human and material resources such as ICT and artificial intelligence facilities, as the curriculum advocates for full adaptation of technology (Ogunode et al., 2024). The problems encountered in the full implementation of CCMAS include funding, infrastructure, ICT gap, shortage of academic staff, and change in management and policy (Nuhu & Imoukhuede, 2025). However, it is possible that the decision if given a chance to survive, the decision could birth creativity, innovation, and 21st-century soft skills, artificial intelligence across our higher institutions. (Abdus-Samiu, 2025). Both CCMAS and BMAS didn't capture AI-related courses explicitly, but some courses are believed to provide some basic knowledge in Machine learning, which is a gateway to AI (James et al., 2026). For the full implementation of CCMAS and making sure that AI courses and 21st-century skills are integrated into the courses and inculcated into the learners, adequate funding is mandatory (Ohiare-Udebu et al., 2023). Benchmark Minimum Academic Standard (BMAS) was formally introduced by the National Universities Commission (NUC) in 2007. It emerged from the merger of the earlier content-based Minimum Academic Standards (MAS) and the outcome-based Benchmark Statements developed during curriculum reforms. BMAS became the principal quality assurance and accreditation framework for Nigerian university programmes (Owojipu et al., 2024).

Figure **1**

BMAS Courses Distribution

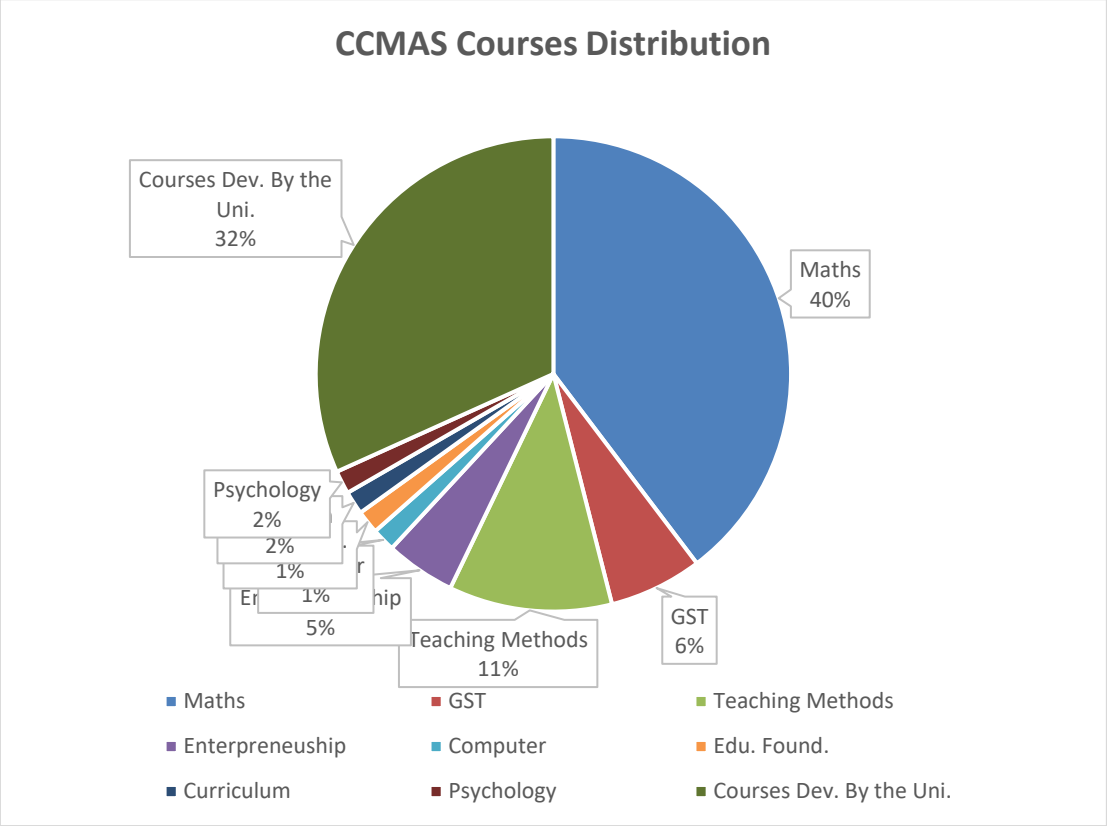


Core Curriculum Minimum Academic Standard (CCMAS) was introduced by the NUC in 2022. In an effort to meet the current demands of society, industries, Nigeria, and personal development. CCMAS is an improved curriculum designed to be implemented through blended learning and developed for the training and development of graduates who are fit to

solve the problems confronting the nation and contribute to national and international development . This is due to the shift from the traditional method to the digital era. The CCMAS stated objectives of the programme, which are similar to those in BMAS, but there is an addition of employment skills and 21st century skills in the CCMAS, which were explicitly stated. These three components of objectives that are expected to be achieved in the mathematics education programme should align with the designated courses of the programme.

Figure **2**

CCMAS Courses Distribution



The 21st century is characterized by advancements in science and technology, which call for improvement or change in instructional practice. Not just instructional practice but even educational outcomes and expectations shifted to a skills-based approach to produce students with generic skills for self-development, community development, and national development. Many organizations have identified several skills as 21st century skills, hoping that if students were inculcated with these skills, they would be able to be productive in the 21st century. Among others that advocated for the inclusion of 21st century skills in the mathematics education program are the EnGauge framework, DeSeCo framework, Partnership for 21st Century (P21) framework, and the National University Commission (NUC) in Nigeria

Artificial Intelligence (AI) is the study and design of intelligent agent systems that perceive their environment and take actions to achieve specific goals (Russell & Norvig, 2021). AI is a branch of computer science that focuses on creating machines and computer systems that can perform tasks that ideally require human intervention but are solely done by a system. It is an imitation of human intelligence. These tasks may include learning, reasoning, problem-solving, understanding language, recognizing patterns, and making decisions. In the 21st century, AI has come to stay. One cannot overlook AI in every sphere of human endeavor, be it health, engineering, life sciences, and many other fields, not to mention. In the education sector, AI can be helpful to teachers, students, and educational administrators. It can enhance and provide a personalized learning experience, automate administrative tasks, analyze students' performance, and improve the teaching and learning process. In 2022, NUC found it imperative to review the mathematics education curriculum. In the review, the objectives of the program were updated. The NUC stated certain skills as 21st century skills. The aim is that

every graduate of mathematics education should possess such skills before he/she graduates. The NUC stated the following skills in CCMAS

1. Critical thinking
2. Problem solving
3. Communication skills
4. Scientific literacy
5. Digital literacy
6. Teamwork
7. Enterprise skills
8. Management skills
9. Flexibility skills

3 Materials and Methods

3.1 Methodology

This research employed a qualitative content analysis design. This design is chosen because the researcher analyzes the existing document using a deductive approach to answer the research questions. Content analysis can still be quantitative if the researcher codes or assigns values to a particular theme or words and later uses descriptive statistics to answer the research questions. In order to collect the required data, the researcher adapted a rubric framework used by (Ruettgers, 2020). The framework was used by the author to check the evidence of 21st-century skills in teacher education programs in the United States. The framework measured the evidence of 21st-century skills through course title, course objectives, course description, and syllabi. The framework was validated by three experts in order to domesticate the framework to our peculiar programme in Nigeria. An inter-rater reliability approach was used to establish the reliability of the instrument. The ratings of the two experts were calculated using Cohen's Kappa (K). The coefficient of Cohen's Kappa was found to be 0.75, which is substantial and reliable. In this research, CCMAS and BMAS were used for the content analysis. The essence is to see whether the BMAS and CCMAS captured Artificial Intelligence-related content and 21st-century skills. The 70% of the courses provided by NUC were analyzed using the adapted rubrics. Course content, course title, and course description were analyzed to see the evidence of 21st-century skills and artificial intelligence-related content. The 21st-century skills checked are skills provided by the NUC as stated earlier in the literature review. The researcher went further to check three Universities that have already developed 30% of their courses to ascertain the presence of courses related to artificial intelligence and 21st-century skills. These three universities were selected purposively because the researchers have access to their 30% courses developed. It is allowed in qualitative research to select a sample without stating the entire population because it explores the problem in detail. The essence of checking the 30% provided by selected universities to check whether AI-related courses were developed in the remaining 30%. Those three Universities are Sokoto State University, Sokoto; National Open University of Nigeria (NOUN); and Northwest University, Kano. These three Universities have started implementing the CCMAS, and their courses are accessible online. The present of indicator/word is recorded as 1 while the absent of it is recorded as 0. But this research will not used descriptive content analysis where such themes/indicators/words are presented using descriptive statistics.

3.2 Table **1**

AI-Related Content Check Framework

Theme	**Words/Indicators**
AI (General)	Artificial Intelligence, AI intelligent system,Machine Intelligence, Intelligent Agent, AI application
Machine Learning	Machine Learning, Algorithsm, Model Training, Prediction,Classification, Regression, Supervised Learning, Unsupervised Learning, reinforcement Learning

Generative AI	Generative AI, Large Language Model,GPT, ChatGPT, Gemini, Claude, Copilot, Text Generation, Image Generation, Content Generation
Computer Vision	Image Recognition, Facial Recognition, Object Detection, Pattern Recognition, Visual Analytics
AI tools and Application	Chatbot, Virtual Assistant, Recommendation System, Intelligent Tutoring System,Experts System, Automation
AI in Education	AI-assisted learning, Adaptive Learning, Intelligent tutoring System, Personalized Learning, Automated Assessment, AI-supported teaching, Learning Analytics

Table 1 above indicates the content check of AI-related content in both BMAS and CCMAS. Themes, categories, and words were checked on the course titles, course descriptions, course objectives, and some course content.

Table **2**

21st Century Skills Check Framework

Skills	**Words/Indicators**
Critical Thinking	Analyze, Evaluate, Reason, Infer, Justify, Interpret, Compare, Critique, Evidence, Reflection, Logical Thinking, Argument, and Decision-making
Problem Solving	Solve, Solution, investigate, Identify problem, Troubleshoot, Inquiry, Strategy, Experiment, Innovation, Resolve and Challenge
Communication Skills	Communicate, Discuss, Present, Explain, Debate, Write, Listen, Oral Presentation, Report, Feedback, Dialogue, and Interaction
Scientific Literacy	Scientific Method, Experiment, Observation, Hypotheses, Evidence, Data, Measurement, Scientific Reasoning, and Research
Digital Literacy	ICT, Computer, Digital tools, Internet, Online learning, Software technology, Multimedia, Coding, Information literacy, e-learning, and Digital resources.
Teamwork	Collaborate, cooperation, Group work, teamwork, Partnership, Peer learning, Shared responsibility, Participation, Collective effort, Collaboration
Enterprise Skills	Entrepreneurship, Innovation, Creativity, Initiative, Opportunity, Business, Leadership, Productivity, Value creation, risk-taking, and Self-employment
Management Skills	Planning, Organizing, Coordinating, Monitoring, Supervision, Delegation, Resource Management, Project management, and Time management.
Flexibility Skills	Adaptability, flexibility, resilience, Openness, adjust, Cope, lifelong learning, Change, Versatality, Willingness to learn, responsiveness

4 Results

Research question one: What changes have been introduced in CCMAS content compared to BMAS regarding digital literacy and AI integration in Mathematics Education programmes?

To answer this research question, document analysis of BMAS, CCMAS, and 30% courses developed by three selected universities is presented in Table 3 below

Table **3**

AI-related Contents Present in BMAS and CCMAS

AI-related Content	**BMAS**	**CCMAS**
Chatbot, Virtual Assistant, Recommendation System, Intelligent Tutoring System, Experts System, Automation	Absent	Emerging/Supported/Flexibility
Generative AI, Large Language Model,GPT, ChatGPT, Gemini, Claude, Copilot, Text Generation, Image Generation, Content Generation	Absent	Emerging/Supported though not explicitly mentioned

AI-assisted learning, Adaptive Learning, Intelligent tutoring System, Personalized Learning, Automated Assessment, AI-supported teaching, Learning Analytics	Minimal	Supported but not explicitly mentioned
Machine Learning, Algorithms, Model Training, Prediction, Classification, Regression, Supervised Learning, Unsupervised Learning, reinforcement Learning	Weak	Supported/Emerging
Image Recognition, Facial Recognition, Object Detection, Pattern Recognition, Visual Analytics	Weak	Supported/Emerging

The analysis revealed that neither BMAS nor CCMAS explicitly contains concepts related to artificial intelligence, machine learning, learning analytics, or AI applications in education. But CCMAS emphasizes digital transformation and emerging technologies, creating opportunities for AI-related competencies without drawing a course to cover the content area explicitly. Furthermore, some courses provide some basic prerequisite knowledge on AI-related content, such as MTH 204, MTH 205, MTH 201, and CSC 202. These courses only provide basic knowledge for machine learning. However, neither BMAS nor CCMAS has a single course that comprehensively teaches the use of artificial intelligence explicitly. Suggesting the need for further curriculum enhancement.

Research Question two: How does CCMAS content provide room to enhance the development of 21st-century skills among mathematics educators compared to BMAS?

To answer this research questions BMAS and CCMAS documents were checked to verify the evidence of 21st century skills. So, also the 30% course contents of the selected three universities were analyzed. The findings are presented in Table 4.

Table **4:21**

Century Skills Present in BMAS and CCMAS

Skills	**BMAS**	**CCMAS**
Critical Thinking	Present but not explicitly stated	Present and stated in Objective of the program
Problem Solving	Present and stated in the objective of the program	Present and stated in Objective of the program
Communication Skills	Present and stated in the objective of the program	Present and stated in Objective of the program
Scientific Literacy	Present in some courses such as Departmental courses	Present and stated in Objective of the program and some courses
Digital Literacy	Present in Faculty courses and Mathematics Courses	Present and stated in Objective of the program and some courses
Teamwork	Present on some Departmental courses	Present and stated in Objective of the program and available in some courses
Enterprise Skills	Present and stated in Objective of the program and available in entrepreneurship courses	Present and stated in Objective of the program and available in entrepreneurship courses
Management Skills	Present and strongly emphasize	Present and strongly emphasize
Flexibility Skills	Present and strongly emphasize	Present and strongly emphasize

The analysis revealed nine major themes: critical thinking and problem-solving, digital literacy, collaborative learning, communication skills, enterprise skills, scientific skills, teamwork, and management skills. Compared to BMAS, CCMAS contains more explicit provisions for these competencies through outcome-based learning, flexible curriculum structures, and technology integration, and these skills were mentioned explicitly in the CCMAS. Consequently, CCMAS appears better positioned to prepare mathematics educators with the skills required for teaching and learning in the 21st century.

5 Discussion

The finding indicates inadequate provision in the course content of courses related to artificial intelligence. The results show that no courses(s) related to artificial intelligence are stated explicitly in either BMAS or CCMAS. This finding confirms the results obtained by James et al., (2026). Their findings show no courses related to AI in both BMAS and CCMAS. However, it is possible that CCMAS could foster creativity, innovation, and 21st-century soft skills, and Artificial Intelligence across our higher institutions (Abdus-samiu, 2025). The CCMAS provides the requisite flexibility and innovativeness consistent with institutional autonomy, which is not found in the BMAS (Ayeni et al., 2024). All these supports the findings of this study that AI-related content is not explicitly mentioned in the CCMAS but is supported and can possibly emerge in 30% of courses to be developed by the universities. But in the BMAS, there is no flexibility and no element of AI-related content, as can be seen from Table 3. The CCMAS is an organized curriculum designed for Nigerian universities with the objectives of improving the standard of the Nigerian universities, making grandaunts from Nigerian universities more employable and to equip with grandaunts local, national and international skills, knowledge and character that are globally acceptable (Ogunode et al., 2023). This proves the opportunity inserted in CCMAS to be globally competitive in inculcating learners with the appropriate skills to succeed. It major contribution is the flexibility nature, course that seem to be promising to provide knowledge and application of artificial intelligence can easily be incorporated without disrupting the entire curriculum. Therefore, this study suggested universities should try to incorporate or generate courses related to artificial intelligence in the remaining 30%. Future researchers can assess the best way for utilizing artificial intelligence in education so as to tap it maximum benefits.

The findings indicate that BMAS didn't state 21st-century skills explicitly either in the course description, course title, or objective of the program, but CCMAS stated 21st-century skills as the objective of the program. This puts CCMAS in a better position for the inculcation of these skills. This finding reaffirms the results obtained by (Nuhu & Imoukhuede, 2025). Even though 21st-century skills were not stated explicitly in the BMAS, there are many courses that foster the acquisition of those skills. Courses like Mathematics, basic computer knowledge, general courses in education, subject-specific courses in science education can foster the acquisition of 21st century skills. The acquisition of the 21st century skills doesn't need to be stated explicitly or in some objectives of the courses but can be acquired even in the classroom such as group assignments, blended teaching approach, collaborative learning and social interaction (Abdus-samiu, 2025). It is in line with the finding of this study that 21st century skills are both available in BMAS and CCMAS embedded not just in the course title, course content, course description or course objectives but may be present in many cases. Therefore, this study suggested that emphasis should be given to the acquisition of these 21st century skills and future research can be carried out to ascertain the impact of the 21st century skills on students' acquisition of employability skills.

6 Conclusion

From the foregoing discussion, it can be seen that neither CCMAS nor BMAS explicitly provides for AI education, but some courses are believed to improve literacy in Machine Learning (ML). The CCMAS seems to support AI integration due to the flexibility nature. This implies that AI is not available in 70% of the courses provided by the NUC but can still be incorporated or generated by the universities based on the 30% left for them. Furthermore, CCMAS clearly stated 21st-century skills, even though 70% of courses do not seem promising in delivering these skills but can still be inculcated through the remaining 30% to be developed by the respective universities. BMAS didn't capture 21st century skills explicitly but can be acquired through other courses. Therefore, teachers are expected to devise a lesson that Is engaging, challenging, innovative, creative, and critical that will foster the acquisiton of 21st century skills. The Conclusion section should succinctly summarise the key findings of the study and their overall significance. It should restate how the research objectives were achieved and highlight the main contributions to knowledge, theory, or practice. Avoid introducing new information or detailed analysis. Emphasise the broader implications of the study and, where appropriate, provide concise recommendations or directions for future research. Ensure clarity, coherence, and a strong closing that reflects the study's importance.

7 Conflict of Interest

The authors declare neither financial nor non-financial conflict of interest.

8 Author Contributions

All the authors contributed from the beginning to the end of this article. The authors are liable for any information or misinformation in this article.

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10 Data Availability Statement

The data used for this study is available on NUC portal and on the portal of the sample Universities.

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