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Natural Language Processing for Agriculture-Based Industrial Skills Development in Polytechnics

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Abstract—Artificial Intelligence (AI) involves the use of a computer system capable of performing tasks that require human intelligence. In Technical and Vocational Education and Training (TVET), integrating generative AI fosters digital literacy and lifelong learning. Limited studies have explored the use of Natural Language Processing (NLP) AI tools, such as ChatGPT, Meta AI, and DeepSeek, among agriculture students in Nigerian Polytechnics, as many have largely focused on universities. This study examined the demographic profile, usage levels, impact, and challenges associated with NLP AI tools among students in agriculture-related programs in Nigerian polytechnics. Using a descriptive quantitative design, data were collected through structured questionnaires from 300 students of 10 Polytechnics in Southwest Nigeria. Findings revealed that 43% of the participants were aged 20–22, and 50% were enrolled in National Diploma 2. A high level of engagement with NLP tools was reported, with ChatGPT (35%) and Meta AI (56.7%) being the most frequently used, primarily for research (60%), assignments, and learning (30.7%). Respondents noted significant improvements in understanding (88.7%), application (93.2%), and problem-solving skills (76.6%) relevant to agricultural competencies. Despite these benefits, students encountered challenges such as limited access, technical difficulties, and issues interpreting AI-generated content. The findings highlight the transformative potential of AI in agricultural TVET if inclusive access and usability are enhanced. It is recommended that the strategic use of NLP AI tools can support skills development in Nigeria's agricultural sector, particularly within polytechnic education.

Keywords-Natural Language Processing, Artificial Intelligence, Agric-based industrial skill development, Nigeran Polytechnics.

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1. Introduction

1.1 Background of the study

This rapidly evolving area of artificial intelligence (AI) encompasses the development of intelligent machines capable of performing tasks that typically require human intelligence, such as comprehending natural language, identifying patterns, and making data-driven decisions across various industries, including medical diagnosis, autonomous vehicles, and education. AI is described as an attempt to replicate human capabilities with machines, creating computer-controlled robots or software that can think intelligently and imitate decision-making, problem-solving, data utilization for various tasks, multitasking, synthesis, analysis, and prediction [1-5]. It was similarly described as utilizing algorithms and computational models to simulate intelligent behaviors, such as reasoning, perception, language processing, spatial processing, and vision recognition, thereby enabling machines to gather information from a pool of data and make human-like decisions [6].

Generative AI is increasingly used across various economic sectors, including finance [7,8], transportation [9], education [10], healthcare, agriculture [11], drug discovery, language translation, and scientific research. As generative AI continues to penetrate different areas of society, its transformative effects are set to reshape industries, redefine human-computer interactions, and open new avenues for innovation [11]. Generative Artificial Intelligence tools such as ExperAI, Paperpal, Chat Bing, Humata, Paperdigest, Elicit, Copilot, Paper Brain, Trinkin.ai, and ChatGPT can analyze student data, including test scores, attendance records, research, assignments, term papers, and academic projects, and provide feedback and recognize areas of weakness and strength, making these processes more efficient [12-16].

In the context of Technical and Vocational Education and Training (TVET), harnessing generative AI in academic practices to build digital literacy is particularly important, as it not only enhances employability but also fosters lifelong learning. TVET constitutes a vital segment of the education system, offering courses and training programs geared towards equipping individuals with skills relevant to employment [17,18]. TVET enhances workforce readiness, critical thinking, and problem-solving skills [19], contributes to economic development by providing a highly trained workforce to meet industry demands [20], and plays a crucial role in mitigating skills gaps and addressing unemployment in certain fields [21]. According to the National Policy on Education of the Federal Republic of Nigeria, TVET encompasses educational processes involving general education, technology studies, practical skills, and knowledge acquisition related to various occupations, adapting to the evolving demands of the digital economy [22, 23].

Despite the necessity for digital literacy and skills acquisition, Nigerian TVET institutions face numerous challenges in integrating generative AI into academic practices. These challenges include inadequate curricula, insufficient tools, a lack of professional development, limited access to technological infrastructure, a shortage of qualified instructors, and a lack of relevant learning resources [5]. Tertiary institution teachers face challenges in acquiring digital skills due to inadequate opportunities for information and communication technology (ICT) training, the high cost of ICT literacy programs, insufficient ICT facilities, and limited sponsorship [24,25]. Moreover, understanding the workings of generative AI and the issues it can address is essential for developing educators' and learners' digital literacy and laying the groundwork for future career development and learning [26-28].

Although there are a few studies on the use of technology for educational purposes [29-31], there remain few findings, particularly on the use of natural language processing AI tools. Additionally, there is limited existing research on its influence on the development of agricultural-based industrial skills among polytechnic students in Nigeria. This gap in research highlights the need for thorough research into the impacts of natural language processing AI tools in TVET and their influence on agri-based industrial skill development among Nigerian polytechnic students.

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1.2 Objectives of the Study

The objectives of this study are to:

1. Determine the demographic characteristics of Nigeria Polytechnic students studying agricultural-related courses
2. Determine the level of usage of Natural Language Processing (NLP) AI tools among Agricultural Students in Nigerian Polytechnics.
3. Investigate the Natural Language Processing (NLP) AI tools (ChatGPT, Meta AI, and DeepSeek) and the learning outcomes of polytechnic students in Nigeria.
4. Examine the challenges and limitations faced by students in using NLP AI Tools and explore ways to improve their effectiveness.

2.0 Methodology

This research employed a quantitative method to gather data from Nigerian polytechnic students enrolled in agriculture-based industrial skill development programmes as participants. Stratified random sampling was used to select participants from ten (10) polytechnics in Southwest Nigeria to ensure representation from different states in Southwest Nigeria. Validity and reliability of the study was secured with Cronbach's alpha value of 0.90 expert review of validity and 0.92 internal consistency of measuring instrument, from a pilot study of 10% of the respondents after which a sample size of 300 participants (students) was selected for quantitative research, using the approved structured questionnaire designed to gather qualitative data on the awareness and use of NLP AI tools among students, the impact of NLP AI tools on agric-based industrial skill development, and the challenges confronting the adoption of NLP AI tools in TVET. It was also used to investigate the specific ways in which NLP AI tools are integrated into agriculture-based TVET programmes. Limitations and benefits of using NLP AI tools for skill development and recommendations for improving the adoption of NLP AI tools in TVET. The data collected were analyzed using descriptive statistics (e.g., frequencies and percentages) and the chi-square test to determine if there is an association between the categorical variables.

3.0 Results and Discussion

3.1 Demographic Characteristics of Agricultural Students in Nigeria Polytechnic

Table 1 indicates that most respondents (43%) were aged 20–22, indicating that most students in the agriculture-related programs are in their early adulthood, a stage commonly associated with high technology engagement and openness to digital learning tools [32]. This demographic is ideal for interventions involving technology, such as NLP AI tools, as younger adults typically exhibit higher digital literacy [33]. Most students (50%) were in National Diploma 2 and were primarily studying Agricultural Technology (47.7%). This distribution suggests a potential focus group for further intervention or studies, as Agricultural Technology appears to be the most enrolled discipline, and National Diploma 2 students are likely to have more exposure to AI tools due to increased academic requirements compared to National Diploma 1 students.

Table 1: Demographic Characteristics of Nigeria Polytechnic students Studying Agriculture

Demographic Characteristics	Frequency	Percentage (%)
Age		
14-16	8	2.7
17-19	60	20.0

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20-22	129	43.0
23-24	55	18.3
25-Above	48	16.0
Total	300	100
Class		
National Diploma 1	55	18.3
National Diploma 2	150	50.0
High National Diploma 1	20	6.7
High National Diploma 2	75	25.0
Total	300	100
Agriculture program		
Agricultural Technology	143	47.7
Agricultural Engineering	27	9.0
Crop Production	40	13.3
Animal Production	48	16
Agricultural Extension	42	14
Total	300	100

3.2 Usage of NLP AI Tools among Agricultural Students in Polytechnic

Table 2 presents the level and purpose of NLP AI tool usage. Daily (40.3%) and weekly (30.3%) use demonstrated strong integration into students' routines. MataAI (56.7%) and ChatGPT (35%) were the dominant tools. These tools provide natural language responses that are useful for learning complex agricultural concepts, simulations, and skill acquisition. Recent studies support the use of AI-powered tools such as ChatGPT to enhance cognitive learning and reduce the burden of rote learning in technical education environments [34].
The primary use was for research and assignments (60%), followed by studying (30.7%) and a smaller proportion for communication (9.3%). This aligns with NLP's design to simplify information retrieval, assist in writing, and clarify complex concepts [35].

Table 2: Level of Use of NLP AI Tools among Agricultural Students in Polytechnic

Level of Use of NLP AI Tools	**Frequency**	**Percentage (%)**
How often are NLP tools used?		
Daily	121	40.3
Weekly	91	30.3
Rarely	88	29.4
Total	300	100
Types of NLP AI tools used		
ChatGPT	105	35
MataAI	170	56.7
DeepSeek	12	4.0
Others	13	4.3
Total	300	100
Purpose for the use of NLP AI		
Research and assignments	180	60.0
Studying and learning	92	30.7
Communication and collaboration	28	9.3

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Total	300	100

3.3 NLP AI Tools and Learning Outcomes

Table 3 reveals that a significant majority (88.7%) agreed or strongly agreed that AI tools improved their understanding of agricultural industry skills. Over 93% of respondents stated that these tools helped them apply agricultural-based industrial skills. This reflects strong educational utility, consistent with the findings of Ukala and Iheukwumere [36], who reported improved engagement and learning outcomes in vocational education due to AI integration.

Additionally, 76.6% of the students agreed or strongly agreed that AI tools have enhanced their problem-solving skills. While only 13.6% reported no improvement or negative impact, this suggests broad acceptance of these tools as effective learning aids. Problem-solving is a critical 21st-century skill, and NLP-based tools are known to support cognitive scaffolding, leading to a deeper understanding of concepts [47].

The chi-square value for problem-solving skills was significant ($\chi^2 = 24.29$, $p < 0.01$), indicating the strongest statistical evidence. This suggests that NLP AI tools greatly improve decision-making, troubleshooting, and analytical thinking abilities. This result is consistent with constructivist learning theory, which emphasizes problem-based, learner-centred and interactive learning environments made possible by digital technologies [38].

Table 3: NLP AI Tools and Learning Outcomes

NLP AI Tools and Learning Outcome	Frequency	Percent (%)	x^2
It has improved understanding of agric-based industrial skills			
Strongly Agree	96	32.0	
Agree	170	56.7	
Neutral	34	11.3	
Total	300	100	7.18NS
NLP AI Tools have aided my ability to apply Agric-based industrial skills			
Significantly improved	157	52.3	
Somewhat improved	123	41.0	
No impact	20	6.7	
Total	300	100	6.87NS
It has enhanced my problem-solving skills in agriculture-based industrial skills			
Strongly Agree	40	13.3	
Agree	190	63.3	
Neutral	29	9.8	
Disagree	7	2.3	
Strongly Disagree	34	11.3	
Total	300	100	24.29**

x^2 - Chi-square, ** - reflect highly significant

3.4 Challenges and Limitations with the use of NLP AI Tools and ways of improvement

Table 4 outlines the Major Challenges, level of friendliness, and suggested improvements for optimal usage of NLP AI tools. Limited access (28.7%), technical issues (22.7%), and difficulty in understanding outputs (21.7%) were the key barriers. These results reflect issues common in digital learning environments in developing countries, especially in resource-constrained settings [39].

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Students suggested clearer responses (15.6%), comprehensive content (11.7%), and error minimization (21%). A notable concern was subscription cost (20.3%), highlighting financial barriers that could impede equitable access. These responses align with global best practices for AI tool design, which emphasize localization, accessibility, and affordability to enhance effectiveness [40]. Additionally, a combined 86.1% of respondents agreed or strongly agreed that NLP tools are user-friendly. This suggests that, although access and clarity are issues, the interface design is largely successful.

Table 4: Challenges and Limitations with the use of NLP AI Tools and ways of improvement

Challenges and Limitations	Frequency	Percent (%)
Challenges faced by students		
Difficulty in understanding the tool's output	65	21.7
Limited access to the tool	86	28.7
Technical issues with the tool	68	22.7
Others	81	27.0
Total	300	100
NLP AI Tools level of user friendliness		
Strongly Agree	117	39.0
Agree	142	47.3
Neutral	41	13.7
Total	300	100
How best NLP Tools can be improved for students use		
No Idea	50	16.7
Make response clearer and real	47	15.7
Make Response comprehensive	35	11.7
Reduced the price of subscription	61	20.3
Minimise error	63	21.0
Make it more user friendly	19	6.3
Make response faster	25	8.3
Total	300	100

4.0 Conclusion and Recommendation

This research demonstrates that the use of an NLP AI tool facilitates skill development in agricultural-based TVET programs. With most students reporting improved understanding, skill application, and problem-solving ability, NLP tools appear to be effective as educational aids. However, technical barriers, affordability, and output clarity remain challenges in its application. Addressing these issues could improve the effectiveness and inclusiveness of the tools, especially in polytechnic environments.

It is hereby recommended that government agencies (e.g., NBTE, NITDA) and educational institutions partner with NLP AI tool developers to provide subsidized or institutional licenses for students. Developers should localize AI tools by training models with agricultural content relevant to Nigeria's curriculum and ensuring that the output is simplified and context-aware. A total of 37.3% of students requested clearer and more accurate responses, indicating a need for the customization and refinement of AI output.

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Also, Agricultural TVET Curriculum designers should formally integrate AI tool usage into coursework and skill development modules with guided exercises and case studies. Over 90% of students reported enhanced learning and application of industrial skills through AI tools, and formal curriculum integration can amplify this.
In addition, collaborations should be fostered between polytechnics, tech startups, and agricultural industries to co-develop AI tools tailored for TVET applications. Such partnerships can ensure that the tools are practical, novel, and aligned with the labor market needs in the agricultural sector.

5.0 Ethical and legal perspective on the use of generative AI

Although generative AI can enhance the efficiency of administrative and grading tasks, its use in academic settings raises significant ethical and legal concerns. However, the potential bias and lack of transparency in automated grading systems may impact fairness and students' ability to challenge academic decisions. Legally speaking, the Nigeria Data Protection Act 2023 (NDPA), which requires lawful processing, purpose limitation, and data minimization, must be followed when processing students' personal data, including names, academic records, and biometric attendance information. Adopting such tools requires institutions to guarantee informed consent and sufficient protection against data misuse. Academic integrity is also compromised when generative AI is used to create assignments, research papers, and other academic content. Submitting AI-generated work as original student work could violate the Copyright Act of 2022 and be considered plagiarism, especially if the AI outputs duplicate protected works. Since Nigeria lacks a stand-alone AI law, compliance with current frameworks, such as the General Application and Implementation Directive (GAID) 2025, is required to guarantee responsibility, openness, and the responsible use of AI technologies in educational settings. Higher education institutions should implement AI-detection and disclosure systems, create explicit policies outlining acceptable and unacceptable uses of AI, and encourage ethical AI literacy among staff and students to reduce these risks.

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