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Artificial Intelligence in Mechanical Technology: A Leverage for Sustainable Development in the Prevailing Economic Uncertainties in Edo State, Nigeria

JEHU OGBEBOR
Edo State College of Education, Edo State, Nigeria

S.O. OSUYI
University of Benin, Benin City, Nigeria

Abstract. This study investigated how artificial intelligence in mechanical technology can leverage sustainable development in a period of economic uncertainties in Edo State, Nigeria. Four research questions guided the study and one hypothesis was tested at 0.05 level of significance. The study adopted a descriptive survey research design with a population of 80 respondents, which consisted fifty-three (53) technical teachers from five public technical colleges and twenty-seven (27) managers of mechanical technology industries in Edo State. The entire population was used as the sample because it was of manageable size A structured questionnaire with twenty (20) items arranged in clusters was used as instrument for data collection. The instrument was validated by three experts from the department of Vocational and Technical Education, University of Benin, Benin City. Cronbach alpha statistical formula was used to test the reliability of the instrument and it yielded a coefficient of 0.85. The findings of the study revealed that artificial intelligence in mechanical technology improves learning experience and learning outcome, increases productivity, improves design accuracy, reduces production labour cost, reduces material wastage, saves time and improves environmental health. Based on the findings, it was recommended, amongst others, that artificial intelligence tools should be incorporated into mechanical technology delivery systems in institutions of learning where mechanical technology is offered and in mechanical technology industries for sustainable development under economic uncertainties in Edo State, Nigeria.

Keywords: Artificial Intelligence, Mechanical Technology, Economic Uncertainties and Sustainable Development

1. Introduction

Vocational and Technical Education is a form of education that combines skill acquisition with general educational knowledge (FRN, 2014). While the primary purpose of vocational education is to prepare people for employment in a recognized occupation, technical education is considered a post-secondary vocational training programme whose major purpose is the production of technicians (Momoh, cited in Osuyi et al, 2024). The authors further explained that while the term vocational education refers to skill-based programmes which are designed for skill acquisition at lower level of education, technical education, is designed to prepare people for entry into recognized occupation at a higher level. Technical education is the inclusion of basic technical and scientific knowledge with the skill-based programme. Reko and Maxwell (2016) sees technical education as the training of technically oriented personnel who are to be the initiators, facilitators and implementers of the technological development of a nation, as it is the practical application of scientific knowledge for the invention of things for man's benefit. Some of the major areas of specialization in technical education includes woodwork technology, building technology, electrical/electronics technology and mechanical technology.

Mechanical Technology is an integration of two different areas of specialization in technical education. It is a combination of Automobile Technology and

Metalwork Technology (Lemo & Olatokun, 2017). Automobile technology equips recipients with knowledge and skills in automobile engine maintenance and repairs, troubleshooting, engine cleaning, lubricating auto systems, engine tune-up, brake system service and repair, auto electricity, auto air-conditioning, auto body repair, auto shop management, service station management, spray painting, auto interior upholstery, chassis repair, vulcanization, radiator repair, crankshaft cutting, engine building/service, wheel alignment and tyre balancing, auto instructing job, the use On-Board Diagnosing machine and motor driver-mechanic. Motor driver-mechanics are motor drivers who are trained to carryout basic automobile diagnosis and maintenance on their vehicles, where the attention of an expert mechanic is not required, or is not readily accessible (FRN, 2000). In addition, metalwork technology equips recipients with skills and knowledge in forming, cutting, joining, machining, fitting job, welding analysis, metallurgy, welding shop management, foundry work and fabrication jobs such as metal door, window and protector construction (Tani & Kalus, 2019).

The method of teaching and service delivery in technical education in general, and in mechanical technology in particular, has largely remained traditional in Nigeria. It involves the use of hand-held tools, devices and equipment such as pliers, screwdrivers, jack, spanners, metal punch, scriber, chisel and other tools used for metal fabrication. The use of these tools leaves the technician physically drained and tired with very little output to show for the energy expended. The twentieth and twenty-first centuries have seen advancements in science and technology, in which cutting-edge technology, using computerized systems and applications, has been used to carry out production more easily and speedily (Ogbebor & Osuyi, 2024). One of such cutting-edge technology is Artificial Intelligence.

Artificial intelligence (AI) is one of the most important global issues of the 21st century. Artificial intelligence refers to the ability of a computer system to perform human tasks, such as thinking and learning, that can usually be accomplished only through human intelligence. Artificial Intelligence, commonly referred to as AI, is already providing a degree of flexibility and customization that was never before possible in education (Sadiku et al, 2021). Sadiku et al further revealed that the modern field of artificial intelligence came into existence in 1956 when the term “artificial intelligence” (AI) was coined by John McCarthy. AI is the branch of computer science that deals with designing intelligent computer systems that mimic human intelligence, as visuals perception, speech recognition, decision-making, and language translation. The ability of machines to process natural language, to learn, to plan makes it possible for new tasks to be performed by intelligent systems. The main purpose of AI is to mimic the cognitive function of human beings and perform activities that would typically be performed by a human being. Without being taught by humans, machines use their own experience to solve a problem. Although the original vision for artificial intelligence was to simulate human intelligence, research effort has gradually shifted to autonomous systems that compete with people. Today, AI is integrated into the daily lives of humans in several forms, such as personal assistants, automated mass transportation, aviation, computer gaming, facial recognition at passport control, voice recognition on virtual assistants, driver-less cars, companion robots, academic research assistants and several others. Despite its advantage and ability to leverage sustainable development, many modern vocational and technical education scholars know relatively little about artificial intelligence. (Xi, 2021)

Sustainable development refers to development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (Schaefer & Crane cited in Mensah, 2019). Furthermore, Abubakar (2017) sees sustainable development as a global development concept that provides the mechanism through which society can interact with the environment while not risking damaging the resource for the future. Thus, it is a developmental concept that brings about the improvement in the living standards of people without causing environmental challenges such air and water pollution, deforestation, climate change amongst others (Browning & Rigolon, 2019). This implies that sustainable development is an effort at guaranteeing a balance amongst economic growth, environmental integrity and social well-being. Basically, proper decisions on sustainable resource management will bring about sustainable growth for sustainable society (Yang, 2019).

Hence, mechanical technology skills that can leverage sustainable development are those that booms the economy, improves social life and standard of living and protects the environment (United Nations, 2018). Artificial intelligence systems guarantee improved teaching and learning outcome, increased productivity, improves design accuracy, saves cost of labour, optimizes material usage, saves time and supports environmental protection through efficient energy consumption and combustion processes (Sadiku et al, 2021).

Currently, the nation grapples with many challenges that could make living difficult. One of such challenge is economic uncertainties. Economic uncertainties refer to a situation in which future economic environment is difficult to predict (Osuyi & Ogbebor). One major event that brought economic uncertainty globally, and to Nigeria in particular, is the covid-19 pandemic (Osuyi & Uwaifo, 2023). The measures taken to contain it, such as lock-down, social and physical distancing, amongst others, resulted in significant economic uncertainties. Osuyi and Ogbebor are of the view that other sources of economic uncertainties in Nigeria in recent times includes the re-design of the naira in 2023 which lead to cash crunch; the total removal of subsidy on petrol by the Federal Government, whereby prices of petroleum product is determined by market forces; the floating of Nigerian currency (naira) exchange rate in the Foreign Exchange (FOREX) market; and frequent cases of civil un-rest, such as hash tag #ENDSARS protest of 2020 and #ENDBADGOVERNANCE protests of 2024. These protests snow balled into looting, with grocery, grains and beverage businesses worse hit. All of which led to rapid price fluctuations and a geometric increase in the cost of goods and services (Osuyi & Ogbebor, 2024). The authors further stressed that at such times of economic uncertainties, vocational and technical education comes handy as a veritable tool to ensure economic stability and sustainable development.

For the purpose of this study, mechanical technology industries refer to industries that renders services in various areas in automobile technology and metalwork technology such as automobile maintenance, metal smelting, turning, milling drilling, metal sheets manufacturing, amongst others.

1.1 Statement of the Problem

Nigeria in general, and Edo State in particular, is currently going through a period of difficulties in which future economic environment is difficult to predict. Several researches have revealed that a system of education that equips individuals with skills is a veritable tool for achieving economic stability and sustainable development. One of such education aid skill acquisition is technical education with mechanical technology as one of the areas of specializations.

Currently, the system of delivering and acquiring of mechanical technology relies heavily on use of hand-held tools which is becoming irrelevant due to advancements in science and technology. Around the world, cuting-edge technology, such as artificial intelligence, are being deployed in various fields of specializations to enhance speed and accuracy in production and maintenance processes. The researchers are therefore worried that if the use of hand tools in the training of students in institutions of learning, particularly in technical education, continuous the recipients might not be equipped with trending process of using modern technology, such as artificial intelligence, in production processes in the industries. Consequently, this could lead to worsened economic uncertainties and the expected sustainable development could become a mirage. This necessitated the current study.

1.2 Purpose of the Study

The main purpose of this study is to determine the extent to which artificial intelligence in mechanical technology can lead to sustainable development under prevailing economic uncertainties in Nigeria.

Specifically, the study determined:

- The extent to which economic uncertainties impact sustainable development in Edo State.
- The extent to which artificial intelligence systems is used in training mechanical technology students in technical colleges in Edo State.
- The extent to which artificial intelligence systems is being used in mechanical technology industries for service delivery in Edo State.
- The extent to which the use of artificial intelligence in mechanical technology leverage sustainable development under prevailing economic uncertainties in Edo State.

1.3 Research Questions

The following research question was raised to guide the study:

- To what extent does economic uncertainties impact on sustainable development in Edo State?
- To what extent are artificial intelligence systems being used in the training of mechanical technology students in technical colleges in Edo State?
- To what extent are artificial intelligence systems being used in mechanical technology industries for service delivery in Edo State?
- To what extent does the use artificial intelligence in mechanical technology leverage sustainable development under

prevailing economic uncertainties in Edo State?

1.4 Hypothesis

One null hypothesis was tested at 0.05 level of significance.

H_0: There is no significant difference between the mean responses of technical teachers and managers of mechanical technology industries on the extent to which artificial intelligence in mechanical technology leverage sustainable development under prevailing economic uncertainties in Edo State.

2. Methodology

The descriptive survey research design was used for this study. Descriptive survey is a research design that uses a representative sample of the population to describe the opinion, beliefs, attitude of the people about a particular phenomenon (Manjunatha, 2019). The result obtained from the sample could be used to generalise for the entire population. This design was found to be suitable for this study because a representative sample of technical teachers and managers of mechanical technology industries were used to generalise for the entire technical teachers and managers of mechanical technology industries in Edo State. Artificial intelligence in mechanical technology was the independent variable, while sustainable development was the independent variable.

The population of the study consisted 80 respondents. This was made up of 53 technical teachers from five public technical colleges and 27 managers of mechanical industries registered with Edo State Government. The data was obtained from Edo State Ministry of Business, Trade and Cooperatives and the Board of Technical and Vocational Education, Edo State. The entire population was used as the sample because it was of manageable size.

The instrument for data collection was a questionnaire titled Artificial Intelligence in Mechanical Technology Questionnaire (AIMTQ). The instrument was made up of two sections, A and B. Section A elicited respondents' bio-data such as occupation, while section B contained 20 item statements arranged in clusters according to the number of research questions. Items for each cluster contains four response category each. The response categories wereVery High Extent (VHE), High Extent (HE), Low Extent (LE) and Very Low Extent (VLE) rated 4, 3, 2 and 1 respectively. The instrument was validated by three experts in the department of Vocational and Technical Education, Faculty of Education, University of Benin, Benin City, Edo State, Nigeria.

In order to establish the reliability of the instrument, it was administered once to twenty respondents made up of 10 technical teachers and 10 managers of mechanical technology industries in Delta State. The data obtained was subjected to Cronbach alpha statistics and it yielded a coefficient of 0.85.

The questionnaire was thereafter administered to the respondents in the public technical colleges and mechanical technology industries in Edo State. The researcher was assisted by 9 research assistants who were briefed on how to administer the instrument. The research assistants administered the instrument to the respondents and retrieved same 100% in seven days.

The data collected were analysed with the aid of Statistical Package for Social Sciences (SPSS). The research questions were answered with Mean ($\bar{X}$) and Standard Deviations (SD) statistics while Z-test statistics was used to test the hypothesis at 0.05 level of significance. The decision rule was based on the criterion mean of 2.50. Therefore, any calculated mean value equal or greater than 2.50 was regarded as high extent, whereas mean value less than 2.50 was considered as low extent. For Z-test, a p-value equal or less than 0.05 alpha means that the hypothesis was rejected whereas p-value greater than 0.05 alpha means that the hypothesis was retained.

3. Presentation of Results

Research Question: To what extent does economic uncertainties impact on sustainable development in Edo State?

Table 1: Mean and Standard Deviation showing the Extent to which Economic Uncertainties Negatively Impact Sustainable Development in Edo State

S/N	Item	N	Mean($\bar{X}$)	SD	Remarks
1	Economic uncertainties make businesses fold up	80	2.83	0.961	High Extent
2	Economic uncertainties cause poverty and starvation	80	2.93	0.930	High Extent
3	Economic uncertainties results in social protection downturn	80	2.88	0.951	High Extent
4	Economic uncertainties lead to environmental degradation as citizens results to unwholesome economic activities for survival	80	2.89	0.940	High Extent
5	Economic uncertainties compromise the possibility of satisfying the economic, social and environmental needs of future generations	80	2.90	0.933	High Extent
	Cluster Mean		**2.87**	**0.100**	High Extent

Note: SD (Standard Deviation), N (Sample Size)

Table 1 showed the extent to which economic uncertainties impacts on sustainable development in Edo State. The respondents rated items one to five as High Extent, with a mean rating ranging from 2.83 to 2.93 while the standard deviation also ranges from .930 to .961. The cluster mean showed a mean of 2.87. With these results, the respondents agreed that economic uncertainties impacted negatively on sustainable development to a high extent in Edo State.

Research Question Two: To what extent are artificial intelligence systems being used in the training of mechanical technology students in technical colleges in Edo State?

Table 2: Mean and standard deviation showing the Extent to which Artificial Intelligence systems are being used in Mechanical Technology Training in Technical Colleges in Edo State

S/N	Item	N	Mean(X)	SD	Remarks
6	Use of virtual training simulators	80	1.78	826	Low Extent
7	Use On-Board Diagnosing machine	80	1.88	.891	Low Extent
8	Use of CNC milling machine	80	1.80	.863	Low Extent
9	Use of CNC lathe machine	80	1.80	818	Low Extent
10	Use of Condition-Based Maintenance system for predictive maintenance	80	1.79	837	Low Extent
	Cluster Mean		**1.81**	**0.03**	**Low Extent**

Note: SD (Standard Deviation), N (Sample Size)

Table 2 reveals the extent to which artificial intelligence systems are being used in mechanical technology training in technical colleges in Edo State. The respondents rated items six to ten as low extent with a mean rating ranging from 1.78 to 1.88 while the standard deviation ranges from .818 to .891. The cluster mean indicated a mean of 1.81. The results depicts that the extent to which artificial intelligence systems, such as virtual training simulators, on-board diagnosing machine, CNC milling machine, CNC lathe machine and condition-based maintenance systems are being used in mechanical technology training in technical colleges in Edo State was low.

Research Question Three: To what extent are artificial intelligence systems being used in mechanical technology industries for service delivery in Edo State?

Table 3: Mean and standard deviation showing the extent to which artificial intelligence systems are being used in Mechanical Technology Industries for Service Delivery in Edo State

S/N	Item	N	Mean(X)	SD	Remarks
11	Use of Quality Control systems such as on-board diagnostic systems	80	2.31	0.963	Low Extent
12	Use Computer Aided Design Systems, such as Autodesk Inventor	80	2.18	0.965	Low Extent
13	Use of Computer-Aided Manufacturing systems, such as CNC lathe machine, CNC laser cutting machine and CNC milling machine	80	2.33	0.991	Low Extent
14	Use predictive maintenance systems, such as condition-based maintenance machine.	80	2.30	1.060	Low Extent
	Cluster Mean		**2.28**	**0.050**	**Low Extent**

Note: SD (Standard Deviation), N (Sample Size)

Data in Table 3 revealed the extent to which artificial intelligence systems are being used in mechanical technology industries for service delivery in Edo State. The table showed that the respondents rated items eleven to fourteen as low extent with a mean rating ranging from 2.18 to 2.33 while the standard deviation also ranges from .963 to 1.060. The cluster mean showed a mean of 2.28. It means that the extent to which mechanical technology industries use artificial intelligence system in Edo State was low.

Research Question Four: To what extent does the use artificial intelligence in mechanical technology leverage sustainable development under prevailing economic uncertainties in Edo State?

Table 4: Mean and Standard Deviation Showing the Extent to which the use of Artificial Intelligence in Mechanical Technology Leverage Sustainable Development Under Prevailing Economic Uncertainties in Edo State

S/N	Item	N	Mean (X)	SD	Remarks
15	Increased productivity as large scale production is achieved within a short period of time	80	2.56	1.112	High Extent
16	Improved Design and production accuracy	80	2.63	1.129	High Extent
17	Reduced labour cost, as lesser hands is required to get the job done	80	2.69	1.001	High Extent
18	Reduced material wastage, as use of available material is maximized	80	2.74	0.928	High Extent
19	Time saving	80	2.65	1.137	High Extent
20	Supports environmental safety through optimization of combustion processes	80	2.80	0.916	High Extent
	Cluster Mean		**2.68**	**0.070**	**High Extent**

Note: SD (Standard Deviation), N (Sample Size)

Table 4 reveals that artificial intelligence in mechanical technology can leverage sustainable development under prevailing economic uncertainties in Edo State. The respondents rated items fifteen to twenty as high extent with a mean rating ranging from 2.56 to 2.80. The standard deviation ranges from 0.916 to 1.180. The cluster mean indicated a mean of 2.68. The above mean scores showed that the use of artificial intelligence in mechanical technology can leverage sustainable development in Edo State to a high extent under the prevailing economic uncertainties.

Hypotheses One: There is no significant difference between the mean responses of technical teachers and managers of mechanical technology industries on the extent to which artificial intelligence in mechanical technology leverage sustainable development under prevailing economic uncertainties in Edo State.

Table 5: Z-test analysis showing mean difference between the mean responses of technical teachers and managers of mechanical technology industries on the extent to which artificial intelligence in mechanical technology leverage sustainable development under prevailing economic uncertainties in Edo State.

Respondents	N	Mean($\bar{X}$)	SD	df	z-value	p-value	Decision
Technical Teachers	53	2.65	0.44				
				78	1.090	.055	H_o
Managers of Mechanical Technology Industries	27	2.68	0.30				Retained.

Value Significant at 0.05 level (Reject Hypothesis) SD: Standard Deviation. df: degree of freedom

The result in Table 5 reveals the mean score of the mean responses of technical teachers and managers of mechanical technology industries on the extent to which artificial intelligence in mechanical technology leverage sustainable development under prevailing economic uncertainties in Edo State. Technical teachers had a mean of 2.65 and managers of mechanical technology industries had a mean of 2.68 while their corresponding standard deviations were 0.44 and 0.30 respectively. With a z-value of 1.09, and testing at df of 78 and probability value of 0.05, the null hypothesis was accepted since the p-value was greater than alpha value. In other words, the null hypothesis which states that there is no significant difference between the mean responses of technical teachers and managers of mechanical technology industries on the extent to which artificial intelligence in mechanical technology leverage sustainable development under prevailing economic uncertainties in Edo State is retained.

4. Discussion of Findings

The finding of research question one showed that the extent to which economic uncertainties negatively impact on sustainable development is high. The finding is in line with that of Osuyi and Ogbebor (2024) who are of the view that economic uncertainties make living difficult and makes future economic environment difficult to predict, thereby negatively impacting on sustainable development.

The result of research question two showed that the extent to which artificial intelligence systems, such as virtual training simulators, on-board diagnosing machine, CNC milling machine, CNC lathe machine and condition-based maintenance systems are being used in mechanical technology training in technical colleges in Edo State was low. This finding is in line with the opinion of Xi (2021) which stated that modern vocational and technical education scholars know relatively little about artificial intelligence and that they still follow the traditional teaching model based on traditional experience and skills. Also, Sadiku et al (2021) had agreed that artificial intelligence is already providing a degree of flexibility and customization that was never before possible in education generally, and technical education, to which mechanical technology belongs, should not be left out.

The finding in research question three revealed that the extent to which artificial intelligence such as quality control systems, computer aided design systems, computer-aided manufacturing systems and predictive maintenance systems, are being used in mechanical technology industries for service delivery in Edo State was low. This finding supports that of Xi (2021) who said modern vocational technologies has hardly been involvedin the use of artificial intelligence.

The finding of research question four indicated that the extent to which artificial intelligence in mechanical technology can leverage sustainable development under economic uncertainties was high. The findings showed that artificial intelligence in mechanical technology can lead to increased productivity, improved design and production accuracy, reduced cost of production and material wastage, saves time and supports environmental safety through optimal and efficient combustion processes. The finding is in agreement with that of Sadiku et al (2021) who outlined the benefits of using artificial intelligence systems to include cost reduction, improved efficiency amongst others.

The finding of hypothesis one revealed that there is no significant difference between the mean responses of technical teachers and managers of mechanical technology industries on the extent to which artificial intelligence in mechanical technology leverage sustainable development under prevailing economic uncertainties in Edo State. The null hypothesis is, therefore, retained.

5. Conclusion

Based on the findings of the study, it was concluded that artificial intelligence in mechanical technology

can leverage sustainable development under economic uncertainties in Edo State since it has the capacity to enhance students training, improve design and production accuracy, reduce cost of production and material wastage, saves time, increase productivity and support environmental safety through optimal and efficient combustion processes.

6. Recommendations

Based on the findings, the following recommendations are made:

To achieve sustainable development under economic uncertainties, Government at all levels and school Administrators where technical education is being taught should incorporate artificial intelligence into their teaching and learning system to provide a good training foundation for students in this emerging technology.

Government at all levels and the Private Sector who are into production and service delivery in the field of mechanical technology should urgently incorporate artificial intelligence into their processes due to its enormous benefit on the economy and the environment.

Owing to the overwhelming leverage of artificial intelligence driven mechanical technology systems on sustainable development, especially under economic uncertainties, more citizens are encouraged to acquire artificial intelligence driven skill.

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