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An Electronic Learning Management System for Higher Education Institutions: Leveraging Visual Semantic Web Ontology

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ABSTRACT

While e-learning platforms are essential in modern education, they often struggle with effectively managing expanding content and providing relevant search results for learners. The aim of this work is to develop an electronic learning management system for higher education institution: leveraging visual semantic web ontology-based system. These limitations include the inability to efficiently manage the ever-growing volume of e-learning content, meet learners' specific search needs, represent knowledge in an accessible format, and facilitate the reuse of e-learning objects. The system provides a standardized interface for learners, educators, and institutional managers to submit and access educational resources. It features an ontology repository to maintain customization information and resource taxonomy, integrating knowledge from various ontologies for enhanced e-learning management. An intelligent search engine enables semantic searches and filters results based on user preferences. Implemented using PHP, MySQL, and JavaScript, the system leverages Object-Oriented Analysis and Design Methodology (OOADM) and Unified Modeling Language (UML) for design, ensuring modularity, maintainability, and reuse. Testing showed the system accurately returned desired search results 95% of the time. The results that were obtained provides efficient ways of managing the growing volume of e-learning content, delivering search results that align with the specific needs of learners, presenting knowledge in a format that is easy to understand and enabling the reuse of e-learning objects.

INTRODUCTION

A learning management system (LMS) is a software program or web-based technology that is used to organize, implement, and evaluate a specific learning process. The professor can use a learning management system to generate and distribute content, track student involvement, and evaluate student performance. Students may be able to employ interactive elements such as threaded conversations, video conferencing, and discussion forums with comprehensive distribution from professors to students using a learning management system (Ghoniem *et al*., 2010). Learning is a crucial support mechanism for improving learners' knowledge and abilities all over the world, and it is also beneficial to educational institutions. The conventional method of learning, in which students and professors must gather in a certain location (classroom) to study, is today considered inefficient. Learning processes have been updated as a result of the introduction of information technology into the educational system to match current educational needs.

The World Wide Web (WWWW) has brought with it a slew of technological tools designed to speed up the learning process. The goal of incorporating e-learning into the educational system is to replace the traditional learning process with a more efficient and on-demand learning process that is tailored to the user's needs. Computer-based training (CBT) was an attempt to automate education, eliminate the need for a paid instructor, and provide self-paced learning (Ljiljana *et al*., 2018). The current WWW is a powerful tool for research and education, but its effectiveness is limited by the user's inability to readily navigate to credible sources for the

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information he seeks. Learners frequently spend hours exploring the internet for specific information, making the e learning management system cumbersome.

Current e-learning systems are centered not just on the transmission of course information, but also on the learners' personalized and adaptive learning styles. Existing e-Learning systems face a number of challenges, including managing the massive e-Learning content that is constantly growing on the web, meeting the learner's requirements when searching for electronic learning content, representing knowledge in an easy-to-read format that allows it to think, and thus allowing re-use of e-Learning objects. The majority of search results include some documents that are irrelevant to the learner's needs. There is a need to streamline search results to the information that the learner is looking for, and this project focuses on constructing a visual semantic web ontology-based e learning management system to meet this problem. As a result, the focus of this study will be on developing an e-learning management system that incorporates sophisticated technological tools such as semantic web ontology in order to produce an effective e-learning system that overcomes the obstacles that now exist in e-learning platforms.

LITERATURE REVIEW

Conceptual Framework

E-Learning

E-Learning is a term that refers to any type of learning that incorporates technology. E-Learning is described as any activity that involves the transfer of information and the application of knowledge during the learning process, with a focus on computer-based technologies (Khan, 2015). E-learning framework can be defined as a clever method for delivering a learner-centric, collaborative, conveying, and simplified learning environment to anyone, anywhere, at any time, by combining the elements and assets of various digital advances with various types of learning resources suitable for an open, disseminated, and adaptable learning situation (Graf & List, 2015).

E-learning Components

Different types of e-learning components, such as E-learning content, E-tutoring, Collaborative learning, and Virtual classroom, can be combined in e-learning methodologies. Simple learning tools, interactive e-lessons, electronic simulations, and job assistance are all examples of e-learning content. Documents, PowerPoint presentations, movies, and audio files are examples of non-interactive learning resources. These materials are non-interactive in the sense that learners can only read or watch content and can't do anything else with them. Even though they do not provide any interactivity, these resources can be swiftly generated and, provided they match established learning objectives and are planned in a structured manner, they can be a great learning resource (Chirag *et al*., 2017).

Interactive e-lessons are a type of Web-based training that consists of a series of interactive e-lessons. They are the most frequent way for self-paced e-learning. An e-lesson is a series of screens including text, images, animations, music, video, and interactive elements such as questions and feedback. Recommended reading and links to online resources, as well as extra information on certain themes, can be included in e-lessons.

System for Managing Learning

A learning management system (LMS) is software that allows you to manage and facilitate a variety of learning and training events and facilities (Rodriques *et al*., 2020). Learning management systems can help improve the speed and efficiency of instructional procedures, as well as interaction among students and between teachers and students, in traditional instructional systems (Som, 2013). The goal of a learning management system (LMS) is to simplify the administration of learning/training curricula within an organization.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

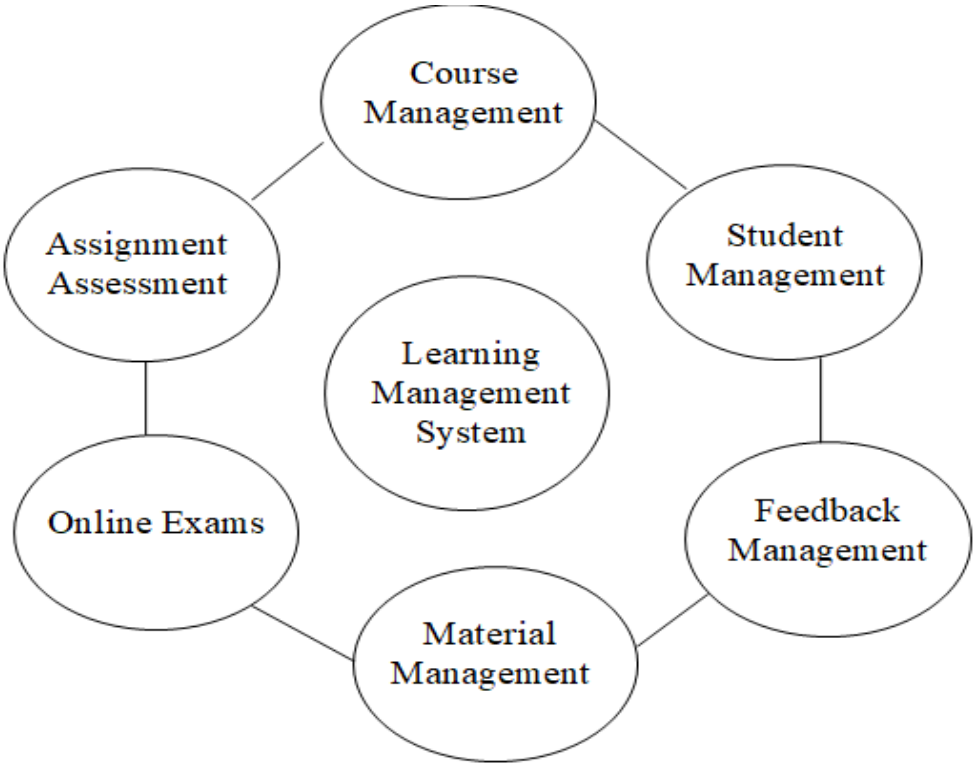

Fig. 1: LMS Management System Components (Chirag *et al.*, 2019).

Course management systems (CMS), learning content management systems (LCMS), virtual learning environments (VLE), virtual learning system (VLS), learning portals, and e-learning platforms are all examples of learning management systems. Depending on your perception, each phrase may have a somewhat different meaning (Wright *et al.*, 2014.). A modern LMS, according to Vishwanath (2019), is specifically designed to be integrated and built in multiple add-ons applications that enable the development, delivery, evaluation, and administration of courses in traditional face-to-face, blended, or online learning contexts. According to Pappas (2014), the decision of how firms adopt Learning Management Systems it really depends on their objectives, online training methodologies, and a strong wish of the outcomes. The most common use of the LMS tool is to put into action the management of online training activities and make it simple by allowing instructors and learners remote access (Pappas, 2014).

Content Management System

A content management system (CMS) is software that allows users to manage different types of content in learning management systems. A useful content management system must enable users to manage content quickly and easily. The first step is to define the material's complicity, whether it will be described in video lessons or through the use of large and complex media pages of text. Because most CMSs can host a wide range of complex materials and media. It's important to understand this because it reduces the amount of coding required to make your system look the way the organization wants it to. The second step is to determine the sensitivity and secrecy of natural material. This provides a comprehensive picture of how security standards should be implemented in terms of controlling content access based on the user's role. Third, is to analyse whether material need to comply with Shareable Content Object Reference Model (SCORM) or API, since some of content management systems are SCORM and Application Programming Interface (API) friendly, this option will help to have a good idea of selecting LMS, which has built in to support with these models. The case firm will undoubtedly identify CMS features that are required for implementing the best learning management system after going over the three options. When content management features are well chosen, the options will provide a clear picture of the implementation roadmap in terms of the best method of delivering created content, as well as whether or not additional communication tools are required.

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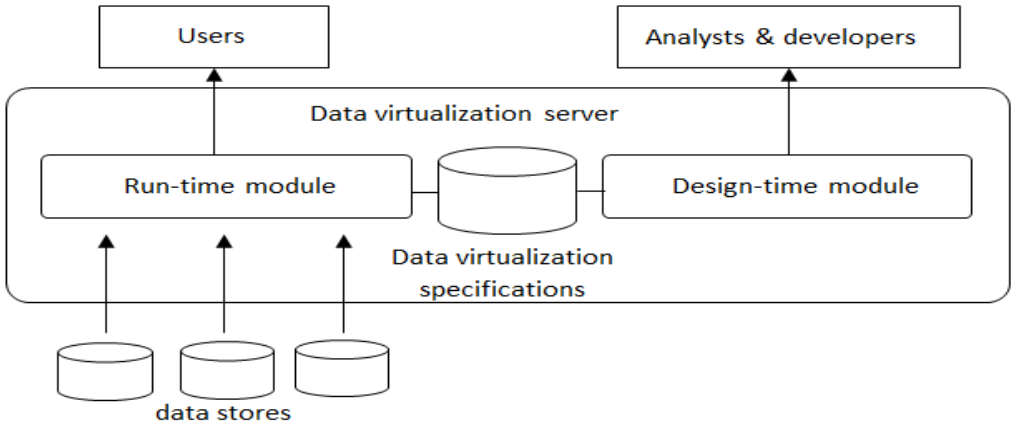

Fig. 2: A Data Virtualization Server

Virtualization

Virtualization aids in the resolution of data-intensive issues. The virtualization process is defined as the transformation of an abstract data set into a virtual space through three major intertwined steps: data selection for representing the problem space, assumptions definition for defining the final virtual space, and metaphor mapping between the starting and final spaces (Magali and Michel, 2015). Virtualization is useful in the administration of dispersed data when dealing with data-intensive challenges like; Data and information must be preserved in its original form. Physical reality is unaffected by the virtual process. Its ostensible evolution; that is, data and knowledge generation can continue in their current state without needing to alter. Portability- The virtualization approach allows software to run on any microprocessor architecture without having to rewrite it, instead compiling it using ad-hoc compilation. Virtualization can be mathematically represented explicitly by two sets, E and V, which correspond to physical and virtual reality, respectively, and the two functions ME and MV. V E, ME: E V, MV: V E.

Ontology

An ontology is a set of rules for naming and defining the attributes, types, and interrelationships of entities in a given domain (Zhihong, 2013). Common Algebraic Specification Language (CASL), Constructing Ontology-Grounded Methods and Applications (DOGMA), Rule Interchange Format (RIF), and Web Ontology Language are some of the languages available for developing ontologies (OWL). The Web Ontology Language (WOL) was created for applications that need to handle information content rather than only display it to consumers.

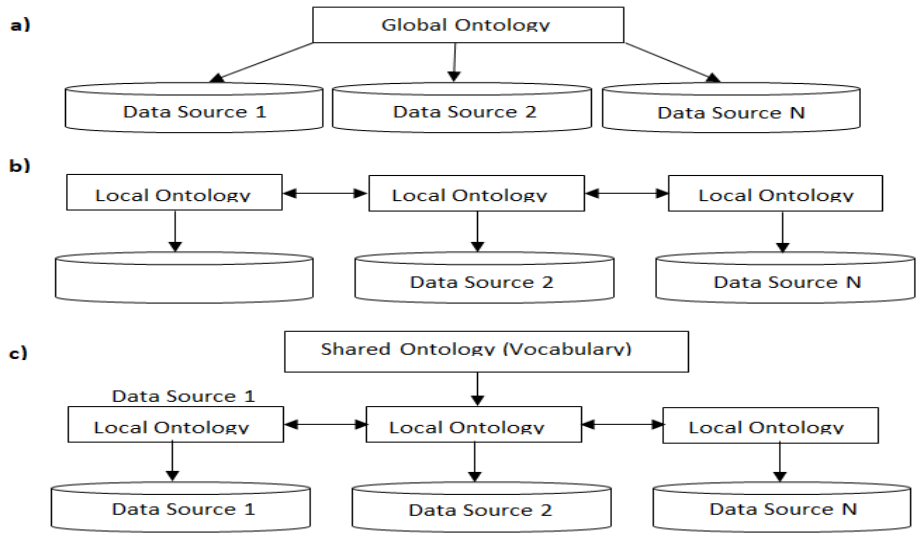

Fig. 3 Clarification of the Philosophical Term Ontology

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As seen in figure 3, an intriguing clarification of the philosophical term ontology synthesized numerous frequent definitions of ontology.

Data integration based on ontologies is a good way to deal with heterogeneous data. The objective behind this technique is to decouple information semantics from data sources. Furthermore, ontologies are superior at supporting changing domains. As a result, data source aspects such as data, schema, schema elements and content, values, entities and attributes, and query result classes must all be examined. It is well recognized that an ontology-based search system returns more relevant query results to the user than a traditional search engine that queries data using syntactic parameters. Data retrieval methods are used to generate the query result. Ontology integration is similar to ontology merging, except that with ontology integration, the integrated ontology is built by reusing existing elements of source ontologies. Both have a critical role to play in the consistency checking process, which must guarantee that there are no unexpected or incorrect consequences in the integrated ontology.

METHODOLOGY AND SYSTEM ANALYSIS

Object-Oriented Analysis and Design Methodology (OOADM) is a technical approach for evaluating and designing an application, system, or business utilizing object-oriented programming and visual modeling to guide stakeholder communication and product quality throughout the software development process. Object-oriented analysis and design approach is often used in current software engineering in an iterative and progressive manner. Analysis models (for OOA) and design models (for OOD) are the outcomes of OOAD operations. The goal is for these to be modified and changed over time, based on critical considerations such as risk and business value. Because of the nature of this system, which combines navigation with the inherent difficulties of dealing with multimedia data, an OOADM approach is required. Because the user interface of Web apps is more complex than that of traditional software systems, navigation and functionality must be seamlessly integrated, and the navigational structure must be decoupled from the app's domain model, OOADM was chosen for its functionalities, which include the ability to use object-oriented abstractions for the analysis and design of information-intensive web applications. Aside from modeling abstractions, it also includes a methodology that helps a developer through various web application development processes.

The existing e-learning system is web-based and may be accessed at any time and from any location. Self-paced and facilitated/instructor-led are the two primary methods to this e-learning system. Learners are alone and entirely independent in a self-paced system, but facilitated and instructor-led e-learning courses give varying levels of support from tutors and instructors, as well as collaboration among students. Learners are supplied e-learning courseware, often known as Web-based training, which can be supplemented with extra resources and tests, under the current system. Courseware is often stored on a Web server, and students can access it through an online learning platform or via a CD-ROM. Learners have the freedom to set their own pace and create personalized learning paths based on their unique needs and interests.

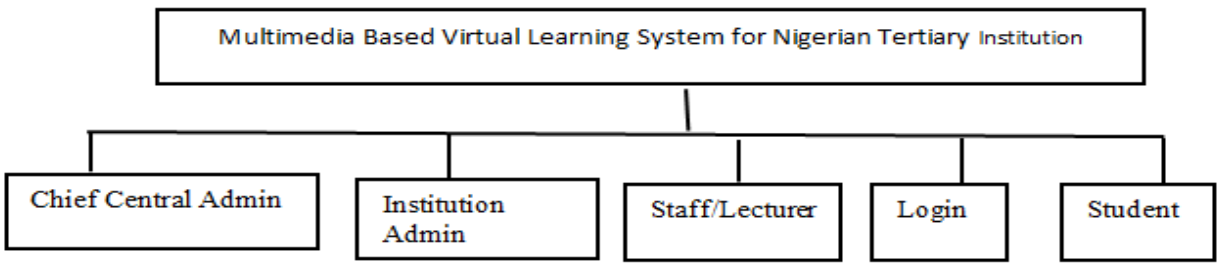

Fig. 4. Control Centre /Main Menu (Source: Field Study)

Proposed System

This work proposed a semantic web-ontology e-learning platform to improve e-learning after observing the shortcomings of the current system. The proposed system is intended to combine the advantages of ontology-based data integration techniques in terms of seamless transition, solving semantic inconsistencies, and

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syntactic accuracy issues, with those of virtual data integration techniques in terms of hiding technical jargon from users and unifying integrated and reconciling views of data residing at various sources and locations for users. These would be deployed in an e-learning environment, therefore improving on current models. The system's goal is to make the web more machine-understandable. It entails creating the necessary infrastructure for intelligent agents to roam the Web and execute complex tasks for their consumers. This Semantic Web will disclose the knowledge embedded in many web-based applications, intelligently integrating information, offering semantic-based Internet access, and extracting information from texts. The Semantic Web attempts to reform the existing web by introducing a layer that enables enhanced automatic analysis of web content, allowing data to be shared and analyzed by people and machines alike. To put it another way, it helps computers interpret online material so they can provide relevant information to users, make inferences and computations from the data, and combine data in innovative ways to support knowledge-based tasks like publishing, planning, navigation, cultural exchange, and research.

RESULT AND DISCUSSION

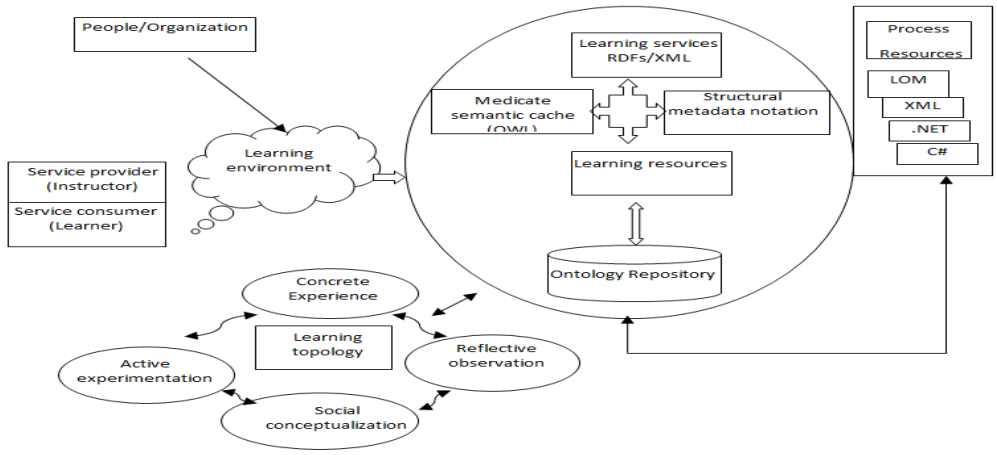

Fig. 5 Web-based data transfer system

The learner or teacher system is used in the e-learning management system, which is built as a web-based data transfer system. When attempting to access a learning system, a learner must fulfill many functions. First, a student must log in if he is already a member of the system; otherwise, he must register in order to fill out the necessary information so that he may access the system again. A student must choose a course to study. Take the quiz and obtain a grade; the grade determines whether you should continue with the course or if you should take a prerequisite course. If the student wants to leave the system, he or she must log out. The instructor side of the system uploads information such as new course additions, course outline, quizzes, and assessments. The administrator maintains the student record in his database and has the ability to modify the information if necessary.

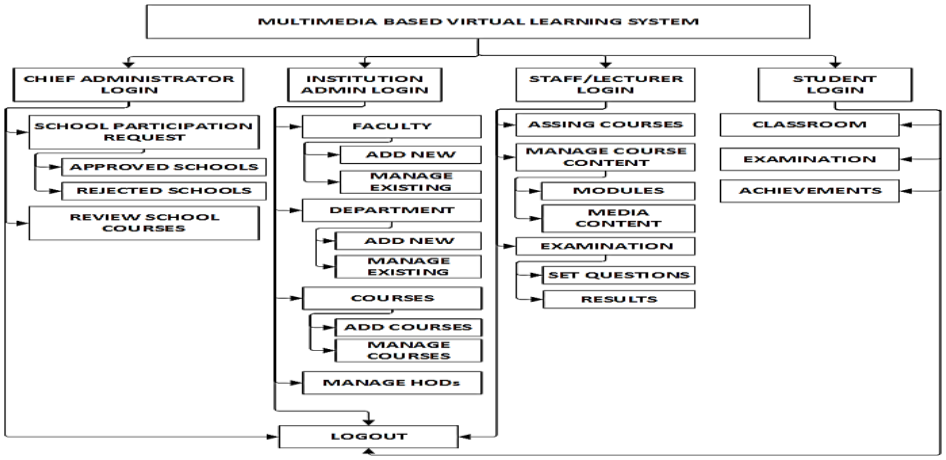

Fig. 6 Program Modules of a multimedia based virtual learning system for Nigerian tertiary institutions

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

The multimedia based virtual learning system for tertiary institutions in Nigeria is web-based and thus can be accessed by many users from different locations. The system has the following built-in modules as shown in fig. 6. This module provides a platform for the central administration of the system for the controlling body (for example Federal Ministry of Education) to oversee and, manage and control all the activities on the system for the institutions. Some of these activities include: Ensuring that every institution using the system is officially registered, generating registration token for every tertiary institution before they are registered on the system and reviewing all the multimedia-based materials uploaded by every institution for every course in order to ensure that standards are maintained.

CONCLUSION

Based on the findings, the Semantic Web has a significant impact on information technology and several study areas such as Knowledge Engineering/Management, Software Agents, and Web Services. One of the most essential goals of the Semantic Web is to transfer over most of the information that is now being done on the web to software agents. Despite the fact that the Semantic Web has reached several milestones, it still confronts numerous hurdles in translating its vision into reality. The OOADM research approach was employed in this thesis to determine the system's particular requirements for e-Learning. For the case studies, all phases are discussed, including background, associated work, methods, data collecting, data analysis, and design of the suggested system, in order to establish an effective e-learning platform. The application's outcome demonstrates that a semantic web ontology-based system can deliver an effective e-Learning framework with relevant web search results. Following the collection of requirements, the research team suggested an Ontology-Based Model for ELearning Management System, with the primary goal of efficiency and high performance. PHP-MySQL and Java Script were used to create the proposed system. The experiment's subjects are drawn from secondary school disciplines. The results of the test reveal 95 percent accuracy in web search result filtering and a 20 percent improvement over existing systems' performance.

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ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

Authors' Profiles

Victoria N. Emmanuel was born in Port Harcourt, Rivers State. She received a Bachelor of Science degree in Computer Science from Imo State University, Owerri, Imo State, Nigeria, in 2012. She earned a Master of Science degree in Software Engineering in 2017, and a Doctor of Philosophy Degree in Artificial Intelligence in 2022, from the same institution.

She began her career in 2014 as a SENIOR RESEARCH ANALYST at Empire Research Institute and later worked with Topcom Integrated Service Limited as a DATA ANALYST. She currently holds a Senior Staff position as a Lecturer in the Department of Computer Science, University of Agriculture and Environmental Sciences, Umuagwo, Imo State, Nigeria. She is the author of *Python Programming for Beginners* (Owerri, Imo State: Eagleprint, 2025), Fingerprint Biometrics-Enabled Database: A Collaborative Crime Information System, *Journal of Software Engineering and Simulation*, (Volume 8 ~ Issue 1 (2022) pp: 20-24) and Emmanuel, Victoria Nkemjika; Enyinnaya, Chibunna Victor; Ezeoha, Bright Uzoma; and Ogbonna, Tochukwu Loveday (2024) – *Developing and Analyzing Deep Learning and Natural Language Processing Systems in the Context of Medical Information Processing*. *International Journal of Research and Innovation in Applied Science (IJRIAS)*, Volume IX, Issue VIII. ISSN: 2454-6194. DOI: 10.51584/IJRIAS. Her current and previous research interests include cybersecurity, data analysis, security, computer vision, software engineering, information technology, and medical and explainable artificial intelligence.

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ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

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