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Automated Classroom Resource Note Ontology Generation Using Semantic Knowledge Graph

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ABSTRACT

An artificial intelligence solution for automation of classroom note ontology generation using semantic knowledge graph was proposed. This research serves as a ground work solution to challenges faced in schools as a result of inadequate and poor note formation in Nigeria school context. The solution leverages on semantic web while emphasizing on web scrapping concept, output from the former leading to enhancement by Apache Stanbol which generates ontologies adoptable and viewable by Neo4j database tool. The application extended the Online Education System (OES) learning management system while using Jboss application server and this leads to improvement of OES learning management system with Artificial Intelligence learning platform.

In implementing this work, Java Programming Language Enterprise Edition (J2EE) was used with MySQL database with Apache Stanbol Restful API. Neosemantics API was also used in Neo4j Graph Database for displace of semantic knowledge graph generated. Finally, based on the topic area resource location, a Resource Development File (RDF) or Turtle file was generated by the system and this resulted in ontologies in a file.

Keywords: Learning Management System, Java Persistence Architecture, Natural Language Processing, Semantic Knowledge Graph, Adaptive Hypermedia.

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Introduction

Improvements in education sector will not only lead to poverty eradication in the African continent, it will also propel skill growth in children utilizing the platform. It allows for equal access to computer science education, a potential way to reach more people with equable learning for an efficient technology-enhanced approach to learning and teaching (Barnes et al, 2016). In education, note formation is an essential daily routine work of any educational practitioner and of recent, this process has led to poor quality of education in African continent, most especially in Nigeria as a result of poor resource understanding and formation of content given to students for learning or notes to be formed, teachers are required to search online resource sites to extract requisite contents. Today, in Nigeria, the process of classroom resources formation still requires teachers to consciously search for content that can be put together and then reformatted for student. The necessity for automating this process cannot be over emphasized. Achieving this classroom lesson note ontology formation will help the unskilled teachers in generating classroom notes and it will aid in consumption of resources on the internet via web technology with less teacher's physical involvement during interaction while using Learning Management System (LMS). It will also lead to introduction artificial intelligence driven module for learning management system in education.

Indeed, a lot of LMS have been made and also added to knowledge but none has integrated a semantic approach which can allow a both human and machine interpretable notes for students to consume with the click of button. In this paper, we propose a novel system that can help in initiating automation of generation of classroom note ontology resources using a semantic web knowledge graph concept. This will lead to automated notes generation for different academic topics. In addressing the observed problems, this research paper is aimed at developing application module that will help to generate lecture or teaching note resource ontology automatically so that when the student is in both unguided and guided mode of LMS, note content can be generated produced. In order to achieve this, a model was constructed to create an automated note ontology. This involves the use of World Wide Web (www), an Apache Stanbol restful API, OES LMS application, semantic web technologies and Java 2 Enterprise Edition (J2EE) architectural design in the implementation of the model design. After the implementation of this research work, ontology file generated was passed into a Neo4j database.

This paper is arranged in the following order. The section 2 contains related works reviewed. The challenge for the research was reviewed in and a model was designed in section 3. In section 4, the implementation of the paper work was done and section 5 states the conclusion.

Related Works

In this section, existing literature work will be reviewed on learning management system, semantic web technology, necessary tools need to implement the paper work. A lot of organizations have done an extensive work in the creation of LMS that is not only admin centric but also students and teachers centric. According to Katsanos et al (2008), it was mentioned that the rearrangement of web content was the focus of the work due to the challenge faced while navigating through the web searches or even the difficulty in forming a cognitive model of the information structure in most LMS. For any work to be automated, the adoption of the semantic web will aid in the automation. AutoCardSorter designer and its functionality were used. AutoCardSorter is a computational tool that is used in the clustering of the web page. The software uses Latent Semantic Analysis and hierarchical clustering algorithms to provide optimal navigation information schemes in an automated manner. The studied discussion focuses on measuring the system semantic similarity measurement that helps to improve the navigation search arrangement.

Considering the Adaptive Hypermedia (AH) and Intelligent Tutoring System (ITSs) of LMS, Goran, Dragan & Vladan (2004), enlisted that there are two groups of adaptive education system most frequently used on the web. The former focuses on the non-linear and adaptable structure of the educational materials which deals with the presentation adaptation techniques and the later provides the user (student) oriented design with the pedagogical knowledge implemented in the system. The AH and ITS are limited in usage because of their cost implication and adoption of AI on them. There is no adoption of semantic web layout on it. In this paper, it was a further emphasis that there is a need to move learning tools to point of reusability. Learning Management System (LMS) empowers the teachers to interact with the students via learning units which are also called learning objects. This means that learning objects (LO) can be reused in further courses in other educational domains so that reliable, machine-interpretable application components can be used to process LO data on both syntactic and semantic levels.

Semantic web agents according to Fakoya, Adewale and Oladoja (2015) discussed extensively on an ontology-based solution for an e-learning management system. He placed an e-learning management solution into 3 different layers namely the management, service integration and management. The solution is used to model out full e-

learning management with limitation of capturing the specifics of each area. An e-learning survey was produced with the help of semantic web agents' intents. This report used the combined qualitative and quantitative research methodology, but note generation was not focused on.

Referring to channels to relate with, Fensel and Musen (2001) discussed the semantic web as a channel will move both the classroom independence and platforms independence of web-based education while investing in authoring tools for its development. It was further stated that there is a need to be to have a good ontology generated in this area. It was also stated that the adoption of pedagogical agents will help very much in learning. Movva et al (2007) also stated that the importance of open and hidden web search engines. It addresses the lack of semantic understanding found on most search engines. It proposes Noesis -type of Ontology, relates search engines as a meta-search document engine. It further states the importance of ontology which arises from domain ontology and application ontology.

In web-based e-learning approach, a model was constructed but generalized and characterized using a metadata ontology concept for description of student resources on the model. It focuses on the development of a semantic web-based e-learning model, which shows on the RDF data model and OWL ontology language. This is the creation of an e-learning service that can interoperate with machine-understandable and intelligent agents can understand it. A way to enable machine-understandable application with education pedagogical model.

According to Allard and Ferre, (2008), Ontology Web Language (OWL) was discussed as medium to expressed Ontology and it was stated that in a way to identify ontology relating to applications as well as specific domain ontologies. It is also stated that descriptive logic formalism helps in the reasoning and representation of ontologies. These descriptive logics can either be in two part namely a descriptive metadata which helps in foundation for quality information governance in application development and secondary the administrative metadata which deals with the file type and file size.

Asgari-Bidhendi, Hadian, and Minaei-Bidgoli (2019) discussed that the paper focuses on the construction of knowledge graphs and in particular, a Persian knowledge graph (PKG). It was also specified that the knowledge graph is more superior and more complex than a knowledge base and the foundation of KG is the ontology creation via the use of RDF. It also highlights different ways to get a knowledge source, knowledge extraction and its construction using rule-based RTE. The PKG is focused on Persian and the PKG is limited with the sparse content issue.

Grainger, AlJadda, Korayem, and Smith (2017) stated the new form of semantic knowledge graph which is more dynamic and automatic leverages on an inverted index and uninverted index while presenting nodes and edges. The proposed work used inverted indexing – doc term indexing and term doc indexing. Semantic relationships between all entities in a given corpus document can be detected, represented, and dynamically traversed using a lossy graph. This proposed work also helps to materialize edges during the traversal of the graph which is dynamically formed. This enables dynamically discovering and scoring interesting relationships between nodes in any given context based on the similarity of nodes. The solution was implemented and results were obtained.

Cebirilc et al (2018) stated that the RDF model that leads the ontology formation of the semantic web, is a directed graph which is the fundamental graph type. Graph homomorphism and graph isomorphism frequently appears in graph summary proposals through the use of SPARQL. The project was a survey and it assisted in the implementation of a Directed Graph (DG) called otherwise RDF in modeling or describing ontology. The result was in the production of queries needed for the recommendation system, report finding while limiting the graph to a domain area.

Haase et al (2018) highlighted how open-standard platform architecture design facilitates its reusability in different application domains and frameworks as well as enabling the convergence of the information network with other parts of the organizational data and software infrastructure. The aim is to support interaction with knowledge graphs and its utilization with organization structure by adopting metahistory software as a way to create reusability. The paper was a review/survey in nature. The application platforms need an update in an area such as intelligent data authoring and Integration with machine learning technologies. Adopting metaphactory software will aid in knowledge graph reusability. This position gives us useful tips about maintaining and leveraging knowledge graphs within corporate organisations, as well as the problems that a general knowledge graph management framework has to face.

Bartalesi, Meghini, and Metilli (2018) adopted the Semantic Web technologies in implementing a particular work of Dante Alighieri's primary sources, the Resource Description Framework Schema (RDF/S) vocabulary helps in reformation of the work to a knowledge-based system, which provides the terms to represent the

knowledge in a machine-readable form. This forms the domain ontology which focuses on humanities. An additional web structure was on top of the ontology. Implementation of the web application Dante resources contains a lot of information that was scattered in books and other areas. Developing of knowledge graph has helped to converge the information from one source. The outcome is, the information stored in our knowledge base may be incomplete and can provide an incoherent representation of Dante's works because some information is addressed using non-semantic web methodology.

Kertkeidkachorn and Ichise (2017) worked on the device Text 2 Information Graph (T2KG), an end-to-end framework. A hybrid combination with a rule-based approach was used in the method, and a similarity-based approach is used to map a predicate to its equivalent predicate within a KG. This paper deals with an Information Graph. A knowledge graph (KG) is a graphically organized knowledge base that stores information in relationship type. The paper helps to implement the bridging of gaps limitation of mapping and searching predicate found in triple (S, P, O) of an unstructured text to the identical predicate in the knowledge graph. It reduced heterogeneity and improve searching capability. This involves knowledge extraction, entity mapping, and data integration. vector-based similarity metric for computing the similarity between the elements of triples to overcome the sparsity problem. The implementation was a rule-based approach and a similarity-based approach for mapping a predicate of a triple extracted from unstructured text to its identical predicate in an existing KG and initial sparsity challenges was faced and poor searching was observed. T2KG is designed to take unstructured text as input and produce a KG as output.

Oren et al (2006) work helps in the differentiation of object-oriented programing language and the implementation of RDF -a bit into the software engineering concept model. This relates with an object-oriented API for creating RDF data that provides complete manipulation and querying of RDF data, does not depend on a schema, and is completely compatible with RDF(S) semantics. This RDF data is a triple type statement consisting of a subject, a predicate, and an object and stating that a subject has a property with a certain value. This paper helps to present the architecture and implementation of such an object-oriented RDF API. It should also be noted that RDF Schema is open-world and description logic-based while object-oriented type systems are closed-world and constraint-based. This helps in variations of challenges that can be resolved by the two technologies. The paper was implemented and presentation architecture was done in Ruby library ActiveRDF, which provides a virtual API for managing RDF data in an object-oriented manner. It was observed that techniques used in object-relational mapping approaches are not sufficient as compared to RDF – semantic outlook. Java programming application was used as a case study. A system was designed for a meta-programming that can help to bridge the difference between RDF and object-oriented programming language. ActiveRDF was built in an object-oriented scripting language to assist the rapid growth of the object-oriented programming language on the semantic web.

Hodrob and Jarrar (2010) helped to address how the Ontology concept, how it can be built and how it can also be simplify using good knowledge informal logic. It addresses creation of an ontology using a graphical notation method that is simpler than other techniques available, even for non-IT specialists such as Object-Role Modeling (ORM). It specifies ORM as being a conceptual modeling tool using in engineering ontology. ORM is more descriptive than modeling of Entity-Relationship (ER) and Unified Mapping Language (UML). ORM and OWL 2 DL are mapped throughout this study. The two advantages - ORM and OWL 2 - have been abused. The work permits us to build an ontology in natural language. ORM is a fact-oriented technique of modeling, independent of implementation-oriented procedures, while OWL is a language of representation of information. The OWL is used to implement the semantic web. Implementation ORM is limited in notation expressivity. This includes an exclusion of classes, data types, transitive closure, intersection and union between relations which are in OWL 2. The output allows the developer to adequately implement variability and expressivity of semantic web modeling natural language in object-oriented ORM. The mapping and automation of this mapping from ORM into OWL 2 was achieved.

Upadhyay and Fujii (2016) showed how knowledge extraction can be realized from a pdf document using the concept of a triple. It makes use of semantic technology i.e. RDF formation as well as the Natural Language Processing (NLP) for sentence correction. In this concept, the user can introduce new rules in search of a new rule to extract new knowledge. This is experimental with an IoT research paper. Text mining tools in this context can analyze large or small quantities of natural language text and detect lexical and linguistic usage patterns gap was filled. The processed data is always stored in a form of triples, the resulted dataset is always fully machine-readable in every stage of cyclic extraction and cleaning of data.

Fernandez-Villamor et al (2010) built mining of unstructured architecture on web scraping retrieval of RDF graphs representing content in HTML documents. Semantic scraping framework was discussed at length and this model enables screen scraping services by linking RDF graph data to content specified in HTML documents implementation of the limited amount of the available resources on the Internet. Ontologies and semantic websites are not widespread and this accounts for its limitation. An RDF resource was generated from the HTML document.

Khamparia and Pandey (2017) describes semantics that is built primarily to reflect facts, models, principles, functions, persons and their relationships, the majority of semantic-designed logic has an underlying unifying meaning. This is a survey into semantic reasoners. It was noted that the inference steps adopted are shown utilizing descriptive language. first-order logic is implemented in many reasoners conduct reasoning, and proceed by inferences among them through ontology reasoner strategies i.e. forward and backward chaining. It depends on the forwarding chaining strategy; reasoner begins with known data, and draws true inferences.

Mccarthy (2017) also noted that the connected data network, commonly called as the semantic web, is a framework where information is organized and connected to provide meaningful content to Artificial Intelligence (AI) algorithms. He argued that the semantic web generates and presents growing levels of uncertainty and confusion in the process of capturing and depiction.

In clarifying the importance of semantic web architecture, Vogt et al (2018) (Vogt L., Baum R., Grobe P., & Köhler C., 2018; Vogt L., Baum R., Grobe P., & Köhler C., 2018) stated that Resource Description Format (RDF) is used to represent information modeled as a "graph." It is a collection of collective objects, as well as a set of links between those objects. The RDF script is also one of the foundational strength of the linked Data resource on the web otherwise, it could be called the Semantic Web.

He further illustrated that RDF -XML is used to serialize information represented using graphs. The above diagram illustrated a table of users with their age. The RDF graphs can be read and written by using the Jena software. Jena software is an API that is used with web Ontology. It helps in the querying of semantic web architecture. It works with SPARQL query language. The above diagram is further explained below.

Considering the Mass Communication sector – which has a close relationship with education, the introduction of AI agents is continually being used in the semantic analysis to automatically extract key information that is made available to the journalists to write their stories (Wayne, Maya & Charles, 2019).

The Problem Description and Proposed model Adopted

In this section, while focusing on this research at hand, for learning cognitive domain to be impacted positively, all classroom engagements must meet set goals and objectives. These depends on three different areas namely the guidelines, teaching activities and materials in Figure 1. The teaching activities and resources are very important part of teaching and when one of these is missing, it because an issue in education for the set goals to be achieved for proper interaction to be effective. For goals achievement to happen, learners must get the right resource notes to consolidate their experiences from each classroom session. Semantic content integration to LMS required automation of this note generation ontology process i.e the resources, and in order to avoid the education sector challenges from been hindered. Semantic web in this paper focuses on topic domain ontology model design.

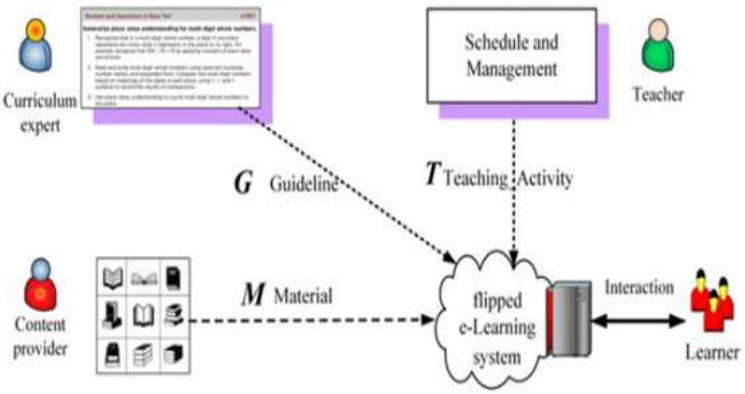

Figure 1: LMS Guideline, Teaching Activity and Materials (GTM) triangle (Chi et al, 2017)

These will enable introduction of smart search capabilities requirement of semantic web technology (Movva et al, 2007). Additionally, school owners request for Learning Management System (LMS) that are equipped with curriculum list for teaching and an up-to-date resource note backing each topic item up to enhance teacher's performance in classrooms i.e. the LMS must be able to create resource note on every topic being taught, needs proper system with adequate model. In Figure 2, the model empowers the creation of automated note ontology. This model is comprised of 3 major technology model structure and it relies on OES learning management system application.

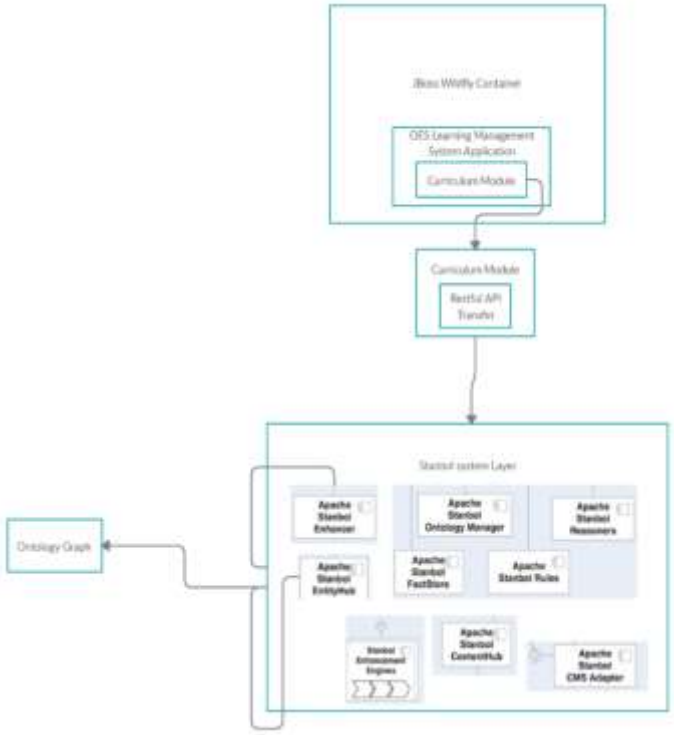

Figure 2: Full Architecture of the Proposed Automated Classroom Resource Note Ontology Generation Using Semantic Knowledge Graph

The upper layer contains Jboss Application Server. This is where OES LMS is deployed. This is where the information to be worked on is being accumulated. The middle layer contains the connector joining the lower layer. This is where JSOUP API is found. The lower layer contains the Apache Stanbol API

The upper layer of the model has Online Education System (OES) learning management system application model in the Jboss. The technology adopted is a Java 2 Enterprise Edition (J2EE) development architecture model. The J2EE uses a Strut framework, thus adopting a Modal-View-Controller (MVC) approach development pattern approach. This helps in separating the modal (Database), View (User Interface), and Controller (Business logic) of the application in a loosely coupled approach. This is shown in Figure 3.

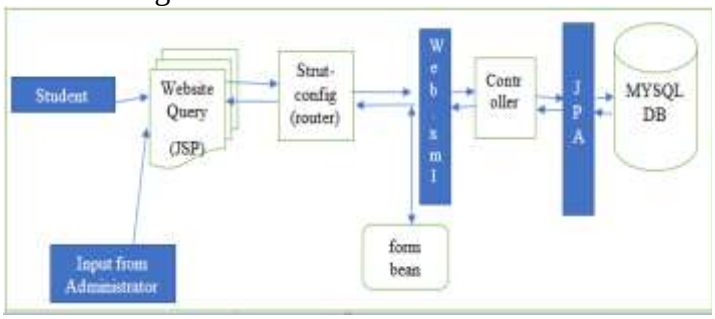

Figure 3: OES Web Design Model Architecture (Hremsoft, 2020)

OES LMS make use of strut MVC J2EE architecture to design its learning management system engine. This connects to the database via Java Persistence Architecture (JPA) architecture.

Implementation

For these steps to be implemented, a descriptive logic metadata was entered into OES learning management system. This was used in implementing the table adopted for curriculum. Nigeria education system was used in designing that taxonomy of the different sector of education and these includes subject domain taxonomy. These are the subjects' classification of education system based on three levels such as university, secondary and primary. The focus of this work is on primary sector (basic school). This taxonomy classification was store in a database by making use of this model in Table 1.

Properties	datatype	
Id	int	Primary key
url	string	
Topic	String	
Subject	String	
Class	String	
age_group	int	
Grade_type	String	
Classroom_lecture	int	Foreign key

Table 1: The Scheme of work data structure.

In Table 1, classroom lecture property is the foreign key to classroom table. To implement the work at hand the flow diagram in Figure 4 was considered.

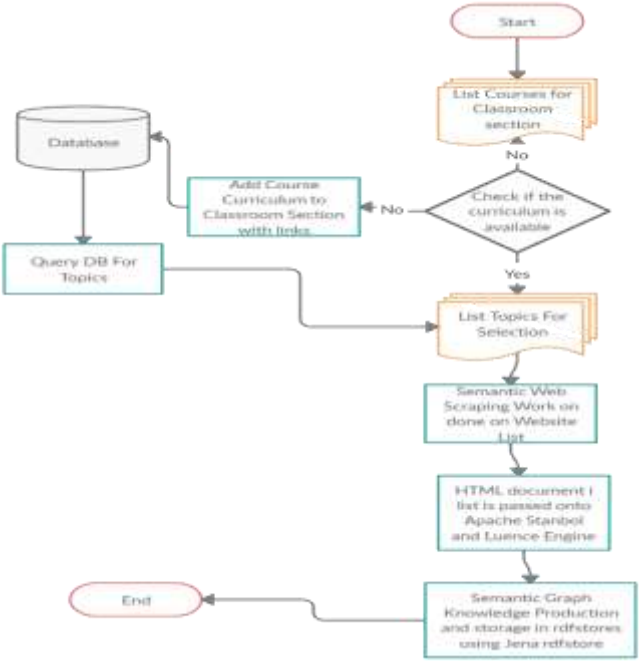

Figure 4: Flow Diagram used in Implementation of the Generated Semantic Graph Diagram.

Proposed tools and Software Development Requirement used

Java Development Toolkit, Netbeans 8.0, MySQL, Java 2 Enterprise Edition (J2EE), EJB 3.0 using JPA Architecture, JSP / Strut Architecture, Apache 7.0 Application Server,

JBoss / WildFly Server, Apache Stanbol, Protégé in Modeling Ontology, Jena/Hermit Reasoner , CoreNLP, Jsoup, JenaTDB, Solr, Maven. In achieving the total implementation of the automated classroom resource note ontology generation, Jsoup API with Apache Stanbol tools was adopted to facilitates creation of semantic web result. This result was further showcased through the use of Neo4j Graph database API called neosemantics 10s tool.

This application connects to database via a Java Naming Data source Interface (JNDI) connection in the application servlets as a controller negotiating through JPA (modal) to the database. The implementation shows the link with the OES LMS application and the automated classroom module for the classroom resource generation which resulted in semantic knowledge graph. The servlet handled the request and response which also inherit a Jsoup API thus aiding the research with web resource extraction.

In the implementation, an MVC approach model was adopted with the query to the database using the MVC pattern concept. The second part of the implementation deals with the classroom and this is further searched via the HttpConnection using the JSOUP API in the servlet. The response is further scrabbled out and the words on the URL is passed to the Apache Stanbol Server awaiting it request in a restful call. The response obtained from the Apache Stanbol is being store in an RDF file so that it can be worked on by a graph database in Neo4j.

Curriculum Dashboard Interface Module (Taxonomy)

This interface in Figure 5 initiates the project processes. When a student logon to OES System, in the curriculum interface, it clicks on the "AI: Generate Topic Note" button, automatically, the RDF resource generation will be initiated by running the code in the layer 3.

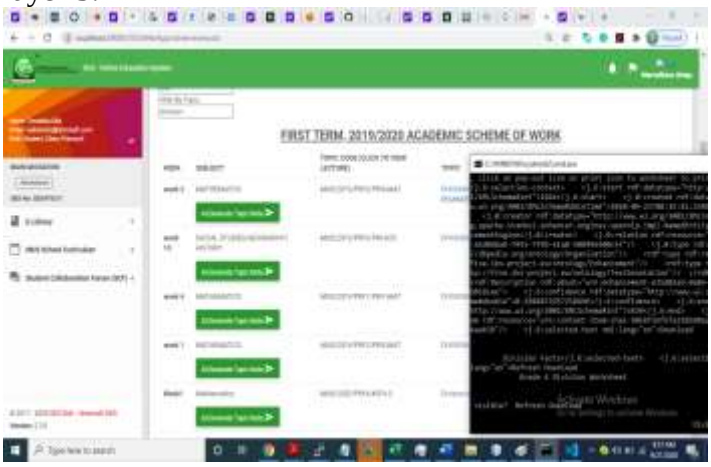

Figure 5: OES LMS Classroom Topic Taxonomy Interface. Initiating the Module.

Apache Stanbol System

The Apache Stanbol System is needed to be started up for the enhancement process of the file sent from the servlet to occur via restful connection process. The enhancement process occurs when the plain text sent to Apache Stanbol is converted to an intelligence, machine readable format information of Subject, Predicate and Object (SPO) through the use of Jena tool. This resulted to generation of semantic web ontology file that can be extracted to a file. This file can be further investigated using a graph database.

Neo4j Graph System Database

Neo4j Graph System is a database that uses SPO graph structures to represent and store information for semantic queries with nodes, edges, and properties. The graph (or edge or relation) is a key concept of the framework. The graph relates the data objects property in the store to a set of nodes and edges, the edges representing node connections. This helps in displacing the SPO concept of semantic web. It is used in displacing the result obtained from the module implemented. This is shown in Figure 6.

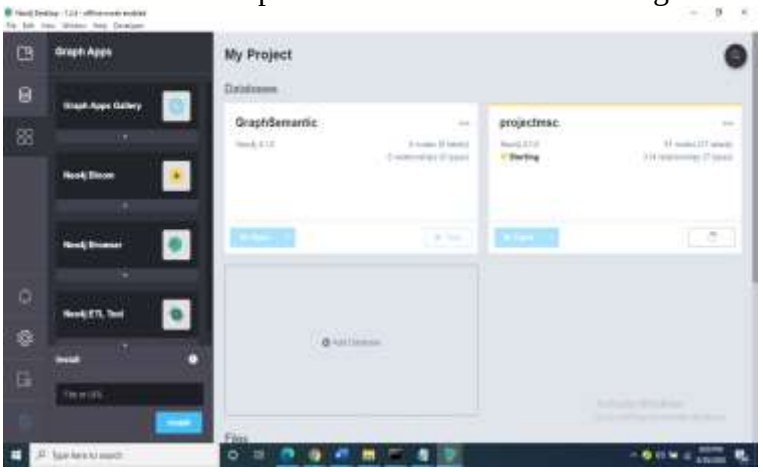

Figure 6. The Neo4j Database Application Interface.

Neosemantics System in Neo4j Database

Neosemantic (n10s) API in neo4j is used in displacing the graph obtained from the module designed. The file generated a semantic knowledge graph and this is call into neo4j database. This n10s is an API is integrated to neo4j db. It helps in the serialization of turtle or rdf file generated from Apache Stanbol. For example, the file generated is DIVISION.ttl, this is called into the graph database with the following command. E.g. Call n10s.rdf.import.fetch ("file:///D:\\Data\\DIVISION.ttl", "Turtle");

The Results

After calling the file into the Neo4j database, the result in Figure 7 shows the semantic knowledge graph obtained on resources proposed by the teachers to note generation. This graph is based on topic on division for grade 2 classroom scheme of work. This document becomes a machine-readable content which has links to lots of other resources.

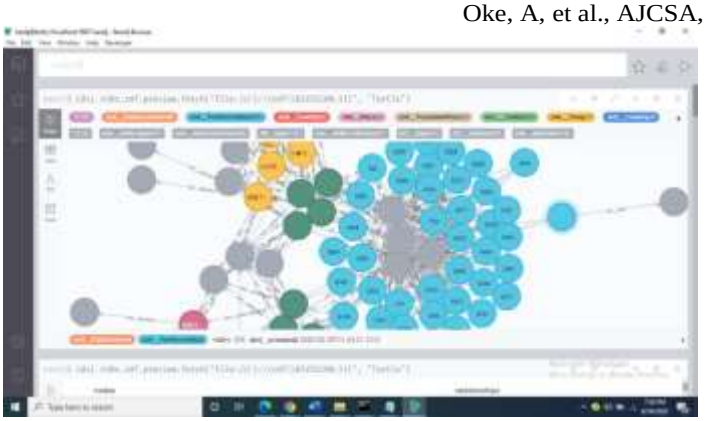

Figure 7: Automated Classroom Ontology Generation into Semantic Knowledge Graph

Discussion

The result obtained can be listed as a database table with properties and relationships. This will empower drawing of information from dataset in the graph. This can be done via SPARQL or the neo4j cypher query language (CQL).

Conclusion

Education continues to be the yardstick of development for any continent, nation, and society. According to the UN, it is an important goal out of all the Sustainable Development Goals (SDG) goals for developing nations to eradicate poverty. Presently, there are still challenges in creation of classroom notes by teachers hence a need to develop an automation process for the sector. In this research work, a foundation was initiated and developed with the use of semantic web technology. It was further concluded that OES application can be used alongside with Apache Stanbol tools to simulate the process and this can lead to generation of Ontologies (Semantic Knowledge Graph), reusable for classroom note resources. Neo4j was also used in viewing the output of the research work through Neosemantic 10s API. This research review critically adoption of Artificial Intelligence on resources created via the web content.

Recommendation

This system can be used by state Ministry of Education (MoE), different universities or education bodies in and outside Nigeria. Policies can be made by MoE to start adoption of e-learning platforms so that our education sector in the country will not be at stand still as compared to what is presently happening in different countries in the world. In doing so, AI can be adopted in education in order to further enhancing the sector. Furthering e-Learning platforms for academicians is important for new findings to be experienced in our society and for that to occur, adoption of Artificial Intelligence in the area of semantic web technology is germane. For this reason, a lot is still yet to be done in this area. The Ontologies generated still need to be query and note necessary to carry out knowledge will still be generated. More research should be done to complete this note formation. Only ontologies are generated with this dissertation.

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