

# Development Of Web Application For Ontology-Based Elearning System

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**Abstract**— In this paper, the development of web application for ontology-based eLearning system is presented. The eLearning contents used as the case study is developed from the tutorial on Mathematics topic 'number base'. The detailed number base learning content was broken down into the following subsections; types of numbers involved, number bases, number base digits, number base conversions, learner level and finally examples and practice questions. The prepared number base learning contents were then used in the Protégé to create the ontology for the eLearning system web application. The web application was developed using three tier architecture and iterative incremental methodology. The application design was based on a functional decomposition in which the system was broken down into modules that included three primary modules, namely, the Home module, Protégé-Based Ontology Module and ELearning Content Module. The developed web application was hosted online using WAMP server which included Windows operating system, apache web server, MySQL database management system and PHP scripting language. The screenshots of various webpages from key modules in the web application were captured and used to explain and demonstrate the operations and applications of the system.

**Keywords**— *Web Application, Ontology, ELearning System, Protégé Software, Functional Decomposition*

## 1.0 Introduction

Over the years, the advancements and synergy of software, electronic and communication technologies have enabled diverse technology driven solutions in every facet of human endeavours [1,2,3, 4,5, 6,7, 8,9, 10,11,12,13,14,15,16]. Similarly, learning technology researchers have taken advantage of the Internet and software technologies to develop learning tools and platforms that enables remote learning, eLearning and other learning systems that enhance

user experience [17,18,19, 20,21, 22,23,24,25, 26,27]. Also, the emergence of semantic web technology has also presented additional features that enables advanced user friendly eLearning contents delivery platforms to be developed [28,29,30,31]. Such advanced eLearning platforms or web applications require contents presented in some specific formats to facilitate detailed cataloguing, linking and identification of the learning contents on the online platforms. Notably, Protégé software has been popularly known as a tool that can be used to extract key information from a raw learning content and then be used to present the extracted learning contents in a format that is suitable for eLearning content presentation and distribution via web application and related software applications [32,33,34,35,36].

Accordingly, this paper presents the development of web application for ontology-based eLearning system [37,38,39,40]. The ontology is extracted from the raw learning content using the Protégé software and then the web application is used for accessing the ontology and utilising them in the presentation and distribution of the eLearning contents. The system architecture for the web application is presented along with the functional decomposition and other phases in the software development methodology are presented along with the screenshots of some web pages obtained from the implemented web application.

## 2.0 Methodology

### 2.1 Development of the web application

This work is meant for the development of web application for ontology-based eLearning system. An iteratively incremental software development approach is adopted in which feasibility study was conducted, along with requirement elicitation and specification, design, coding and testing [41,42,43,44,45, 46,47, 48, 49, 50,51,52]. Also, the three tier architecture is used. The functional decomposition of the web application into modules is presented in Figure 1. In the functional decomposition of the web application (Figure 1) the system is broken down into modules that includes three primary modules; Home module, Protégé-Based Ontology Module and ELearning Content Module.

**The Home Module:** This Home Module is further broken down into sub-modules (Figure 2) that includes Introduction module and User Authentication Module. The flowchart for the Home Module is shown in Figure 2. The Introduction module is where literature explaining the purpose of the website is presented. It enables the users (especially new users) to have the basic information about the objectives of the website and the requisite technology behind the system. With the basic information, the user can decide to proceed to enter the website or to leave. If the user decides to enter the site restricted area, then user authentication module is invoked. The expected process flow within the Authentication module is shown in Figure 3. After the authentication module, the user who is expected to sign in with valid details should then have access to the Registered Users Contents section of the website which is a restricted area for only registered users on the website.

**Ontology module:** This module is to operate in the backend and as such will neither be visible nor directly accessible to the user. The ontology module is meant to interface between the ontology and the modules it communicates with. This communication occurs when there is any form of query from the user on the data in the ontology or when there is a query response from the ontology to a user query. The expected data and process

flow through the ontology module is represented in Figure 4 and in more details in Figure 5.

The user is expected to carry out the various forms of query inputs (typing and clicking) on the user interface which sends the inputs to the input sub-system for reformatting and then sent to the query management module where the query is processed, the output is sent to the output sub-system for appropriate formatting and onward transmission to the user interface for the user's viewing.

A more detailed process and data flow through the Ontology module is shown in Figure 5, where the engine that was shown in Figure 4 is further expanded to show its components. The PHP-RDF library is used to convert PHP commands to RDF format and vice versa. The aspect of the ontology to be queried has to be converted to RDF graph to enable it to be read. The engine in use (in this case EasyRDF) is responsible for these conversions and also for converting the PHP coded query into a SPARQL query which is the standard query language stipulated by W3C for querying the RDF on the semantic web.

**E-Learning Content Module:** This module has the various eLearning contents provided by different registered users in the system. It provides access to both teachers and learners. It also contains worked examples and exercises

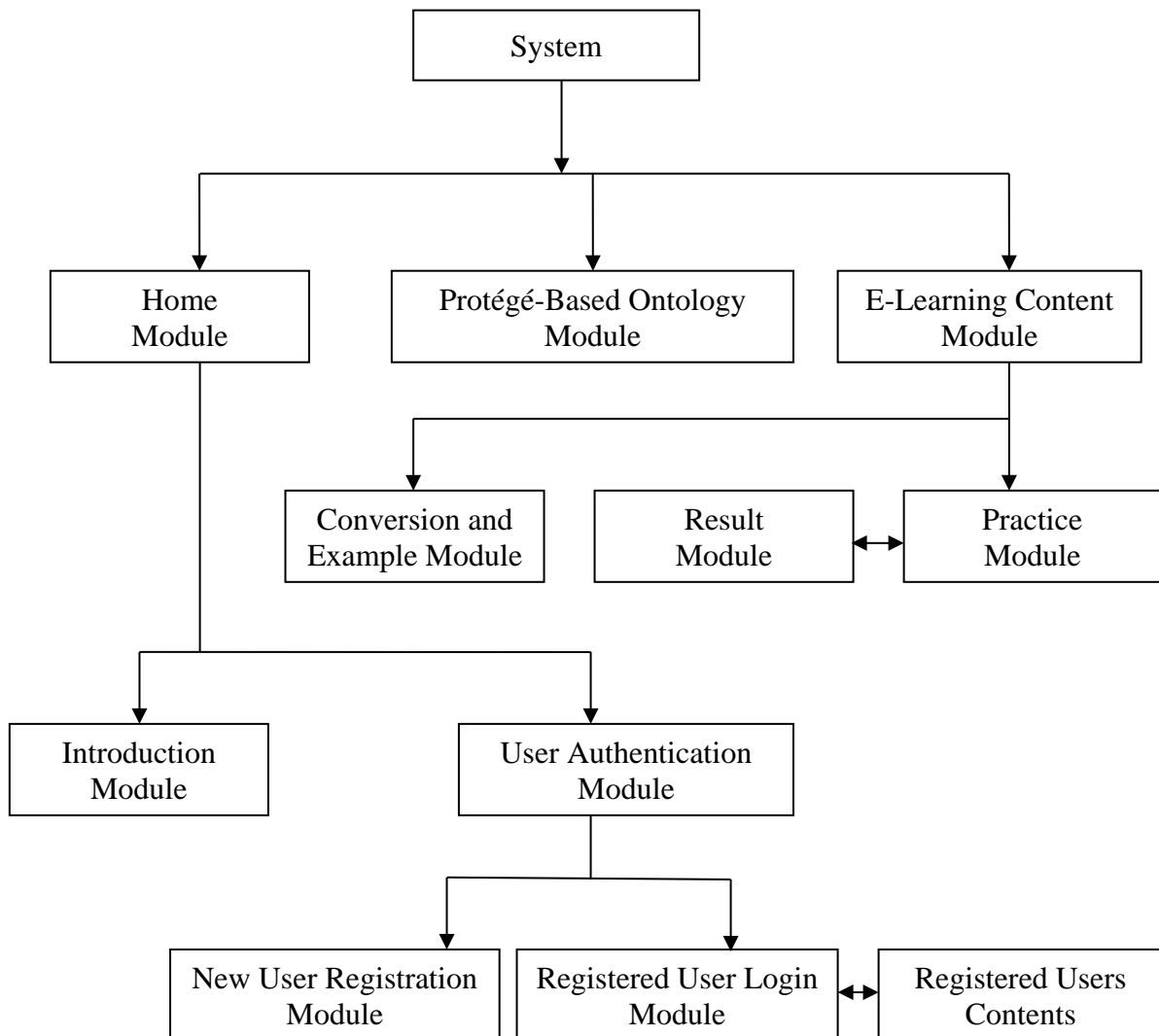


Figure 1: Functional decomposition of web application into modules

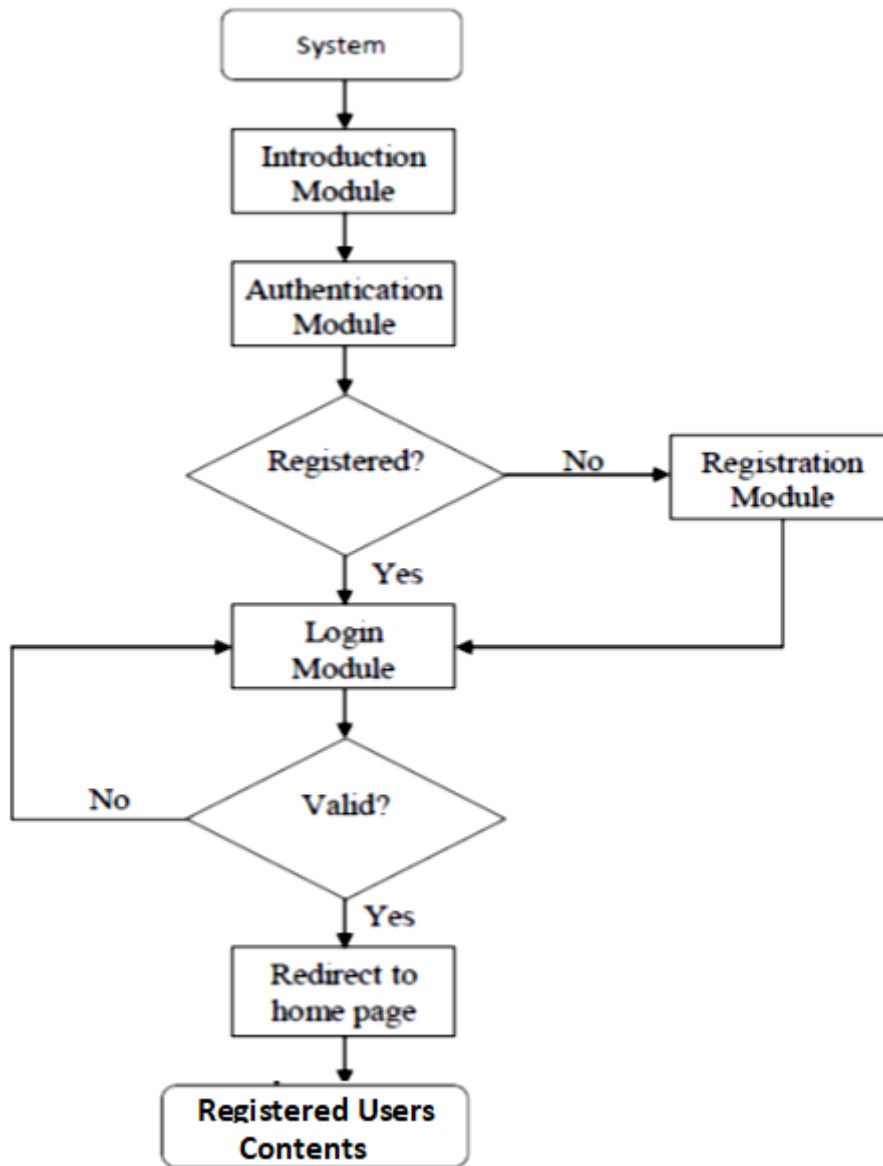


Figure 2: The flowchart for the Home Module

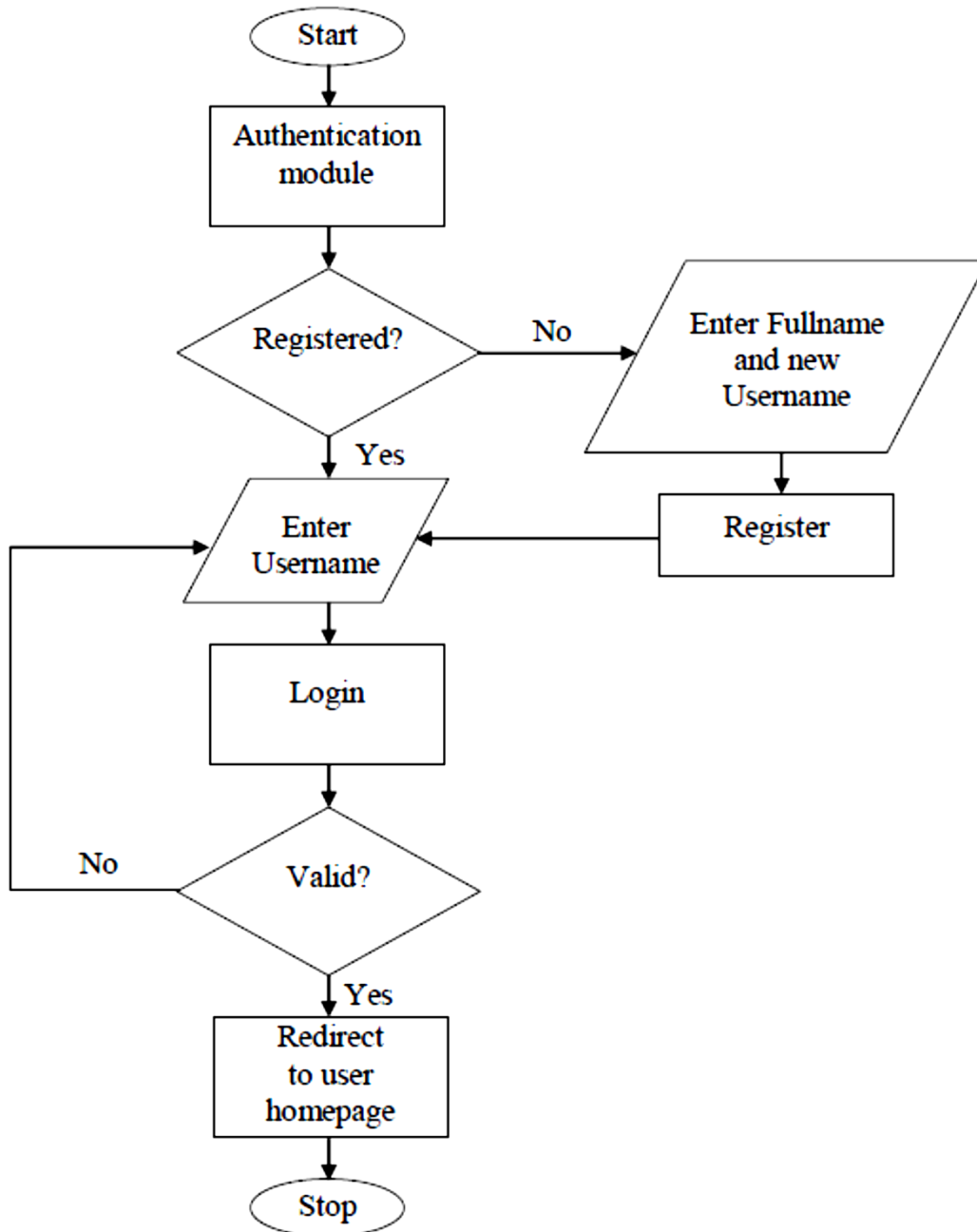


Figure 3: Process flow within the Authentication module

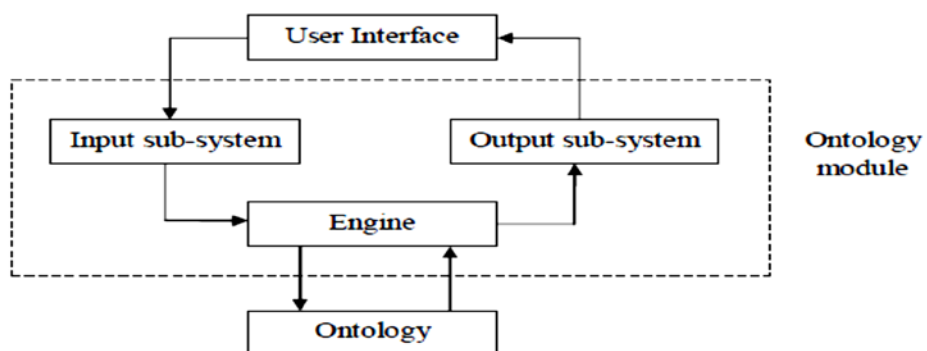


Figure 4: Simplified model showing data flow through the Ontology module

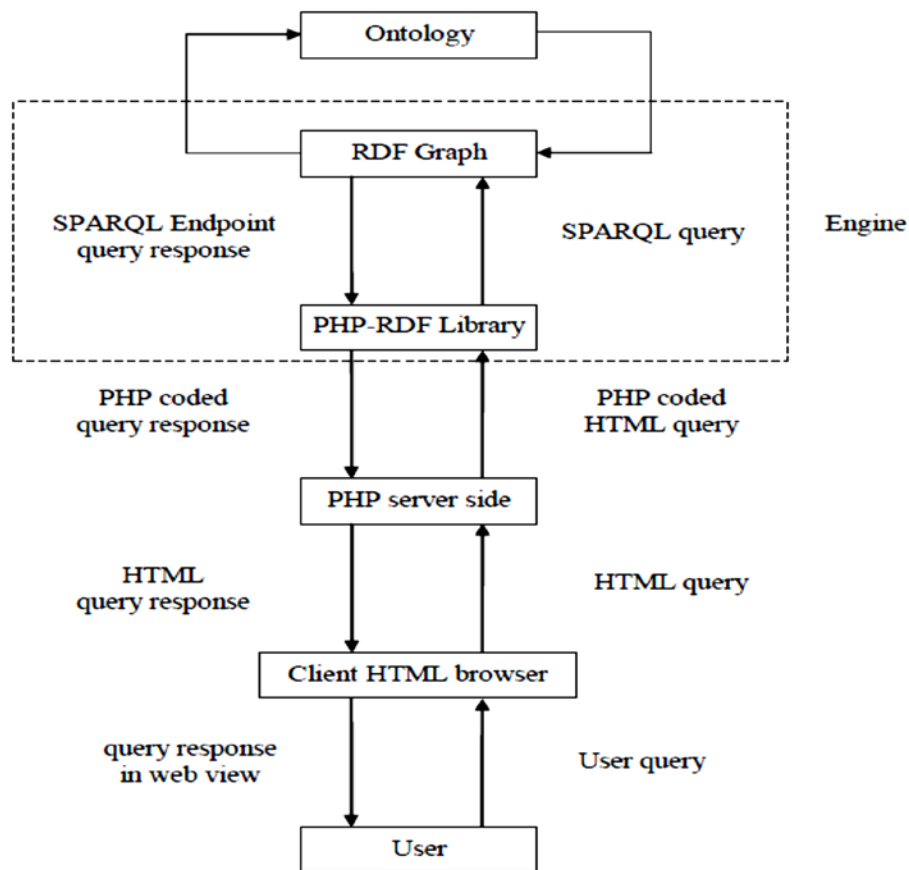


Figure 5: Detailed model showing process and data flow through the Ontology module

**Pedagogic module:** This module has three primary sub-modules; Conversion module, Example module and Practice module. There is also a secondary module, Result module which is under the Practice module. The process flow within the Conversion module is shown in Figure 6 while the process flow expected within the Examples

module is shown in Figure 7. Also, the process flow expected within the Practice module is shown in Figure 8. The Practice module also interacts with the Result module. The process flow which should be followed in the Result module is shown in Figure 9.

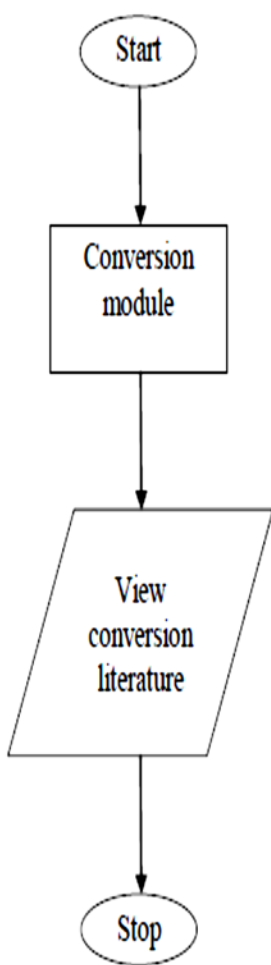


Figure 6: Process flow within the Conversion module

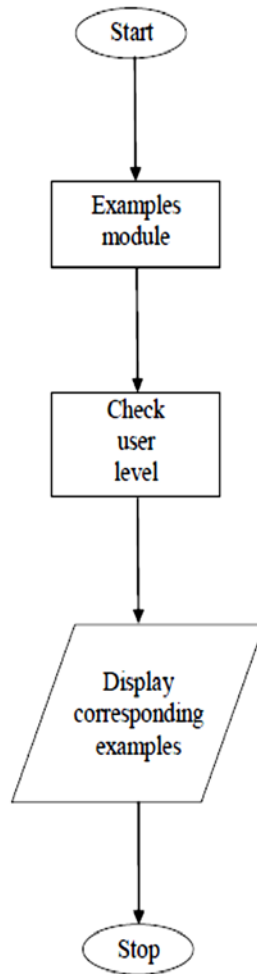


Figure 7: Process flow within the Examples module

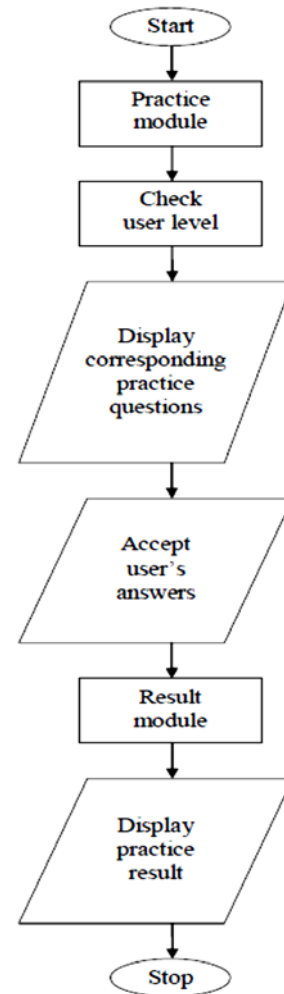


Figure 8: Expected process flow within the Practice module

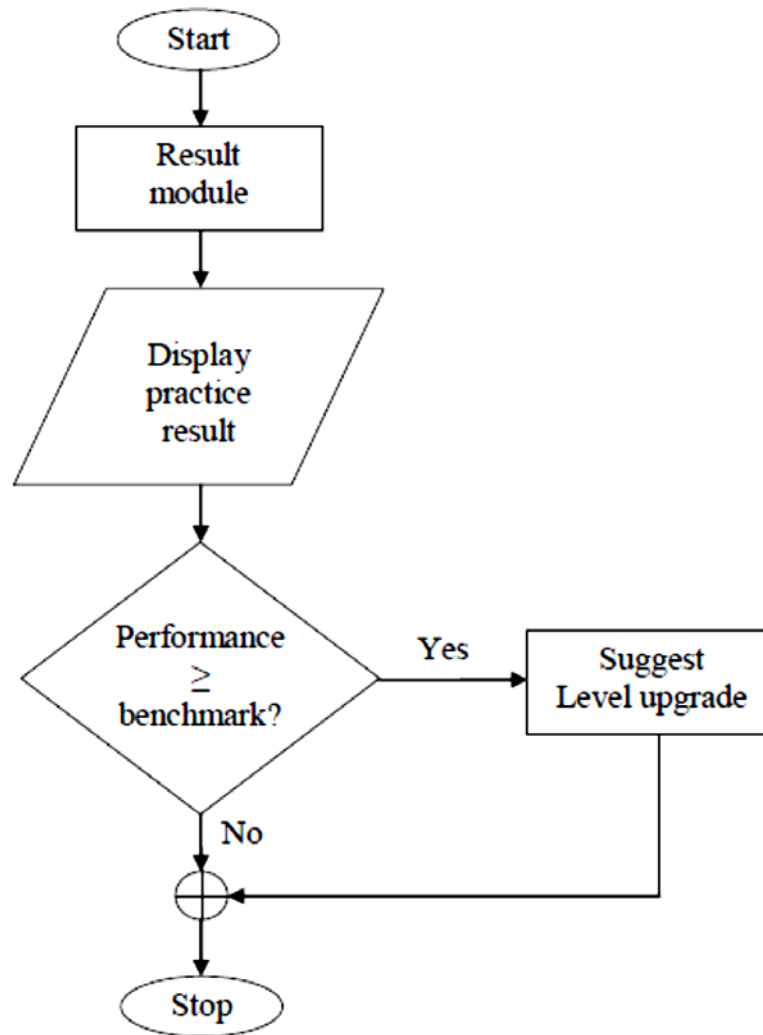


Figure 9: Expected process flow in the Result module

**The System Architecture for the Web Application:** The system is built on three-tier architecture as depicted in Figure 10. The architecture separates the functionality of the system into three independent tiers, namely the Presentation Tier, the Application Logic Tier and the Data Tier. The Presentation Tier is subdivided into two; the client side user interface component and the backend that manipulates the scripts and code for sending to the server side or, after receiving the scripts from the server side, for generating web pages. The presentation tier receives the user interaction in the form of mouse gestures, mouse clicks and keyboard inputs. These inputs are evaluated and the appropriate operations in the application logic tier are invoked. When the results are returned, they are displayed to the user using the appropriate user interface controls.

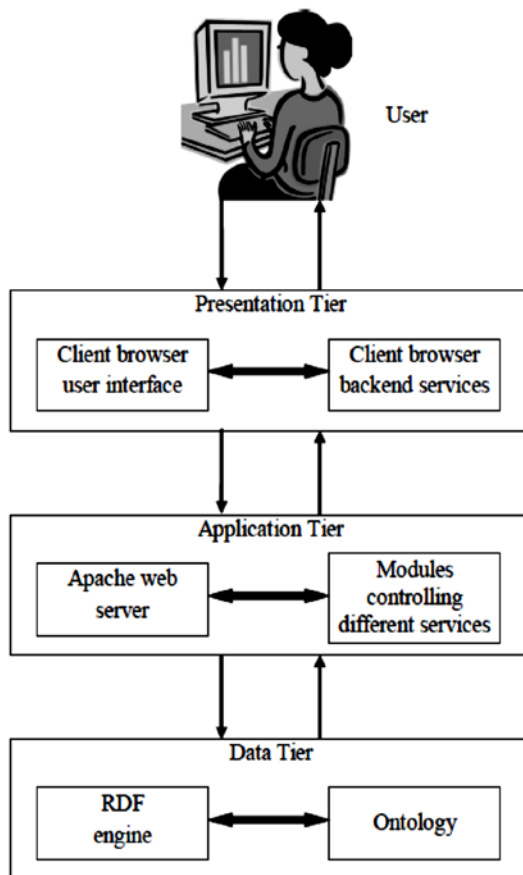


Figure 10: The 3-Tier Architecture of the System

The Application Logic Tier implements the problem-solving functionality of the system. This tier is made up of multiple independent and co-dependent services, which are controlled by modules responsible for performing well-defined tasks. Each service is defined by the set of operations it performs and by the description of the results gotten from these operations. When a service operation is invoked, the module responsible for that service answers the request either by using its internal information, or by building and issuing the appropriate queries to the Data Tier and manipulating the data returned.

Finally, the Data Tier provides data management functionality independently from the software technology. This tier receives information retrieval and manipulation requests expressed as a query, evaluates the query, and returns a set of data objects that are represented using an appropriate language.

**Tools used in the web application development and deployment:** The web application development and deployment tools and technologies used for the realization of the system are as follow:

- i. PHP: PHP (used as the server side scripting language )
- ii. MYSQL: MYSQL (used as the backend database server )
- iii. APACHE: ( used as the web server)
- iv. WINDOWS OPERATING SYSTEM ( used as the operating system)

- v. DREAMWAEVER: (used for the webpage design, editing and interface controls)
- vi. ADOBE PHOTOSHOP: (used to develop graphics for the front-end interface)
- vii. PROTÉGÉ: ( used to create and modify the ontology).
- viii. D2R SERVER: ( tool used to test the created ontology )

## 2.2 The ontology creation in Protégé for the web application

In other to use ontology to organise and manage the eLearning content, the eLearning content need to be created and then the ontology extracted which is then used to create the ontology-based eLearning content with requisite hyperlinks. The methodology employed for the ontology creation starts with the creation of the eLearning contents which are entered via the web interface. In this paper, the eLearning contents is developed from the tutorial on Mathematics topic 'number base'. The detailed content is broken down into subsections as following;

- Types of numbers involved (which includes Whole numbers, Integers and Real numbers)
- Number bases (which includes Binary, Octal, Decimal and Hexadecimal)
- Number base digits (which includes Binary – 0, 1, Octal – 0, 1, 2, 3, 4, 5, 6, 7, Decimal – 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 and Hexadecimal - 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F)
- Number base conversions (which includes Binary: Binary-to-Octal, Binary-to-Decimal, Binary-to-Hexadecimal, Octal: Octal-to-Binary, Octal-to-Decimal, Octal-to-Hexadecimal, Decimal: Decimal-to-Binary, Decimal-to-Octal, Decimal-to-Hexadecimal and Hexadecimal: Hexadecimal-to-Binary, Hexadecimal-to-Octal, Hexadecimal-to-Decimal)
- Learner level (which includes Beginner – Zero to very insignificant previous knowledge, Intermediate – Some previous knowledge of topic and Expert – A lot of knowledge on the topic)
- Examples and practice questions presentation for learner levels (which includes Beginner – Whole number only, Intermediate – Integers and some real numbers with small-value whole number part and Expert – Decimals with large value integer part)

The prepared learning contents are then used in the Protégé to create the ontology for the eLearning web application. Protégé ontology creation processes starts with the development of the eLearning content (this is called concepts development). Afterwards, the other steps



includes defining the classes, defining the class hierarchy (sub-classes under a given class), specifying the relationships between classes, specifying the class properties, defining the constraints which are employed to create the rules and in the creation of the instances. The procedure employed in the Protégé ontology creation is as follows:

1. Launch Protégé
2. Create new ontology and save it using the new name you specified
3. Create classes for your ontology. The class is a super-classes created under the main class named "Thing. This is where you create class names to identify the different subsections in the eLearning content you created. Such subsection in this paper includes, Concept-Description, Syntax, Flowchart, Algorithm, Sample-Code, Worked-Examples, Exercise-Questions
4. Create instances that represent values for each of the classes you created in step 3

5. Map the instances you created in step 4 to their corresponding classes created in step 3
6. Add properties to the instances and the classes that reflect the constraints
7. Add annotations to the instances and classes where necessary
8. Check your model if there are errors and correct the errors where necessary
9. Save the ontology in the required format

After creation of the ontology, it was tested using FaCT++ and HermiT v 1.3.8 APIs which were installed in the Protégé software.

### 3. Results and discussion

After the web application was developed, the screenshot of key webpages were captured and explained. The screenshot of the homepage of the web application for ontology-based eLearning system is shown in Figure 11 which is controlled by the Introduction module. The Introduction module contains the pages which introduce the user to the essence of the application and the technology behind the system.



Figure 11: The

screenshot of the homepage (Introduction module)

The screenshot in Figure 11 indicates that the homepage contains 5 tabs (HOME, NUMBER BASE, MY

ACCOUNT, NB ONTOLOGY and D2R SERVER). The HOME tab is a link to the current homepage, NUMBER BASE tab is a link to the number base introduction

literature of the Introduction module, MY ACCOUNT tab leads to the Authentication module, NB ONTOLOGY tab links to the Ontology module thereby aiding the user to view or download the ontology in use (the action carried out on clicking the link will depend on the browser in use), and the D2R SERVER is a link to the D2R server used to test the ontology. The D2R server is a developer tool and will be disabled for everyday use but can be activated for a developer on request. The lower view of the homepage in Figure 11 contains a preview of what the system and technology is about. It also contains the different number

bases considered in this work. As the user hovers the mouse pointer over each of these number base names, the component digits of the number base are displayed. The user can continue to the next portion of the Introduction module by clicking on the NUMBER BASE tab to view further literature and introduction to number bases with a partial view of this shown in Figure 12. After going through the literature, the user moves on to the Authentication module by clicking MY ACCOUNT tab. The interface gotten after clicking MY ACCOUNT tab is shown in Figure 13.

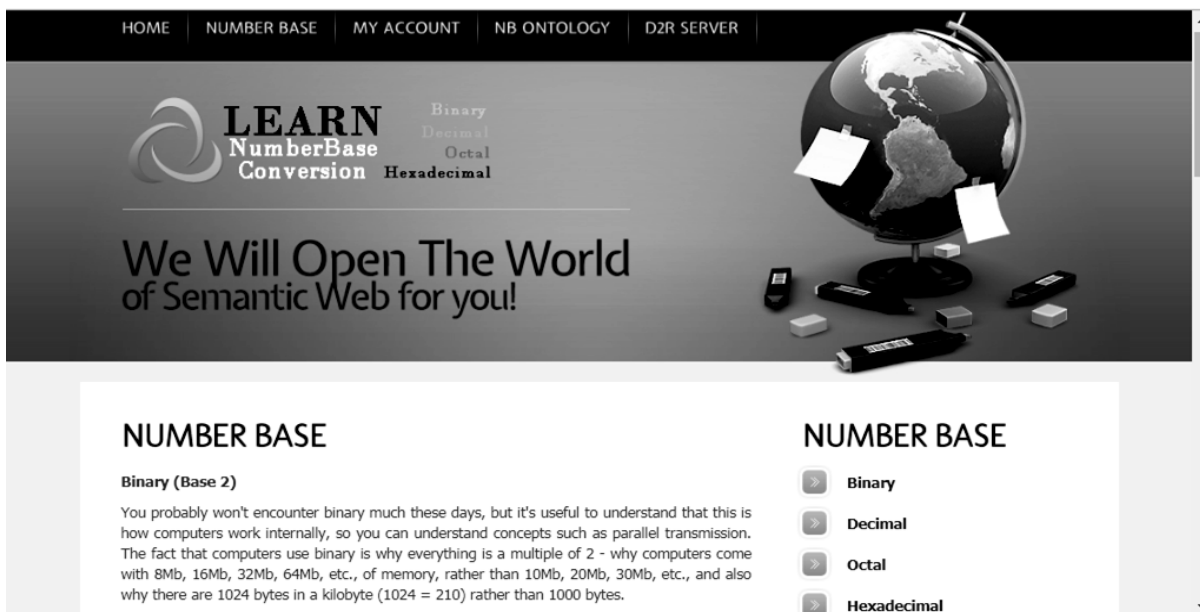


Figure 12: Upper level view of the NUMBER BASE tab (Introduction module)

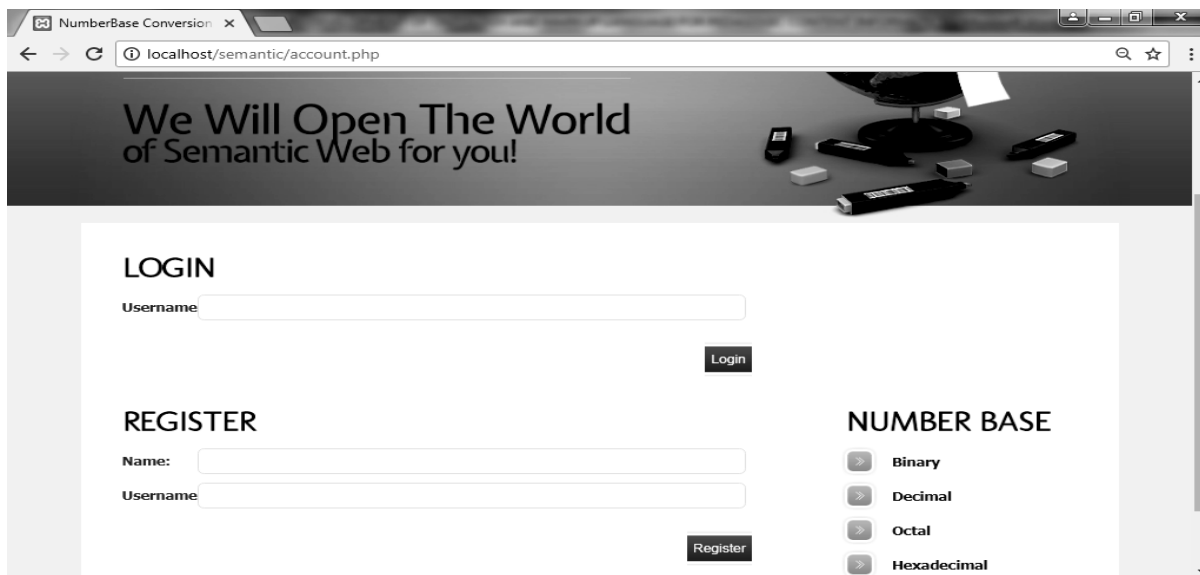


Figure 13: Interface of MY ACCOUNT tab (Authentication module)

As shown in Figure 13, MY ACCOUNT tab offers an existing user an interface to input username and login while offering a new user an interface to register by providing the user's name in full and a unique username. After a new user registers, the module will present an interface for the user to login in and have access to the application's resources. After a successful login, the system directs the user to click on the LEVEL tab which opens up an interface as shown in

Figure 14 for the user to select a desired or proposed proficiency level on the subject. The interface is controlled by the Level module. The Level module also provides a previously registered user a means to upgrade or downgrade the previously set proficiency level based on test result recommendation or personal preference.

After selecting the appropriate level and clicking Update, the system registers that proficiency level for the user as

reflected on the user's homepage shown in Figure 15. The user then proceeds to the Pedagogic module which contains sub-modules such as Conversion module, Examples module and Practice module. The Conversion or Examples interface can be accessed by clicking the CONVERSION tab or the EXAMPLES tab respectively. The Conversion

tab contains details in the most basic form on how to convert between the different number bases with excerpts shown in Figure 16 and Figure 17 while Examples tab shows the user examples of conversion between the number bases based on the user's selected proficiency level.

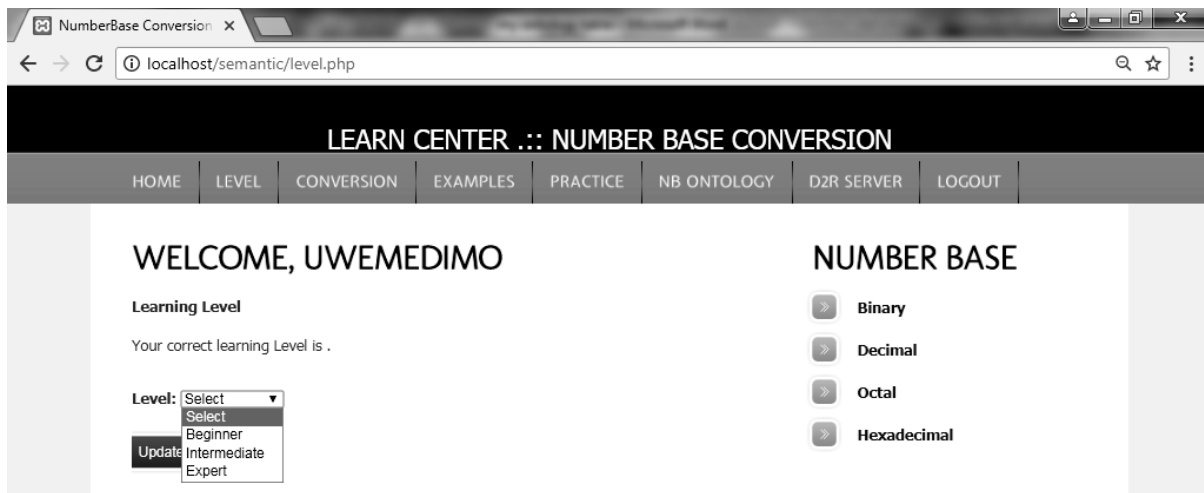


Figure 14: Interface of LEVEL tab (Level module)

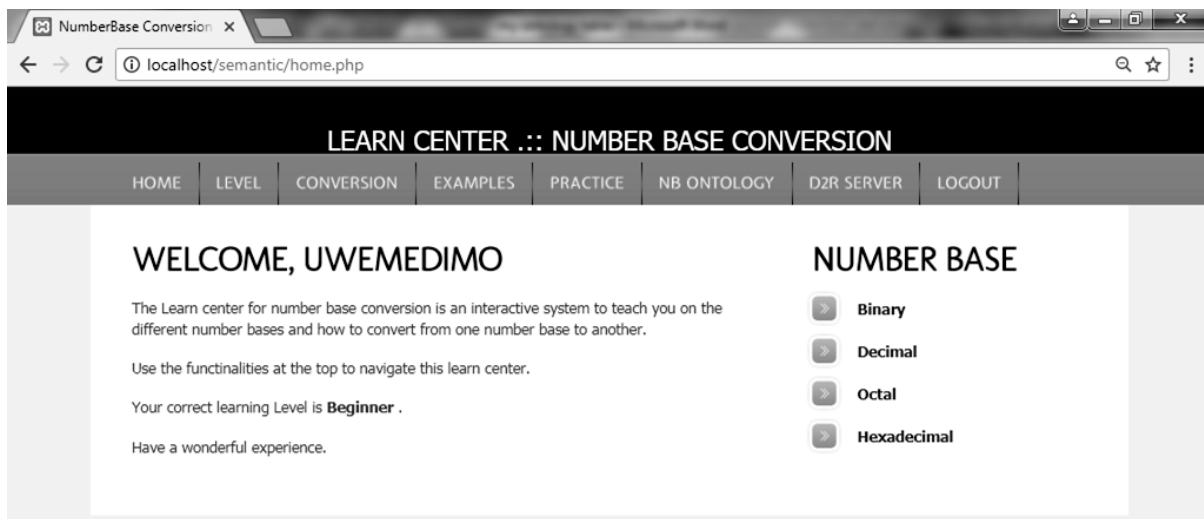


Figure 15: User homepage showing proficiency level

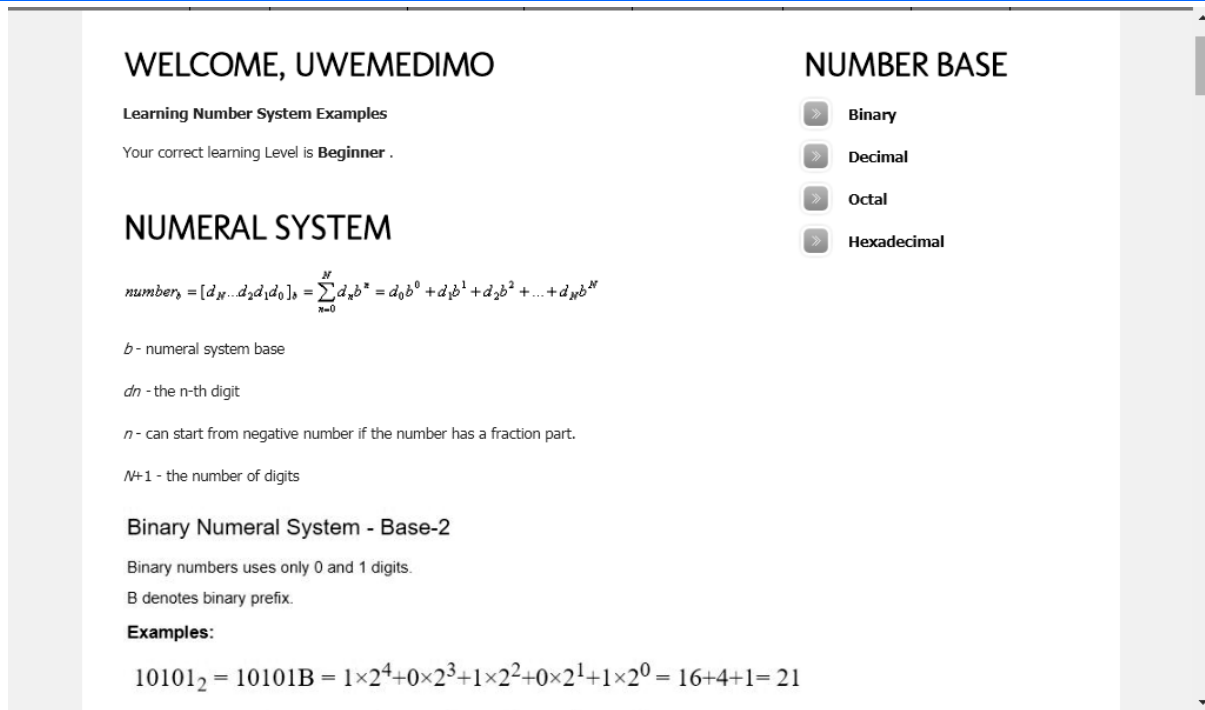


Figure 16: Partial view of CONVERSION tab interface

The literature in the conversion module is the same for all levels of proficiency because this serves as the core introduction to the subject matter. The examples presented to the user change as the user progresses or retrogress on the proficiency level. This is so because according to an educational resource person (personal discussion), if the example does not match the user’s level of proficiency, the user could develop lack of interest and abandon the learning process all together. The examples at the different levels of proficiency are shown in Figures 17, Figures 18 and Figures 19.

When the user feels satisfied as having mastered the techniques shown in the examples, the user can then proceed to the Practice module. The Practice module contains practice questions to be attempted when the user wishes to practice what has been learnt from the Conversion and Examples module. The questions accessed are mapped to the proficiency level previously selected by the user as shown in Figures 20, Figures 21 and Figures 22. The module can be accessed by clicking the PRACTICE tab.

**NUMERAL SYSTEMS CONVERSION TABLE**

Decimal Base-10	Binary Base-2	Octal Base-8	Hexadecimal Base-16
0	0	0	0
1	1	1	1
2	10	2	2
3	11	3	3
4	100	4	4
5	101	5	5
6	110	6	6
7	111	7	7
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F
16	10000	20	10
17	10001	21	11
18	10010	22	12
19	10011	23	13
20	10100	24	14
21	10101	25	15
22	10110	26	16
23	10111	27	17
24	11000	30	18
25	11001	31	19
26	11010	32	1A

Figure 16: Partial view of CONVERSION tab interface

**LEARN CENTER .:: NUMBER BASE CONVERSION**

HOME
LEVEL
CONVERSION
EXAMPLES
PRACTICE
NB ONTOLOGY
D2R SERVER
LOGOUT

## WELCOME, UWEMEDIMO

Learning Number System Examples

Your correct learning Level is **Beginner** .

### EXAMPLES

Binary-to-Decimal

#### Binary-to-Decimal Conversion

**Example 1: 11011010**

**Example 2: 10011101**

	Column 8	Column 7	Column 6	Column 5	Column 4	Column 3	Column 2	Column 1
<b>Base<sup>exp</sup></b>	2 <sup>7</sup>	2 <sup>6</sup>	2 <sup>5</sup>	2 <sup>4</sup>	2 <sup>3</sup>	2 <sup>2</sup>	2 <sup>1</sup>	2 <sup>0</sup>
<b>Weight</b>	128	64	32	16	8	4	2	1
<b>Example1</b>	1	1	0	1	1	0	1	0
<b>Example2</b>	1	0	0	1	1	1	0	1

## NUMBER BASE

- Binary
- Decimal
- Octal
- Hexadecimal

Figure 17: Examples interface (Beginner)

**LEARN CENTER .:: NUMBER BASE CONVERSION**

HOME
LEVEL
CONVERSION
EXAMPLES
PRACTICE
NB ONTOLOGY
D2R SERVER
LOGOUT

## WELCOME, UWEMEDIMO

Learning Number System Examples

Your correct learning Level is **Intermediate** .

### EXAMPLES

Binary-to-Decimal

### Convert From Binary to Decimal

128 64 32 16 8 4 2 1 weight

0 0 1 0 0 1 1 0

32 + 4 + 2 = 38 decimal

**Powers of 2**

2<sup>0</sup> = 1

2<sup>1</sup> = 2

2<sup>2</sup> = 4

2<sup>3</sup> = 8

2<sup>4</sup> = 16

2<sup>5</sup> = 32

## NUMBER BASE

- Binary
- Decimal
- Octal
- Hexadecimal

Figure 18: Examples interface (Intermediate)

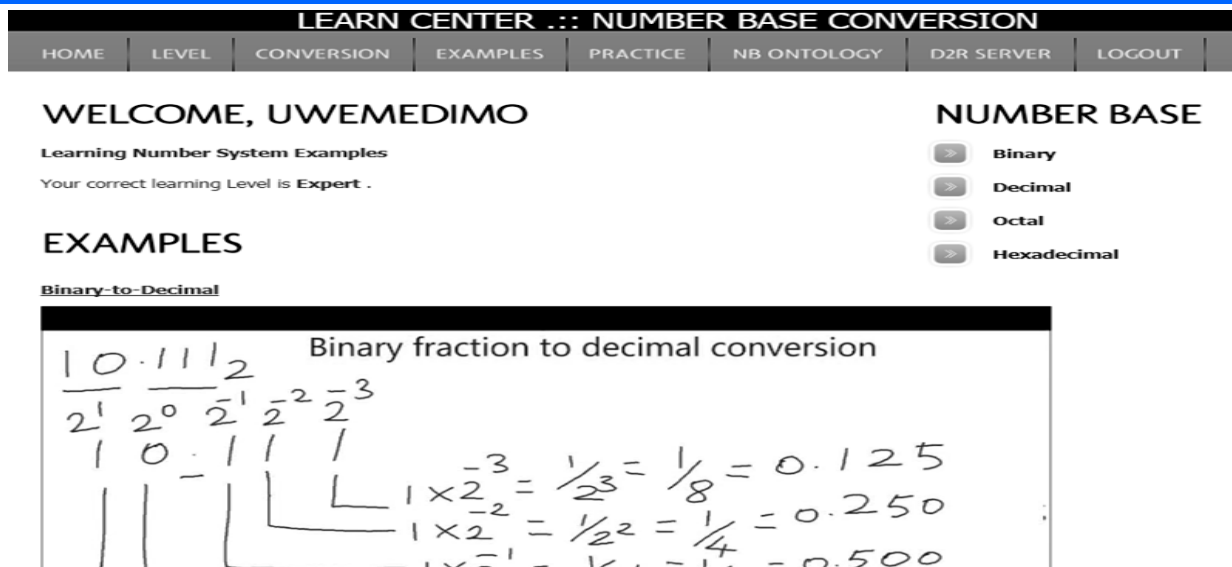


Figure 19: Examples interface (Expert)

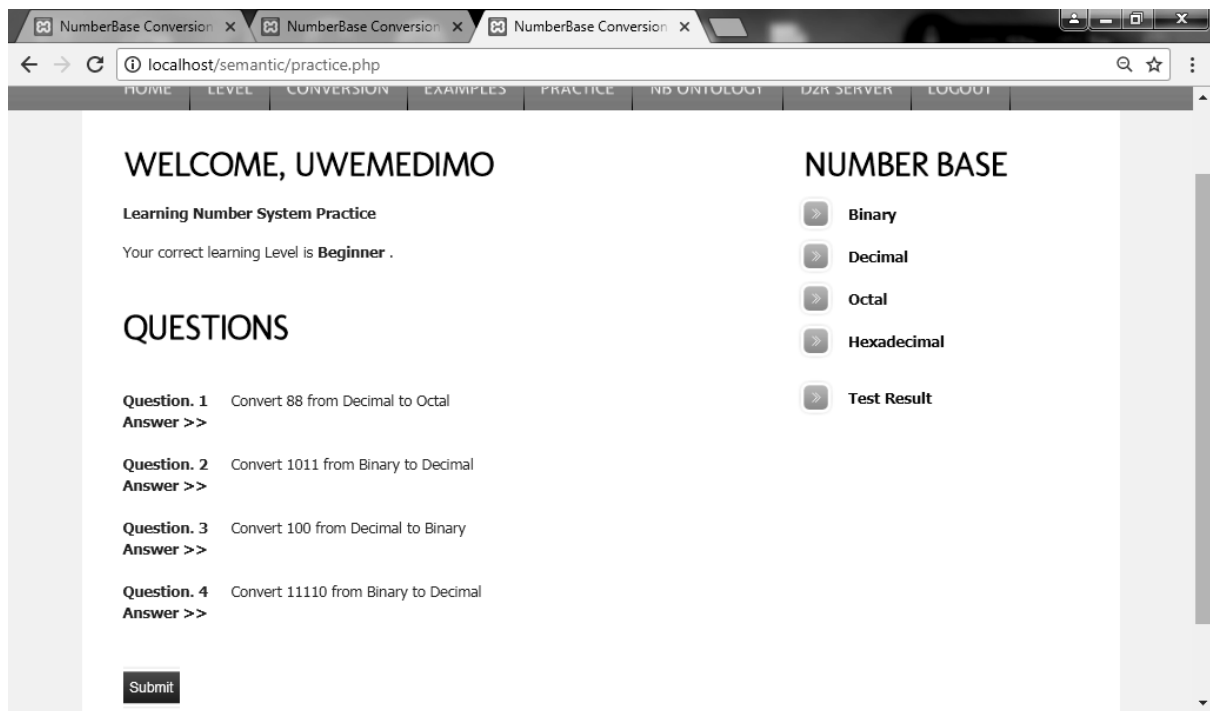


Figure 20: Interface showing practice questions before user provides answers (Beginner)

A user at a beginner learner level is shown in Figure 20 having just accessed the practice question pool but has not provided answers yet. The user shall use the techniques learnt in previous modules to solve these question and provide answers as shown in Figure 21 and then click on the submit button. The interface that comes up after clicking on the Submit button is shown in Figure 22.

The test result in Figure 22 shows that the user provided an incorrect answer to one of the questions and as such will have to retry the practice. It could also be noticed that the system informs the user of not achieving the required benchmark the system regards as an excellent performance. When the user gets a score which is greater than or equal to the set benchmark, the system recommends that the user

may upgrade to the next proficiency level as shown in Figure 23.

Figure 23: Test result interface showing recommendation for user level upgrade (Intermediate)

The user who now is at the Intermediate level but has gotten a recommendation to upgrade can do so using the LEVEL tab as the user has been adjudged to have mastered the rudiments of the intermediate level. The test result of the user's expert level practice is shown in Figure 24.

At the end of the practice, the practice results are displayed. The comprehensive performance result can also be viewed by the user. All data and operations that concern results are controlled by the Results module which could be accessed



by clicking the “Test Result” link on the Practice page. The comprehensive test result interface is shown in Figure 25.

The LOGOUT tab is linked to the Authentication module and is used by the user to exit the current session of application use. On clicking this tab, the user’s session is

ended and the authentication page shown in Figure 13 is displayed. The NB ONTOLOGY and D2R SERVER tabs are linked to the Ontology module which, as previously stated, will not be directly accessible to the user as these are more of developer tools and not much of learning tools.

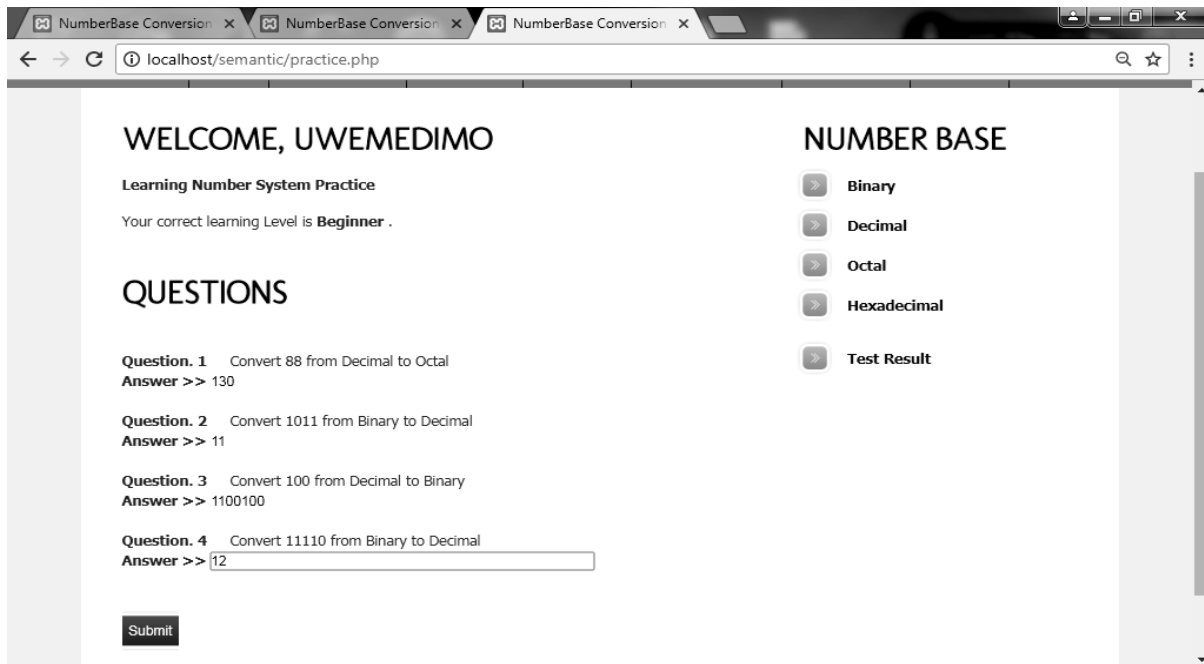


Figure 21: Interface after user has provided answers to the questions (Beginner)

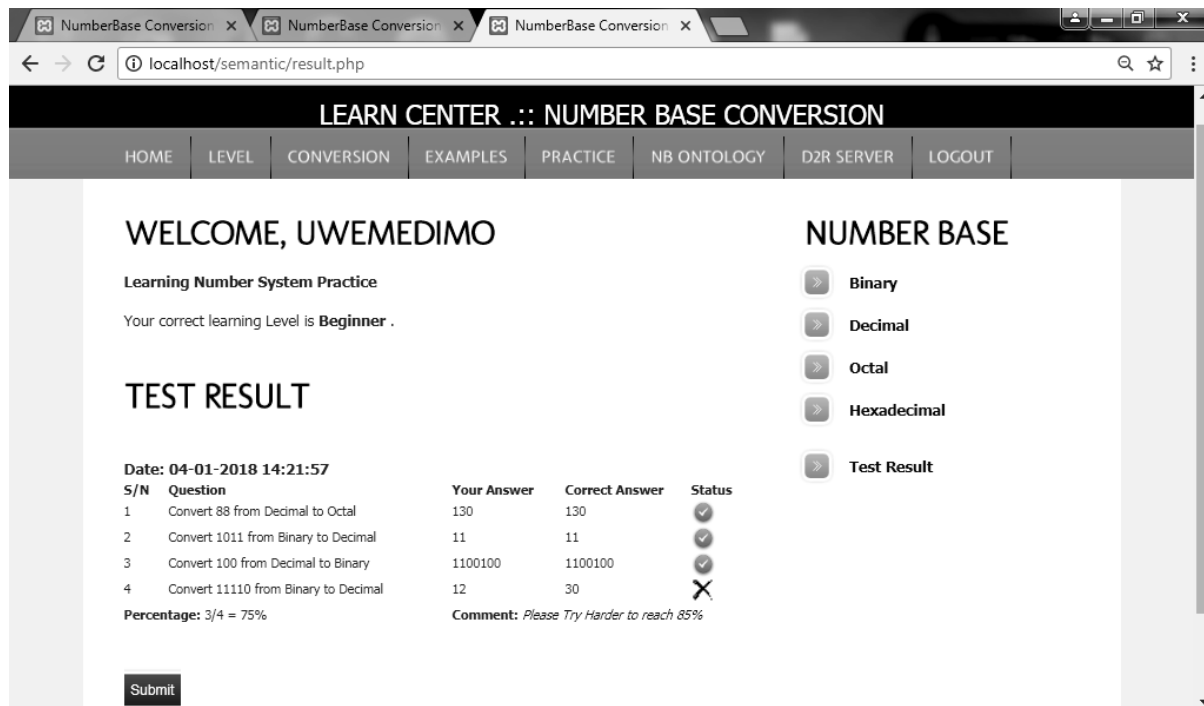


Figure 22: Interface showing test results from answers provided as shown in Figure 21

NumberBase Conversion x NumberBase Conversion x

localhost/semantic/result.php

## LEARN CENTER :: NUMBER BASE CONVERSION

HOME LEVEL CONVERSION EXAMPLES PRACTICE NB ONTOLOGY D2R SERVER LOGOUT

### WELCOME, UWEMEDIMO

Learning Number System Practice

Your correct learning Level is **Intermediate**.

### TEST RESULT

Date: 05-01-2018 21:54:28

S/N	Question	Your Answer	Correct Answer	Status
1	Convert 357.121 from Octal to Decimal	239.1582	239.1582	✓
2	Convert 1.83 from Decimal to Hexadecimal	1.D47	1.D47	✓
3	Convert 0.10011 from Binary to Decimal	0.59375	0.59375	✓
4	Convert 158 from Octal to Hexadecimal	d	d	✓

Percentage: 4/4 = 100%      Comment: You can proceed to the Next Level

Date: 05-01-2018 21:49:30

S/N	Question	Your Answer	Correct Answer	Status
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NUMBER BASE

- Binary
- Decimal
- Octal
- Hexadecimal
- Test Result

Figure 23: Test result interface showing recommendation for user level upgrade (Intermediate)

NumberBase Conversion x NumberBase Conversion x

localhost/semantic/result.php

## LEARN CENTER :: NUMBER BASE CONVERSION

HOME LEVEL CONVERSION EXAMPLES PRACTICE NB ONTOLOGY D2R SERVER LOGOUT

### WELCOME, UWEMEDIMO

Learning Number System Practice

Your correct learning Level is **Expert**.

### TEST RESULT

Date: 06-01-2018 19:30:51

S/N	Question	Your Answer	Correct Answer	Status
1	Convert 456FF from Hexadecimal to Decimal	284415	284415	✓
2	Convert 0.2558 from Decimal to Hexadecimal	9fe	9fe	✓
3	Convert 4B2.1A6 from Hexadecimal to Binary	10010110010.0001101010010110010.00011010		✓
4	Convert 22158 from Octal to Hexadecimal	48d	48d	✓

Percentage: 4/4 = 100%      Comment:

NUMBER BASE

- Binary
- Decimal
- Octal
- Hexadecimal
- Test Result

Figure 24: Interface showing user's expert level test result



HOME LEVEL CONVERSION EXAMPLES PRACTICE NB ONTOLOGY D2R SERVER LOGOUT

## WELCOME, UWEMEDIMO

Learning Number System Practice

Your correct learning Level is **Beginner** .

## TEST RESULT

**Date: 04-01-2018 14:26:29**

S/N	Question	Your Answer	Correct Answer	Status
1	Convert 88 from Decimal to Octal	130	130	✓
2	Convert 1011 from Binary to Decimal	11	11	✓
3	Convert 100 from Decimal to Binary	1100100	1100100	✓
4	Convert 11110 from Binary to Decimal	30	30	✓

**Percentage:** 4/4 = 100%  
**Comment:** You can proceed to the Next Level

**Date: 04-01-2018 14:21:57**

S/N	Question	Your Answer	Correct Answer	Status
1	Convert 88 from Decimal to Octal	130	130	✓
2	Convert 1011 from Binary to Decimal	11	11	✓
3	Convert 100 from Decimal to Binary	1100100	1100100	✓
4	Convert 11110 from Binary to Decimal	12	30	✗

**Percentage:** 3/4 = 75%  
**Comment:** Please Try Harder to reach 85%

**NUMBER BASE**

- Binary
- Decimal
- Octal
- Hexadecimal
- Test Result

Figure 25: Interface displaying user's Beginner level comprehensive test results

#### 4.0 Conclusion

The details of the development of web application meant for eLearning system based on ontology and semantic web technology is presented. The case eLearning contents is developed from the tutorial on Mathematics topic 'number base'. The number base learning content was first prepared and broken into five different submodules and then Protégé software was used to extract the ontology which was used in the web application for hyperlinking the various section of the learning content.

The web application was developed using an iterative incremental approach and three tier architecture was adopted. The developed web application was hosted online using WAMP server which includes Windows operating system, apache web server, MySQL database management system and PHP scripting language. The screenshots of various webpages from key modules in the web application are captured and used to explain and demonstrate the operations and applications of the system.

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