Personalization of Learning Objects according to the Skill Set of the Learner using Knowledge Graph

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Article History: Received: 10 November 2020; Revised 12 January 2021 Accepted: 27 January 2021; Published online: 5 April 2021

Abstract: There are numerous eLearning tools have been developed to provide the learning objects for the learners to grow in knowledge in any discipline. There is an increasing need and the demand for educational applications which provides learning object based on the ability of the learners to acquire the learning content according to their ability. Even though there were quite a lot of factors like motivation, geographic location and prerequisite knowledge that influences the learning ability, the knowledge representation for different types of learners is an important factor. Hence a system called Knowledge Graph for Online Learner (KGOL) is proposed to create a knowledge graph for the learning objects and enable the learners to understand the learning concepts better. The system utilizes heterogeneous pedagogical data from the education domain to provide personalized learning content in an eLearning environment. The learner is categorized by their learning ability and the system identifies the relationship between the concepts and pulls out the concepts in the learning objects. Specifically, it adopts the information extraction technique called Named Entity Recognition (NER) which uses spaCy, which is an open-source library for advanced Natural Language Processing in Python. The proposed system also uses student skill set from learning activity to find out the learning ability level to peruse the course content based on the classed such as highly skilled, moderate and slow learners. The proposed system demonstrates the architecture with the knowledge graph constructed for the Programming language to different types of learners. The researchers have demonstrated the proposed work with the python language. For learners' classification, a machine learning algorithm called random forest has been used; NER and spaCy library have been used to extract the information and to construct KG for learning object on python programming language. There are three predicate levels used to provide the learning object using KG to different learners based on their learning ability like highly skilled, moderate and slow learner.

Keywords: Knowledge Representation, Knowledge Graph, eLearning, Learning Object, Machine Learning.

1. Introduction

Humans are good in reasoning, analysing and understanding things by nature. Human can access real world objects with the knowledge acquired. When it comes to a machine, it is difficult for the machine to understand and reasoning things. Artificial intelligence has to be fed to the machine for reasoning. Artificial intelligence is the way where the knowledge is represented in such a way that the machine can easily understand the things and perform semantic analysis.

Now a day, most of the people are learning through online. Even the current scenario of the world, due to covid-19 pandemic, people is forced to adopt eLearning technologies. eLearning enables the learner to learn anything from anywhere in the world. All the resources are available over the internet, which plays vital role in eLearning. In recent times, eLearning had a great growth, and even school students have started learning through eLearning systems.

Knowledge graph is a prominent example that represents real world entities and relations through a multi-relational graph [8]. It is an information repository of heterogeneous data from different domains. Few

prominent examples for the applications of knowledge graphs are: Presently knowledge graph is used in semantic search by Google [9], IBM Watson for deep question and answering [10] and Personal Assistant in Apple's devices [11]. These mentioned applications are in generic knowledge graph which require deep domain information. MOOC provides learning objects in different forms like audio, video, text and illustrations [12]. Our focus is on how the knowledge graph for a learning object can be created in eLearning systems and personalized for the learners. .

Though eLearning is an emerging trend, it is required to develop eLearning system with Knowledge Representation in the form of Knowledge Graph (KG) for the better understanding of the content. Most of the eLearning resources are developed with pre-recorded videos, audios, text and other learning materials. It is important to include personalization to improve learning better.

The knowledge based system can be developed using ontologies. Ontology is "formal, explicit specification of a shared conceptualization." [1]. Ontology is a collection of concepts, relations, properties, instances and axioms. Initially, the concepts related to the specific domain are collected and arranged in a hierarchical order. The relationship between the concepts is established and the instances are created. Axioms are applied to retrieve knowledge based results. Many Ontology applications for educational domain have been created like instructional code [2], course ontology [3], curriculum and syllabus ontology [4], automatic quiz generation [5] etc. Most of the education ontologies are focused on the learning content in irrespective of learners.

Penghe Chen et. el., constructed the knowledge graph for the K-12 educational subjects irrespective of learners capabilities [26]. In the research work of Weiguo Zheng et.al, proposed a system of question answering over a knowledge graph [27]. Zhongxian Bai proposed a model for improving the searching algorithm for searching the content [28]. Feedback is received from the learning to construct the knowledge graph for the learning object [29]. Most of the work is based on the construction of the knowledge graph to enhance the learning object. As the learner is the stake holder of any eLearning system they should be provided with the learning objects according to their learning ability and need. We have used the learners' profile to classify the learner into highly skilled, moderate and slow learners then we use knowledge graph to provide the personalized learning objects which enable them to understand the concepts better.

This study focuses on to provide personalized learning content to different kinds of learners. The objective is to provide learning content to the learners in such a way that they understand the learning objects in an easy manner and enable the learner to have better learning experience based on their learning capability.

In this investigation, the introduction is given in section 1. State-of-the-art or Domain background is explained in section 2. Section 3 gives methodology of building KG for programming language. Section 4 provides a case study for constructing KG. Results and discussion are given in section 5 and the conclusion is given in section 6.

The proposed work is flexible and extensible architecture from a technological viewpoint. Through this study the following contributions were consummated.

- The study analyses the importance of KG in eLearning systems and the related existing applications the results are tabulated.
- The proposed work uses the profile to test the skill set of the learner and suggest learning objects.
- The machine learning algorithm is used to classify the learners based on the performance in learning activity such as high skilled, moderate and slow learners.
- KG is constructed for python language to make an attempt to provide personalized learning objects using KG according to the learning ability of the learners.

2. State-of-the-art

2.1. Learner Experience in eLearning

It is important to understand, what is eLearning? eLearning is one of the formalised learning systems with the electronic resources. eLearning can also be termed as a network enabled transfer of skills and knowledge. It is possible to deliver knowledge to a large number of people by using eLearning systems at the same time. Earlier, it was not accepted by many due to the lack of human intervention. But now, there is great evolution in it and it has a rapid growth. An open source, MOODLE - a Learning Management System (LMS) widely used in schools, colleges and universities. There are other LMS like Chamilo, Canvas, Froma, ILIAS, Opigno [13], supplement the traditional learning. The table 1 shows the difference between the versions of education in which the recent update calls for personalized teaching and learning [21].

Table 1. Time line of Education

	Education 1.0	Education 2.0	Education 3.0	Education 4.0
Meaning	Teacher Centred System	Underestimated student-centered approach	Student-centered Approach	Student-centered Approach
Teaching takes place by	Teacher to student	Teacher to student and student to student	Teacher is a facilitator and the students does researching	Self learning, Development of personalized teaching and learning
Technology	Technology is forbidden in the classroom	Invasion of technology and social networking	Technology is everywhere	Increased use of virtual reality.

People are very much interested to know things day by day. Many platforms like web pages, videos, audio messages, and social media and so on play vital role in knowledge sharing. It is important to understand that the learning not only takes place in schools and colleges but it also happens everywhere. eLearning provides great opportunities to wide our knowledge through various methods. It may vary depends on user's need, task, subject and evaluation. The developer must take them into consideration while developing eLearning applications. And also, it is very much important to find the right method to develop eLearning applications. The system developer should clearly identify the different forms of learning object, types of learner, teaching method, and evaluation technique while developing the systems.

Learning Objects could be personalized, learner-centric and interactive materials could be provided. All these activities are carried out in traditional learning. The major different between traditional learning and eLearning is, in traditional learning, learners are forced to study based on the syllabus irrespective of their likes and dislikes. In case of eLearning, learner can filter and choose the learning object that they want to learn. It also provides different kinds of learning objects in the form of audio, video, animations, presentations and documentation etc. It also enables the user to discuss directly with experts [6].

2.2. Knowledge Representation

Knowledge representation can be happened in many ways such as ontologies, semantic methods and so on. Let us understand what to represent and how to represent knowledge before starting the development of KGOL. Actually knowledge is already known things, human brain use that knowledge and produce intelligent information. In case of machine, it is necessary to make the system to understand the things. To make the machine to understand, the real world phenomenon is to be fed into the system to provide meaningful information. Entities, objects, relations, facts, rules, operations, performance are used to construct valid intelligent system.

Knowledge can be classified in different ways viz., i) structural, ii) declarative, iii) meta, iv) heuristic and v) procedural knowledge. Structural knowledge is the basic to resolve the problems. It describes the relationships between the concepts or entities. Declarative knowledge is also known as descriptive knowledge which represents the knowledge by using concepts, objects and facts. Meta knowledge is the knowledge about other types of knowledge. Heuristic knowledge is framed with the knowledge of experts, experience and awareness. Finally, procedural language, it is also known as imperative knowledge, which produces the knowledge for doing things. It includes axioms, rules, protocols, procedures and agenda to perform tasks. It is task oriented knowledge [7].

Knowledge has to be represented in such a way that the system should provide the intelligent results. This kind of knowledge representation can be adapted in eLearning systems to provide learning resources to different kinds of learners. Knowledge is represented in many ways like, simple relational, hierarchical, inferential, procedural knowledge and knowledge graph [7]. This study focuses on representing Learning object using Knowledge Graph (KG) to provide the Learning object to different types of learners.

2.3. Named Entity Recognition

It is difficult to extract data and information from raw text and to create knowledge graph. Named Entity Recognition (NER) is a technique that uses linguistic knowledge capability to extract useful information from the text [15]. Information extraction with NER is one of aspect in Natural Language Processing (NLP). It converts unstructured text into computer readable structured data [16-19]. SpaCy is one of the open source

library for NLP in Python programming language [20]. SpaCy enables to construct applications; it processes, understands and extracts information from a large volume of raw data. The researchers have used NER for extracting the information from Learning Object and spaCy library for constructing the knowledge graph.

3. Methodology

Though there are different kinds of learning objects available in eLearning, it is necessary to provide an appropriate learning object according to the learning capability of the learner. As mentioned earlier different kinds of learners are there like highly skilled, moderate and slow learners. Highly killed learners have thirst to learn many things whereas it is enough to provide the mandatory and core concepts to the moderate and slow learners. It clearly defines the need of an amendment in eLearning systems.

The knowledge graph represents a collection of interlinked descriptions of entities, objects, events or concepts. It helps to relate data through relations and semantic metadata. It also provides a framework for integrating data, similarities and, analytics. KG can be developed basically using the following four steps: i) identifying the use case / domain; ii) organize relevant data; iii) establish relationships and iv) creating knowledge Graph. Figure 1 represents the conceptual architecture of proposed research work to construct a knowledge graph for the learning object and to provide personalized learning materials to the learner with diverse learning capability.

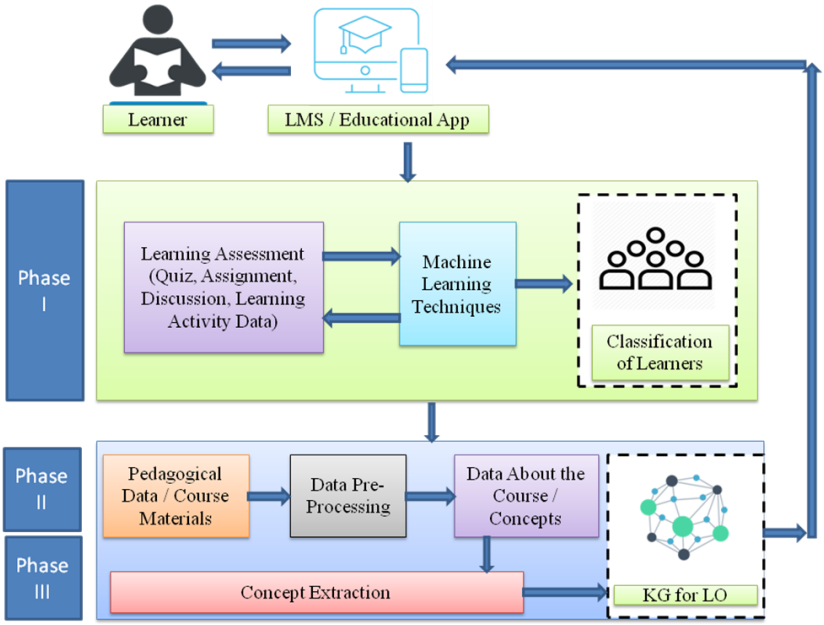


Figure 1. Architecture to Construct Knowledge Graph for Learning Objects

The proposed framework has three phases' viz., i) Didactic Relation Identification, ii) Concept Extraction and iii) KG construction phase. Initially the learner opens the Learning Management System (LMS) and chooses the course of their interest. The system classifies the learner by using the user profile as highly skilled, moderate and slow learner; the machine learning algorithm is used for classification. Data pre-processing is done then the KG for LO is created, based on the learner's ability the L.O is given to the learner through LMS. The phases of proposed work are as follows:

Phase 1 : Didactic Relations Identification
Phase 2 : Concept Extraction
Phase 3 : KG Construction

Phase 1: Didactic Relations Identification

The objective of this phase is to classify the learner into categories viz highly skilled, moderate and slow learner then to provide learning objects using KG for better understanding and learning.

Assessing the learning style is an important process which categorizes the learner and provides the appropriate learning content. The learning activity data greatly influences the learner's knowledge acquisition process which

determines the learning ability of learner. The machine learning algorithm specifically random forest algorithm is chosen by the researcher to classify the learner with the data collected in this phase. The learner's activity data is collected from the profile and classification model is created to classify the learners.

Assessment can be done through various modes such as conducting quiz, assignments, discussion forum and viva-voce etc., average of these criteria are taken into consideration to classify the learners as shown in Table 2. The assessment components are not fixed, the course teacher can fix or the system developer can decide the number and the type of learning activities.

Learners' type can be assessed using the following formula.

$$\sum_{i=1}^{n}\left[\frac{T_n + Q_n + A_n + D_n + V_n .....X_n}{X}\right] - - - (1)$$

Where ,
n – Number of learners
T – Test
Q – Quiz
A – Assignment
D – Discussion forum
V – Viva-Voce
X – number of Activities

Threshold value is set by the course teacher which is used to classify the learners based on the academic performance in the learning activities. The learners are classified into three categories viz., highly skilled, moderate based on the performance in the learning activities.

Phase 2: Concept Extraction

In this phase, course content and concepts are extracted by pre-processing the data from the learning object and then knowledge graph is constructed.

Data Pre-processing

Data pre-processing transforms raw data into an understandable format. Real-world data is often incomplete, inconsistent, and/or lacking in certain behaviours or trends, and is likely to contain many errors. Data pre-processing is a proven method of resolving such issues. In the process, noisy data such as images, tables, phrases are removed from the chosen course content. Apache Tika is another library which is used for document type detection and content extraction from various file formats. The researchers have used this library to extract concepts in pdf file excluding the images and tables from the learning objects.

From the pre-processed course content, the most important topics are filtered in concept extraction process. The content is grouped based on semantic similarities which helps to frame the Knowledge Graph. Sentences are made up of sequence of words that are called Part Of Speech (POS). In English language there are different POS like noun, pronoun, verb, adverb, preposition, conjunction and intersection, this gives meaning to the sentences. SpaCy is an open source library for Natural Language Processing which is used by majority of NLP experts. This library is kept up to date which is the strength of the spaCy library. Figure 2 represents the workflow of Named Entity Recognition (NER). NER is capable of discovering entity elements from raw data and determines the category of the elements as mentioned in the document of spaCy library [22]. This model can be trained with custom training data.

Spacy is written in Python and Cython. Spacy provides a Tokenizer, a POS-Tagger and a Named Entity Recognizer and uses word embedding strategy. It has pre-trained model in several languages. The researchers have used the spaCy library to extract the information.

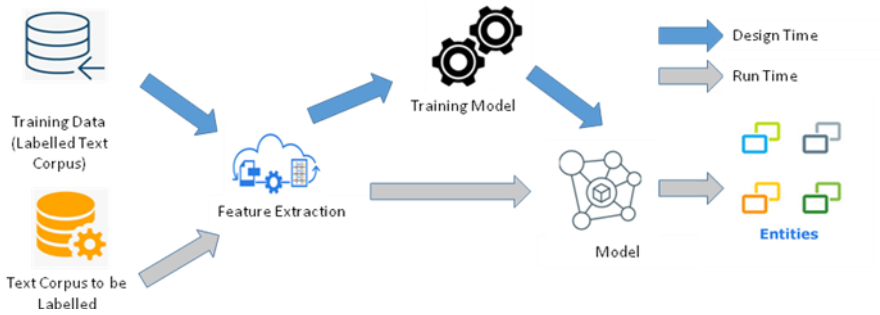


Figure 2. Workflow of NER

Phase 3 : KG Construction

Knowledge Representation brings the ability to represent entities and relations with high reliability, explainability and reusability. Recent advancement in knowledge Representation includes mining logical rules from the graph [23]. The most important thing in KG is to identify the nodes and the edges between them. The nodes are entities that are present in the sentence. Edges are the relationships that connect these entities of the sentences. A graph can be defined as a set of nodes and edges. In the figure 3 node A and node B are the two different entities and they are connected by an edge that represents the relationship between these two nodes.

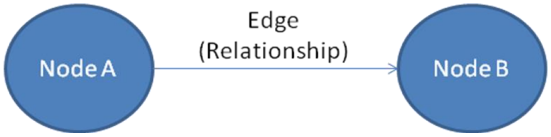


Figure 3. Sample graph

Figure 4 shows the representation of a sample knowledge graph. If Node A = "Python" and Node B = "Programming Language", then the edge between these two node would be "is" and "is similar to". A node or an entity can have multiple relations also. For example as shown in an example graph Python ***is*** a programming language and it ***is similar to*** PERL.

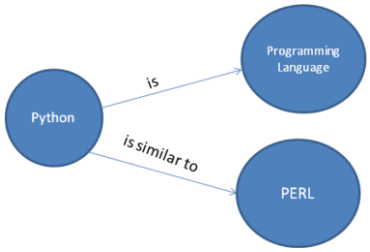


Figure 4. An example of Knowledge Graph Representation.

The approach for extracting the entity and relations in the give learning object are as follows: For the given learning object corpus the relations *'r'* can be represented in the form of $(e_{s1n}, e_{s2n}, ...)$ where $n \in 1 \ldots k$ entities in the concept set *S1*, such that e_{s1n} has relation '*r'* between them. The output obtained is illustrated in following algorithm. KG is constructed from the output entities and relations.

Algorithm for data pre-processing, concept extraction and KG construction.

Data Preparation from L.O

1. *Start*
2. $inputL.O = \{textcorpus\}$
3. *Convert the data into spaCy acceptable formate (.csv, JSON etc)*
4. *Feed the data into the model in spaCy*

Concept Extraction

5. *Use the entity type from pre-defined trained model in spaCy*
6. *If model has finished prediction then*
7. *Output the recognized entity*

8. *Otherwise go to step 5*
9. *Use entity and predicates to construct KG.*
10. *Stop.*

4. Case Study

The usability of the proposed framework is evaluated by taking 150 students. They are involved in the case study and the snapshot of their performance details are tabulated in the table 2. For convince the marks obtained by the students for 10 marks in each activities like Test, viva-voce, MCQ, Assignment and Discussion is computer for 10 marks.

Table 2. A snapshot of users, marks in learning activities and their classes

User	Test	Viva-Voce	MCQ	Assignment	Discussion	Total	Marks(10)	Class
User1	5	9	7	2	5	28	5.6	Moderate
User2	9	4	9	3	4	29	5.8	Moderate
User3	2	3	2	7	1	15	3	Slow
User4	9	1	4	8	9	31	6.2	Moderate
User5	9	4	3	8	3	27	5.4	Moderate
User6	9	2	9	4	5	29	5.8	Moderate
User7	6	5	6	6	2	25	5	Moderate
User8	6	3	2	9	3	23	4.6	Moderate
User9	2	10	9	1	7	29	5.8	Moderate
User10	10	8	5	3	1	27	5.4	Moderate

We set the threshold value (Marks) as >7.5 for highly skilled learner, >3.5 & <7.5 for Moderate learner and <3.5 for slow learner. Following were the classes of 150 learners.

Moderate 131
Slow 11
High 8

This research work uses learning object of python programming language taken from [24] and converted into .csv file format. If it is in other formats then Tika library could be used to extract the text. For concept extraction we have used open source python library called spaCy. This library extracts information from text data. From the extracted entities and relations / predicates KG is constructed for the chosen learning object. The visualization of python programming language is depicted in Figure 5.

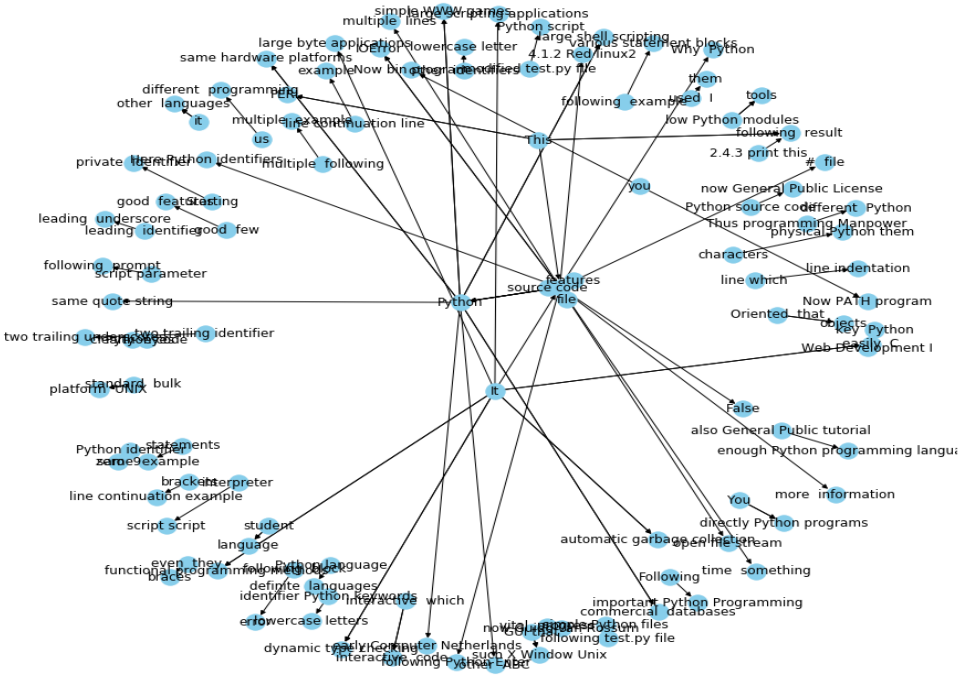


Figure 5. A snapshot of Knowledge Graph for Python Programming

Few sentences extracted from the given learning object [24] are listed below.

```
Python is copyrighted. Like Perl, Python source code is now available under
the GNU General Public License (GPL).

Python is Interpreted. Python is processed at runtime by the interpreter.
You do not need to compile your program before executing it. This is
similar to PERL and PHP.

You can add low-level modules to the Python interpreter. These modules
enable programmers to add to or customize their tools to be more efficient.

Thus, in Python all the continuous lines indented with same number of
spaces would form a block. The following example has various statement
blocks
```

Few extracted entity pairs from extracted sentences in the chosen learning object are given below:

```
[['', 'Why  Python'],
['it', 'other  languages'],
['Web Development I', 'key  Python'],
['This', 'PERL'],
['You', 'directly Python programs'],
['Oriented  that', 'objects'],
['Python', 'simple WWW games'],
['', 'Python'],
['Following', 'important Python Programming'],
['It', 'functional programming methods'],
['It', 'large scripting applications'],
['It', 'dynamic type checking'],
['It', 'automatic garbage collection'],
```

```
['It', 'easily  C']]
```

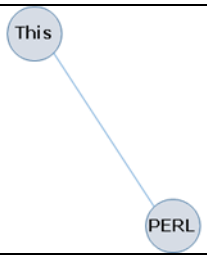
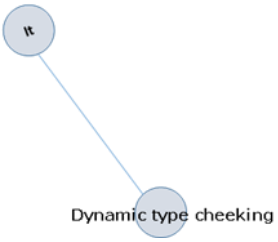
The relations or predicates that we have just extracted from the portion of given learning object are listed in the table 3 in which the numerals represents the number of occurrence of predicates in the sentences. In our example we have listed 50 predicates that are extracted from the given learning object.

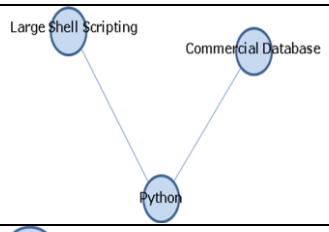
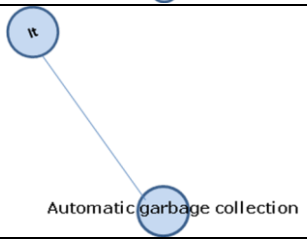
Table 3. Extracted predicates.

is 15	print 8	provides 6	supports 4	try 4
For 3	Hello 3	sys.exit 3	produces 3	else 3
file.close 3	except 3	integrated with 2	enable 2	file_finish 2
sit at 2	is similar 2	was 2	supports automatic 2	True 2
run on 2	indicates 2	Answer 2	Type 2	python 2
used as 2	are 2	break 2	Programming 2	open(file_name 2
uses English 2	supports functional 2	allows 2	has 2	maintained by 1
filename 1	file_text 1	Enter 1	Let 1	and 1
Applications of 1	del 1	ignores 1	Statements 1	test.py 1
make sure 1	made 1	start with 1	has various 1	Features 1

The collected entities and predicates are used to construct the KG. The graph provides filtering condition which enables the course teacher to provide different kind of learning content depends on the learners' learning capability. For example let's start with the relation and the embedded knowledge in the graph for highly skilled, moderate and slow learner as shown in the table 4. The course teacher / system developer can decide what to give to those learners. Core and mandatory concepts are given to the moderate and slow learners whereas the highly skilled learners are given a chance for mastering the concepts as explained in the section result and discussion.

Table 4. The entity, relation and the embedded knowledge in the knowledge graph

S.No	Relation / predicate	Graph	Knowledge Embedded in the graph (Information)
1	"is similar"		Python is similar to PERL programming Language
2	"provides"		It provides very high-level dynamic data types and supports dynamic type checking. Python provides a better structure and support for large programs than shell scripting. Provides interface to commercial database.

			
3	"supports automatic"		It supports automatic garbage collection.

5. Results and discussion

Most of the existing eLearning applications which are developed in education domain are focused on the learning instead of learners. The objective of proposed architecter is to provide learning object based on the ability of the learner. This helps the learner to learn with their learning ability. It reduces the burden of the learner. It provides freedom to the learner to learn the concept without any hesitation. Core and mandatory content helps the moderate and slow learners to learn the concept in an easy manner. At the same time, highly skilled learners can learn concepts with more exercises and application knowledge. The learning objects provided by traversing the KG with different predicate logic in different levels. Combination of different predicate in different levels can be used for the highly skilled learner to explore more related concepts.

Based in the ability of the learners the system can decide what is to be given for different learners. They get the learning objects as follows:

Let E be a set of entities and R be a relations. A knowledge graph G is defined as a set of triples like (s,r,t) where $s,t \in E$ and $r \in R$. For example $(PERL, is\,similar\,to, Python)$. Information can be retrieved from the knowledge graph by querying and traversing the graph. A path query q consist of an initial entity, s, followed by a sequence of relations to be traversed, $p = (r1, r2, ...r_n)$. The result is of the query is $\|q\|$, is the set of all entities that can be reached by traversing p. This can be represented as follows:

$$\|q/r\| = \{(t, s \in \|q\|,\ (s,r,t) \in G\} ----(2)$$

The knowledge graph is traversed and the embedded information is provided to different types of learners based on the following predicate logic. PLr_1 for slow learner, PLr_2 for moderate learners and PLr_3 for highly skilled learners.

$$PLr_1 = \{is, was, are, it, uses\,as, allows, has, produces, provides, indicates, runs\,on, etc\ \}$$

$$PLr_2 = \{\text{sup}\ ports, \text{sup}\ ports\,automatic, etc\}$$

$$PLr_3 = \{\text{int}\ egrated\,with, ma\ \text{int}\ ained\,by, etc\}$$

These three predicate logics can be generalised as follows.

$$\bigcup_{i=1}^{3} PLr = \{relation_1, relation_2, relation_3, ...relation_n\} ---(3)$$

Where

*PLr is the predicate*log *ic or relation*

Learning Objects for Slow Learner:

The Learning Object for Slow Learners (SL) can be given as follows by relating the entities with relations. Only the core concepts that are considered to be mandatory are given to the slow learners.

$$SL(L.Os) = PLr_1\{e_1, e_2, ...e_n\} - - - (4)$$

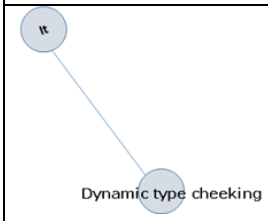
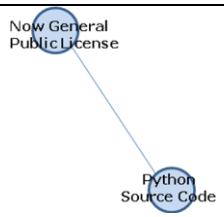
Where

$SL(L.Os) - is\ Learning Objects\ for\ Slow Learners$

$e - is\ the\ entity$

Example graph for slow learners is given in the table 5.

Table 5. Embedded Knowledge in KG for Slow Learners

$SL(L.O) = PLr_1(provides, \{it,$ *dynamic type checking*$\})$	$SL(L.O) = PLr_1(is,$ $\{$*General Public License*, *python Source code*$\})$
 It ***provides*** very high-level dynamic data types and supports dynamic type checking.	 Python source code ***is*** avalaible under General Public License

Learning Objects for Moderate Learners

Along with the core concepts in equation (4), supplementary concepts are given by adding new relations to provide the learning object using KG to the moderate learners. Here are the predicates / relations include the Learning Objects of Slow Learner and additional Learning Object that is presented in equation (5).

$$ML(L.Os) = SL(LOs) + PLr_2\{e_1, e_2, ...e_n\} - - - (5)$$

Where

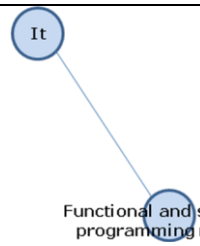
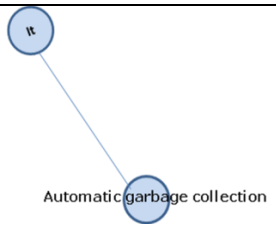
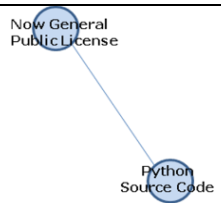
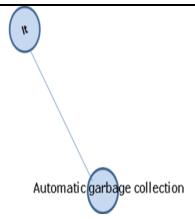
$ML(L.Os) - is\ the\ Learning Objects\ for\ Moderate Learners$

$e - is\ entity$

Example graph for the moderate learners is shown in the table 5.

Table 6. Embedded Knowledge in KG for moderate Learners

$ML(L.O) =$ $PLr_2(\sup ports$ *funcational*, $\{it,$ *structured progra* $\min g$ *methods*$\})$	$ML(L.O) =$ $PLr_2(\sup ports$ *automatic*, $\{it,$ *garbage collection*$\})$	$ML(L.O) = SL(LOs) + PLr2\{e1, e2, ..en\} \approx$ $(is, \{$*General Public License*, *python source code*$\}) +$ $(\sup ports\ automatic, \{it,$ *garbage collection*$\})$

 It ***supports*** **functional** and structured programming methods as well as OOP.	 It ***supports automatic*** garbage collection.	 Python source code ***is*** avalaible under General Public License	 It ***supports automatic*** garbage collection.

Learning Objects for Highly Skilled Learners

For the highly skilled learners along with mandatory, additional concepts other related and relevant concepts are given them to enhance their skill in learning. Here the predicates / relations include the learning objects of *SL*, *ML* and newly extracted information by including new relation for highly skilled learner or retrieved learning object from the existing learning objects of *SL* and *ML* is shown in the equation (6).

$$HL(L.Os) = ML(LOs) + PLr_3\{e_1, e_2, ...e_n\} + PLr_2\{LS(LOs)\} + PLr_1\{ML(LOs)\}) - - - (6)$$

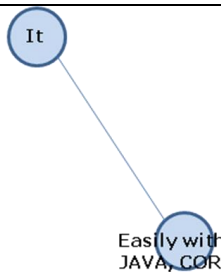
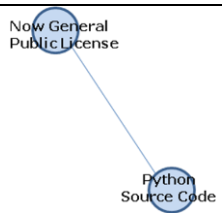
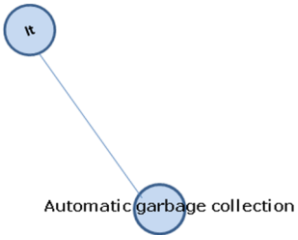
Where

$HL(L.Os) - is\ Learning Objects\ for\ Highly Skilled Learners$

$e - is\ entity$

Example graph for highly skilled learners is shown in the table 7.

Table 7. Embedded Knowledge in KG for Highly Skilled Learners

$HL(L.O) =$ $PLr_3(\text{int}\ egrated\ with), \{it,$ $easily\ with\ C, JAVA,$ $CORBA\})$	$HL(L.O) = PLr_3 + PLr_1(ML(LOs) + PLr_2 \approx$ $(\text{int}\ egrated\ with, \{it, easily\ with\ C, JAVA, CORBA\}) +$ $(is, \{General\ Public\ License, python\ source\ code\}) + (\text{sup}\ ports\ automatic,$ $\{it, garbage\ collection\})$	
 It can be easily integrated with C, CORBA, and Java.	 Python source code ***is*** avalaible under General Public License	 It **supports automatic** garbage collection.

When the learning materials are provided according to the capability of the learners, it reduces the stress level of the learners. In traditional learning method, learners are forced to learn things even though they are unable to do it. But in case of eLearning with KG, it helps the leaner to learn within their capability. This method encourages all kind of learners to learn effectively and efficiently.

We have demonstrated to extract information from a learning object in the form of triples KG is created from it. Also we have demonstrated how the learning objects are provided to the learners by traversing the knowledge graph. Traversing the graph vector and providing the embedded information is decided by the course teacher or by the system developer or the system can automatically deliver when it gets matured.

Though KGs are an asset and provide structured and semantically rich information to the learners to have personalized learning objects. The reliability of the knowledge retrieved from the knowledge graph relies upon the quality of knowledge graph. There are state-of-art validation frameworks for the validation of knowledge graph [25]. These tools could be used for validating the accuracy, correctness and the reliability of knowledge graph.

As mentioned earlier there other factors that influences the learner to understand the concepts better like motivation, geographic location, economical background, prerequisite knowledge about the concept and the availability of ICT tools. These factors also could be considered for the holistic approach in learning through eLearning applications.

6. Conclusion

Knowledge Graph concept can be applied to any domain that contains entities and relationships between them. In this research work, Knowledge Graph for Online Learners (KGOL) in eLearning system has been proposed for delivering personalized learning object. Programming with Python has been used as a case study. This research used learner profile to classify the learners into highly skilled, moderate and slow learner by using machine learning technique. Learning object on Python Programming Language is chosen, concepts extracted, entities, relations, identified and KG is constructed. For slow learners only the core and mandatory learning objects are given, for the moderate learners along with the mandatory learning objects additional learning objects are given to enhance the knowledge. The highly skilled learners are given all the learning objects to become mastery in the concept. The proposed KGOL provides an opportunity to have personalized learning objects according to their learning ability. This personalization of learning object through knowledge graph helps the learners to learn the concepts fast and an easy manner.

References

1. Go´mez-Pe´rez A, Ferna´ndez-Lo´pez M, Corcho O (2004) Ontological engineering with examples from the areas of knowledge management, e-commerce and the semantic web. Springer, London
2. Sridhar Chimalakonda · Kesav V. Nori, An Ontology Based Modeling Framework for Design of Educational Technologies, International Journal of Artificial Intelligence in Education, Springer, 2017.
3. Ayesha Ameen, Khaleel Ur Rahman Khan, B.Padmaja Rani, Creation of Ontology in Education Domain , 2012 IEEE Fourth International Conference on Technology for Education
4. Katis E., Kondylakis H., Agathangelos G., Vassilakis K. (2018) Developing an Ontology for Curriculum and Syllabus. In: Gangemi A. et al. (eds) The Semantic Web: ESWC 2018 Satellite Events. ESWC 2018. Lecture Notes in Computer Science, vol 11155. Springer, Cham. https://doi.org/10.1007/978-3-319-98192-5_11
5. O. Rodriguez Rocha, C. FaronZucker, Automatic Generation Of Educational Quizzes from Domain Ontologies, International Conference on Education and New Learning Technologies, 2017
6. https://elearningindustry.com/choosing-right-elearning-methods-factors-elements
7. https://www.javatpoint.com/knowledge-representation-in-ai
8. A. Singhal, ``Introducing the knowledge graph: Things, not strings," Official Google Blog, CA, USA, Tech. Rep., 2012.
9. Apple Inc. (2017). *Apple Siri*. [Online]. Available: https://www.apple.com/ios/siri/
10. *IBM Waston*. [Online]. Available: https://www.ibm.com/watson/, (2017).
11. *Wolfram Alpha*. [Online]. Available: https://www. wolframalpha.com/ (2017).
12. https://www.bestcolleges.com/blog/platforms-for-online-courses/
13. https://elearningindustry.com/top-open-source-learning-management-systems
14. An, J., Lee, S., & Lee, G. G. Automatic acquisition of named entity tagged corpus from world wide web. In Proceedings of the 41st Annual Meeting on Association for Computational Linguistics-Volume 2 (pp. 165–168). (2003).
15. Anna Śniegula Et.al "Study of Name Entity Recognition methods in biomedical field" Procedia Computer Science 160:260-265, DOI:10.1016/j.procs.2019.09.466
16. W. Sun and Z. Cai and Y. Li and F. Liu and S. Fang and G. Wang, "Data Processing and Text Mining Technologies on Electronic Medical Records: A Review", Journal of Healthcare Engineering, 2018:4302425, 2018.
17. C. Sutton and A. McCallum, An Introduction to Conditional Random Fields", arXiv:1011.4088 [stat], November 2010.
18. Y. Wu and M. Jiang and J. Xu and D. Zhi and H. Xu, "Clinical Named Entity Recognition Using Deep Learning Models", Proceedings of AMIA Annual Symposium, pp. 1812–1819, 2018.

19. Y. Sasaki and Y. Tsuruoka and J. McNaught and S. Ananiadou, "How to make the most of NE dictionaries in statistical NER", Vol. 9(11):S5, ISSN 1471-2105.
20. https://spacy.io/usage/spacy-101
21. Prof. Dr. Gregoris A. Makrides Professor of Mathematics, President of the Mathematical Society of South-Eastern Europe, "The Evolution of Education from Education 1.0 to Education 4.0"
22. https://course.spacy.io/en/chapter3
23. Bonatti, Piero A. et al. "Knowledge Graphs: New Directions for Knowledge Representation on the Semantic Web (Dagstuhl Seminar 18371)." *Dagstuhl Reports* 8 (2018): 29–111
24. https://www.tutorialspoint.com/python/index.htm
25. Elwin Huaman, et al, "Knowledge Graph Validation", Cornell university, 4 May 2020.
26. Penghe Chen et.al, "An automatic Knowledge Graph Construction system for K-12 Education", IEEE Access, May 22, 2018.
27. Weiguo Zheng et.al. "Question Answering Over Knowledge Graphs: Question Understanding via Template Decomposition" Proceedings of the VLDB Endowment, Vol. 11, No. 11, 2018.
28. Zhi=ongxian Bai, "Variable incremental adaptive learning model based on knowledge graph and its application in online learning system", International Journal of Computers and Applications, 10 February 2021.
29. Sijin Zhou et.al., "Interactive Recommender System via Knowledge Graph – enhance Reinforcement learning". ACM ISBN 978-1-4503-8016-4/20/07. July 2020.