A Semantic Web Model for the Personalized e-Learning

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Abstract

Personalized e-Learning is aimed in adapting the learning process of e-Learning based on needs and preferences of the learner instead of providing a one-size-fit-all learning model as in the conventional e-Learning. Exiting solutions for the personalized e-Learning depends on the metadata and various standards defined on the content and user. This paper proposes a semantic web model for personalized e-Learning through which personalization can be further enhanced. It describes a proper mechanism to handle learning content by maintaining a separate knowledge layer for knowledge representation and another one layer to store the content according to the knowledge represented in the above layer. Both the Subject Domain of the learning content and the User Profile for learner's information would be modeled using an Ontology approach in the semantic web. The proposed model generate the most matching learning path for the learner in a goal oriented way and then could be used to extract relevant learning content.

Index Terms **e-Learning, personalization, learning path, user modeling, data and knowledge representation, ontology and semantic web.**

1. Introduction

The use of Information and Communication Technologies in education could significantly change the way of learning take place. "e-Learning" is the best output of this process change and it has followed quit an impressive transformation during last few years due to internet penetration. As a result, learners are provided anytime and anywhere access removing traditional boundaries of time and place in a learning environment.

Currently, most of e-Learning systems provide a one-size-fit-all learning model which means a single set of learning resource is provided to each and every one. But learning is a highly dynamic and highly personalized activity in reality. Learner could have various needs, interests and they may belong to several level of expertise (competency levels) and hence can not be treated in a uniform way. Hence, the research community in e-learning is motivated in customization the services of e-learning systems based on the needs of the user. Such a customization would lead to serve learner's personalized need automatically by adapting ordinary e-learning services into personalized e-learning services. Personalized e-Learning adapt its learning process according to the factors like user needs, preferences, background knowledge, context, user competency, learning patterns/behavior, etc. Generally, the key objective is to identify the most suitable learning path in the exploration of knowledge based on the individual needs and requirements.

In order to provide a personalized service an e-learning systems should establish proper mechanisms to represent content and as well as to maintain learners profile to facilitate between the learners need and what is available. A proper meta-data set plays an important role in describing the content and it is selected based on the existing standards. On the other hand, a keyword set is used to describe the user/learner profile. Technically personalization is achieved by matching these keywords in the profile with profile meta-data or actual learning content. However, this mechanism was not sufficient enough to provide adequate information to provide personalized service for the satisfaction of the learners.

Semantic web is a novel approach that allows web content to be expressed more meaningfully not only for humans but also in a format that can be read by the machine, thus making finding, sharing and integrating the information easier. Ontology based modeling under Semantic web is used to increase meaningful knowledge representation and sharing for a particular domain or across different domains. Hence the semantic web modeling have been used for effective content representation for fast few years in various contexts and applications such as searching methods to improve their effectiveness and expressiveness.

This paper proposes a novel mechanism to apply semantic web modeling based on the ontology approach

to provide personalized e-learning services in a more effective way. Main focus of this paper to propose a semantic web model to present a more effective and expressive mechanism to handle e-Learning content representation in order to derive most matching content for the learner according to his need and profile. In order to come up with these goals authors emphasize the importance of maintaining a separate knowledge layer for knowledge representation and a content layer to store content according to the knowledge represented. That means that the content is stored on top of the knowledge layer. Ontology has been used in this case to represent the knowledge for the subject domain and to represent the learner's profile and this lead to serve the personalized need for a learner in a goal oriented way rather than matching selected arbitrary keywords. Hence the proposed mechanism generates the most suitable learning path for the learners.

Rest of the paper has been structured as follows. Section II describes the related work identified by authors together with a brief description of their limitation, sections III presents the overall design of the system. Section IV describes the ontology implementation details in this work and Section V describes the test results of conducted user studies. Section VI states the conclusion of this piece of research work and Section VII gives the future work by mentioning the improvement that can be carried out in the future.

2. Related work

Existing solutions for the personalized e-Learning had been carried out by addressing content representation and user profile management separately without a proper integrated solution. Most existing solutions for the content handling and representation adapt standard format for describing learning content with metadata. Sharable Content Object Reference Model (SCORM) is a typical most widely considered standardization for e-Learning products published by ADL. SCORM integrates a set of interrelated technical standards, specifications and guidelines designed to meet high-level requirements for learning content and systems. [1] User profile handling is again based on different standards like IEEE PAPI [2] and IMS LIP [3].

Research community believes that usage of metadata do not obtain all information required for advanced learning services like personalization.[4] has stated that these specifications and standards can not be used to adapt the learning content that matches with the student's objectives, preferences and knowledge level. Generally meta-data has used to describe the process details of e-Learning content with a very long set of keywords according to authors references. Hence it prevents to interpret explicit meaning with respect to learner preferences.

Above limitation motivated research community to apply semantic modeling to achieve personalization. In the literature there are some efforts in finding solutions for personalized e-Learning using the semantic web based architecture. Some of those are discussed here that relates with the work presented in this paper. [5] used semantic web to represent learning resources and their relationships. The key objective was to dynamically select, sequences and links learning resources for personalization. On the other hand [4] proposed an ontology based framework aimed at explicit representation of context specific metadata derived from the actual usage of learning objects and learning designs. [2] proposed a Framework for Adaptive Educational Hypermedia Systems by utilizing Semantic Web Resource Description Formats for automatic generation of hypertext structures from distributed metadata.

These existing methodologies for personalization tried to search particular resource that matches with the learner's need from the existing resources by comparing keywords of the user needs and metadata of the resources provided by the content author. Even though they used ontology it has been used to represent the relationships between resources. Similarity based relationship among resources is not adequate enough to describe knowledge representation on top of all these resources. Hence proposed solutions are limited with respective expressiveness and efficiency.

This paper's specific contribution is to highlight the potential benefits of improving personalization by representing knowledge and store content on top of that rather that describing existing resources. Both knowledge representation and user representation are based on the ontology that comes under the Semantic Web.

3. Semantic model for personalization

Proposed Semantic Web Model for personalization in this paper serves the personalization requirements of a learner who is interested to have a personalized service to avoid information overhead in a particular domain. However if the learner is not willing and/or if there is no information overhead, the personalization given here is not an applicable approach. For the simplicity of implementation as well as for the clarity of presenting our approach authors has selected the subject domain of "learning JAVA programming language". At the same time a learner is not a beginner who wants to get this service. However concepts and methodologies described can be applied in other domains too.

Subject domain for a particular course module would be modeled using an ontology in a way that gives common understanding of that subject domain. This step has to be carried out with the involvement of the subject matter expert (SME) for the subject. Content provided by SME for a particular subject will be stored in a resource library according to the represented knowledge in the subject domain ontology by maintaining separate content layer and knowledge layer. Once the user selects his goal or learning objective in the JAVA course, it will be mapped with the JAVA domain ontology under the process of the ontology mapping by considering the learner's objectives and objectives of designed JAVA domain ontology.

This mapping allows searching for the knowledge user desire to obtain and then extracting the content matches to the knowledge while traditional approach was blindly search the knowledge from the content by using metadata defines on the resources.

Output of the mapping of user objective and domain ontology will be further validated using the ontology built on the user profile. Here we assume the user has maintained up to date profile to represent his/her learning objectives in the course. User profile is dynamically updated allowing continuously assesses in order to keep up to date details of the user. The Ontology built on top of the user profile is modeled based on background knowledge, competency level and preferences.

Mapping the user objective with the domain and user profile would result in a new learning path that can be considered as a representation of the extracted knowledge from the subject domain. At the same time it can also be considered as a particular sequence of learning content after attaching the necessary learning resources. If it is necessary this generated learning path would be further validated by conducting a questionnaire/pre-test in order to assess the user's background knowledge in necessary areas.

Generated learning path after testing background knowledge can be considered as the most optimum learning path with respect to user's objective and which compiles with the user's interest, background knowledge, competency level and preferences. The browser for the learning resource library selects the content or learning materials according to the generated learning path and it is the personalized service of the system.

When a user follows a course module, it is assessed by the system when a user completes each stage by using the questionnaire/post-test. This results are used to update the user profile. Hence this will facilitate the continuous refinement in the personalization process. Figure 1 gives the overall design of the prototype system built to evaluate this model.

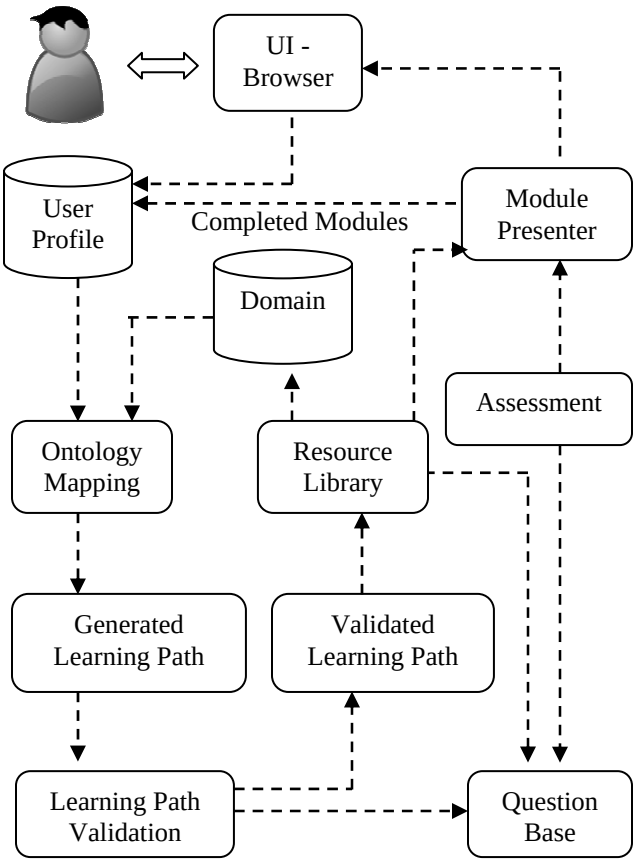


Figure 1. Overall Design of Semantic Model

3.1 Component of the model

3.1.1 Domain ontology. Domain ontology component include the ontology that is designed to represent the domain of the subject. In the prototype system developed authors have built a Java Domain Ontology representing the concepts and relationships of the "Learning Java programming" domain. It is possible to extract of subject domain information through traversing this ontology and this feature helps to identify different learning path in the ontology. Another important feature is the required prerequisite concepts with respect to each concepts identified in the domain. Subject Matter experts identify these prerequisites. It is a kind of a heuristic but it has a direct influence on the success of personalized process.

This Ontology is written using the Ontology Web Language (OWL). Designing the Java domain ontology should be handled with the involvement of the SME (Subject matter expert) who provides the learning

resources. There are tools available that can be used to design the ontology like Protégé which makes easier the lecturer or content authors tasks.

3.1.2 Resource library. Resource library/repository attached to the relevant Domain Library is responsible for providing the relevant learning materials. With respect to metaphor of classes and library, the ontology defines the concepts in the domain as classes the resources similar to the objects under the class hierarchy. (i.e. concepts defined in the subject domain) Each learning material will include the learning objective it holds and the relevant competency level that a particular learning material matches with. There are three system level competency as beginner, intermediate and advanced. Defining relevant competency level for the resource is Subject matter expert.

3.1.3 Question base. Resource library/repository is also correlated with the Question Base which consists of large collection of assessment questions that are used by the learning path validation process and assessment. This leads to store the questions that matches with the learning objects identified in the domain ontology and competency levels system support.

3.1.4 User profile ontology. Learner modeling that can be identified as one of the most critical aspects in any personalization environment is handled by using the user profile ontology. Initially user has to give his or her general information, goal or objective currently plan to follow and his preferred preferences like language, file type and device type and initial profile is built using that information.

Background knowledge about the learner which can be helpful to achieve learner's objective will not be gained directly from the learner because there might be a situation that learner have wrong measurements of his knowledge or the background knowledge he already got might not be in the expected level system requires. Identifying the background knowledge is done at the later stage after generating the learning path. User can initially request lessons from a competency level they desire but system will validate their competency level from the questionnaires starting from the beginner level and then decide the competency level they deserve in order to achieve their learning goal.

User profile ontology is again modified in the later stage if the learner successfully completes the tests associated with his/her objectives. At that point learner's competency level along with the achieved date will be updated in the user profile. User knowledge validation along with the time have been identified as a major issue in this process and as a proposed solution, knowledge validity period would be defined by the system according to the grades obtained at the assessment phase but this period would be a constant period for any body. This issue, how to ensure someone's knowledge along with the time on a particular domain, is not within the scope of this piece of work. Therefore, the suggested choice for the knowledge validation might not be the perfect solution but it improves performance of the system in to certain extends.

3.1.5 Ontology mapping. Ontology mapping component analyze the learner's objectives and objectives of given in the domain ontology without blindly searching for the content. It will generate a learning path which is a sequence of learning objects (node represents concepts in the domain ontology) that should be followed in the proper sequence by the learner in order to achieve a specific learning goal.

3.1.6 Learning path validation. The generated learning path has to be validated further in order to clarify the user's background knowledge if it is adequately not in the system. Hence a special questionnaire will be used to capture the background knowledge at the beginning. At the same time, the system interacts with the learner to access the competency level with respect to background knowledge.

This component present set of a questionnaire that covers the background concepts/objectives with respect to the learning path to check the learner's background knowledge of those contexts. Questions are extracted from Question Base according to the concept and competency level. While carrying out this process system have the capability to remove necessary nodes from the learning path that user has already proved his fluency according to the particular competency level as depicts in the figure 2.

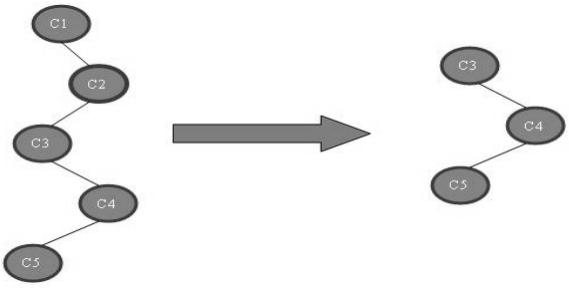


Figure 2. Learning path validation

3.1.7 Assessment. Assessment component make sure that the learner correctly proceeds with the provided learning materials and updates the user profile ontology about the completed courses with the acquired competency level up to that point and also specifies the validity period of the knowledge.

The way learner performs for the assessment leads the system to decide about the competency learner obtained through the system and take necessary actions accordingly.

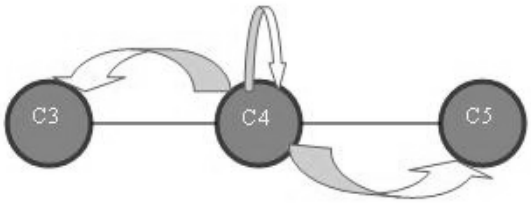


Figure 3. Assessment

- If learner has obtained sufficient mark to prove his competency system allows him to move on to the next chapter (next learning resource identified according to the path) and update the profile
- Learner have not obtained sufficient mark to move on to the next chapter he will be directed the current chapter (learning resource) again
- If learner performs poorly, the system suggests him to backtrack and will direct him to the previous chapter (relevant resource) again

Figure 3. depicts those actions

4. Ontology implementation for the prototype

The domain ontology and the user profile ontology would be the major components of the system which is responsible for representing the knowledgebase of a particular subject context or domain. Ontology Web Language (OWL) is the w3c standard ontology language for the semantic web to design ontology. OWL allows formalizing a domain by identifying concepts in the domain as classes and specifying relationships between those classes [6]. Protégé 3.3.1 which is a free and open source ontology editor and knowledgebase framework which is used by system developers and domain experts to develop knowledge based system have been used to design Java Domain Ontology and User profile Ontology [7]. Proposed solution use Protégé 3.3.1 for developing Java Domain Ontology and User Profile Otology. OWL DL that supports maximum expressiveness without loosing computation completeness has been used.

4.1 Java domain ontology implementation

Java Domain represents the concepts covered under JAVA and represents the relationship between identified concepts. Figure 4 represents a part of the OWL code developed to show how to define classes and relationships.

Other than the object properties which define the relationships between concepts covered there are other data type properties.

```
<owl:Class rdf:ID="JAVA">
  <rdfs:label rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >JAVA Ontology</rdfs:label>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string">
  An example ontology for JAVA</rdfs:comment>
</owl:Class>

<owl:Class rdf:about="#Object_Oriented_Programming">
  <rdfs:subClassOf rdf:resource="#JAVA"/>
</owl:Class>

<owl:ObjectProperty rdf:ID="implements">
  <rdfs:range rdf:resource="#Object_Oriented_Programming"/>
  <rdfs:domain rdf:resource="#JAVA"/>
</owl:ObjectProperty>
```

Figure 4. OWL code segment for defining classes and relationships

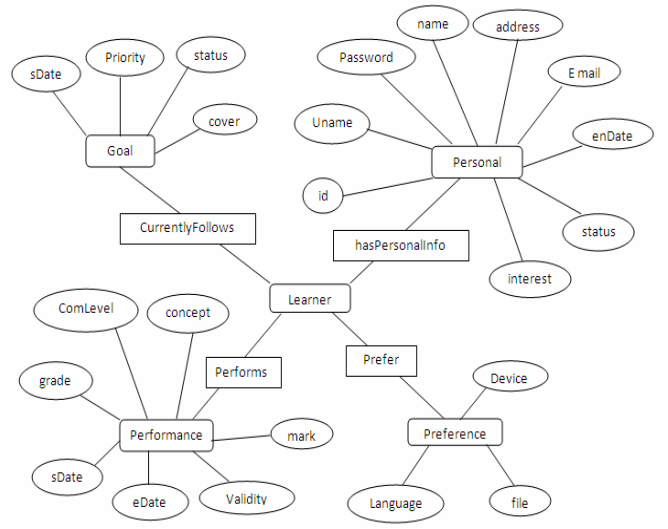
- *lesson_no:* identification of the concept
- *Prerequisite:* prerequisite for a particular concept
- *level_of_competency*
- *independent: Independence of a lesson*

Assignment of values to the data type properties for concepts form an instance or individual and in our case instances of the concepts would denote the actual learning resource that has categorized by considering several factors. Any concept must have three lessons that is categorized according to the competency level such as beginner, intermediate and advanced. Figure 5 shows the sample code for a instance that is formed for Input and Output with values assigned.

Figure 5. Resource Instance for JAVA Domain

```
<Input_and_Output rdf:ID="Input_and_Output_3">
   <lesson_no rdf:datatype="http://www.w3.org/2001/XMLSchema#string>
            6.2
   </lesson_no>
   <prerequisite rdf:datatype="http://www.w3.org/2001/XMLSchema#string>
            Java_Statements
   </prerequisite >
      <prerequisite rdf:datatype="http://www.w3.org/2001/XMLSchema#string>
            Object_Oriented_Programming
   </prerequisite >
   <independent rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean>
   </independent>
</Input_and_Output>
```

Figure 6. Basic structure of the user profile



4.2 User profile ontology implementation

User profile is responsible for keeping the track of user's information regarding the context of his/her learning and it supposed to be continuously updated. In the prototype implementation, user profile is developed considering the factors which affect the learning process within this solution context in order to provide a personalized service but this prototype is not a fully featured required for other service implmentation.

The structure of the user profile consists of user's currently following goal, user's personal information, user's performance and user's preferences as depicted in the user profile. User performance is the most important part of the user profile because it tracks the concept user have already covered, competency level completes along with their marks and grade. The start day that user begins to follow the system and the end day user completes is also taken into consideration under the user profile. The valid until property keeps track of the threshold day that system accepts user is aware of that concept into this competency level. Due to the fact that learners forget what they have learned, validity date represents as a threshold that system uses to check whether learner really aware of those concepts or not.

Personal information keeps the learner information in general and preferences keep information of his preferred language, device type and file type. Goal stores learner's currently progress goal in here. Figure 6 depicts the basic structure of the user profile and Figure 7 depicts the sample owl code for a learner instance.

```
<Learner rdf:ID="s1">
    <hasPersonalInfo rdf:resource="#Personal_s1_1"/>
    <currentlyFollows rdf:resource="#Goal_s1_1"/>
    <prefer rdf:resource="#Preference_s1_1"/>
    <performed rdf:resource="#Performance_s1_1"/>
</Learner>
<Goal rdf:ID="Goal_s1_1">
        .....
        <goal_Covering_Concept rdf:datatype="http://www.w3.org/2001/XMLSchema#string">
                Object_Oriented_Concepts
        </goal_Covering_Concept>
        .....
</Goal>
<Performance rdf:ID="Performance_s1_1">
    <Performed_Competency_Level rdf:datatype="http://www.w3.org/2001/XMLSchema#string">
        Intermediate
    </Performed_Competency_Level>
    <conceptPerformed rdf:datatype="http://www.w3.org/2001/XMLSchema#string">
        3
    </conceptPerformed>
    .....
</Performance>
```

Figure 7. Code Segment for Learner Definition

In advance user profile has the capability to handle every use's profile information who logs in to the system within the same OWL file without any overhead because it is simply a text file

For further implementation Protégé-OWL API have been used and it is an open-source Java library for the Web Ontology Language (OWL) [8] and have been designed in a way for the development of standard alone applications (e.g., Eclipse plug-ins). This API has been used for implementing the functionalities of the proposed solution by creating OWL data model from the previously designed ontology's. Protégé-OWL API supports manipulating the OWL data model. Further implementation details are given in the dissertation. [9]

5. Testing and Evaluation

Testing have carried out to verify that the ability of the proposed semantic web model in generating the most suitable set of learning resources for the learner that matches with learner's personal goal or objective. It should accomplish the fact that learner should be learned successfully or in other words learner should be able to accomplish his goal or objective with the better performance on the generated learning path with generated set of resources.

Testing have been carried out using two approaches

- Generated learning path validation
- Measure learner performance on the generated learning path in comparison to the conventional e-Learning

5.1 Testing Procedure

5.1.1 Generated learning path validation. System generates the learning path by considering the information obtained from the domain ontology and user profile ontology along with the learner specified goal. Since basic learning path is generated using the domain knowledge representation it is possible to verify the system basically generated learning path along with the knowledge representation of the domain. Once system is generated the learning path that learning path can be verified with the expert designed domain because expert designs the domain by implicitly guiding the learning paths by specifying concepts and corresponding relationships between concepts. After that system validate the generated path with the user specific information in the user profile and this again can be verified manually with the help of the information stored in the user profile.

5.2.2 Measure learner performance. The generated learning path would be the most suitable learning path for the learner if learner can perform well through that learning path. In any situation a learner could not ideally finish the learning process that means it is impossible to find the best and complete performance from a learner because learning is highly personalized. What can be done is a comparison between conventional learning system and the proposed learning system and measure the performance difference of the learners.

Testing is conducted in both environments and one uses the proposed system that implements semantic web model and the other use conventional e-Learning system. Same set of learning resources are provided for the conventional e-Learning system that is used by the proposed system and resources are categorized as beginner, intermediate and advanced. These resources follow the conventional learning path that is defined default.

Testing has been carried out using 10 selected students who have the desire to learn JAVA. These samples have been chosen from the ICT first year students at UCSC. These students do not taught JAVA before but all of them are familiar with the computing and have some programming experience. Even though they do not know JAVA they have the understanding of what are programming languages and its context. Sample student belongs to the same age group, consists of 6 male students and 4 female students and within the period that test have been carrying out they were asked to not to follow any outside JAVA learning materials.

Students divided into two groups to follow the suggested system and conventional system. Student uses the proposed system to choose their goal from the concept list provided and the relevant competency level. Same goal with the same competency are given for the set of students who follow the conventional system. That means there is a couple of student that follows the same goal in the proposed environment and conventional environment. Students have a fixed time to finish their lesson according to the competency level they have selected. After a one day conducting the learning process both groups are given a paper to answer prepared based on the goal they have selected. Marks obtained are analyzed to measure the performance of the proposed system.

Initial test includes only 10 students to verify functionality and applicability of the concept given in this paper. . However detail testing is supposed to be done in the future to make the final contribution of the paper.

5.2 Test Result

5.2.1 Generated learning path validation. Generated learning path validation performed by considering each and every single concept (prior to the background test) and all of them is consistent with the path defined in the domain. That means system deliverables (learning paths) are consistent.

5.2.2 Measure learner performance. Students choose following concepts as their goal while conducting the testing with the mentioned competency.

	Goal	Competency
1.	Data Type	Intermediate
2.	Selection Statement	Beginner
3.	Overriding Methods	Advanced
4.	Exception Fundamental	Intermediate
5.	Thread	Beginner

Same goals gave to the learner's that use conventional e-Learning system also.

Table I shows the marks obtained by student that have been carried out.

5.2.3 Evaluation of the result. Validating the generated learning path verified that the generated learning path would be the most matching learning path according to the domain knowledge represented and the user profile information.

Looking at the results in the Table I it can be clearly seen that the all of the students use the proposed system have scored more than 70 and three out five students uses the conventional learning system have scored below 65 but none of the student have scored less than 65 from the students who use the proposed solution.

Comparing the results of a particular goal with conventional system and proposed systems concepts

Overriding Methods, Exception fundamental and Thread have shown clearly better performance in using proposed system. But concept Selection Statements show poor performance in using proposed system and the concept Data Type performs almost same performance in using

Goal	Competency	Marks Obtained for the Proposed System (Out of 100)	Marks Obtained for the Proposed System (Out of 100)
Data Type	Intermediate	82.65	79.58
Selection Statements	Beginner	80.3	88
Overriding Methods	Advanced	76.47	58.33
Exception Fundamental	Intermediate	79	64.85
Thread	Beginner	72	50

Table 1 – Marks comparison of proposed system and conventional system

proposed system with the conventional system.

When analyzing the results derived it can be seen that the concepts that does not show any significant difference that depicts poor performance are simple (primary) concepts like Data Type and Selection Statement. Results would become more significant when learner tried to learn more advanced concepts like Overriding Methods, Exception Fundamental and Thread. When consider those results their performance in using proposed system is really interesting.

Conclusion that can be obtained from the above result is that proposed system work well when there are more advanced goals to be achieved that consists of more advanced concepts but with simple goals that consists of more primary concepts may be the conventional system would work better or both may show same performance.

Explanation for the mentioned behavior can be analyzed as follows. When there are more complex concepts to learn it is hard to identify which concepts should be covered in order to accomplish that complex concept from the largely defined domain. In that case serving their goal of learning with the help of the domain knowledge, user awareness and proper background testing would be much helpful to learners to accomplish their personal goal or objective. When follow simple (Primary) concept it is possible to follow the conventional learning path because even in the conventional learning path more simpler or primary concepts are presented at the beginning of the learning path. Students do not meet any specific personalized path for simpler concepts.

6. Conclusion

The proposed model in this paper could provide an effective personalized service. To implement the suggested approach proper representation of the knowledge was the biggest challenge. This Objective has been achieved using Ontology approach in semantic web. Evaluation results have proven that the path system generates would be valid with the path defined in the ontology and that implies learning path is consistent with the domain. Also finally generated learning path was consistent with the user profile as well like mentioned in evaluation. But this suggested approach may not be applied to normal web personalized service because it is hard to identify the knowledge user is looking for in those scenarios. In the context of e-Learning environment, it is feasible because e-Learning has a more firm structure for the learning content in the course. In the e-Learning environment responsible person for a particular course module or course coordinator (known as the Subject Matter Expert) has to play an important role in defining have the scope and structure of the course module.

Defining the domain in a consistent way is really important to the whole success of this piece of work. Incorrect deviation of the knowledge the learner looking for would degrade the expected performance. But one drawback met while preparing resources for several competency levels there are certain simple concepts that it is hard to design resources that match with several competency. Representing the domain knowledge and user profile using an ontological approach allows more efficient mapping in generating the learning path. Otherwise information used in the user profile can be maintained even in a database but representing user profile in ontology allows easier mapping with the domain representation hence it allows to interpret the information stored in two ontologies in an uniform way.

According the evaluation results it is clear that proposed solution's result becomes significant when user is looking for advanced concepts because advanced concepts have complex relationships with the other concepts resides in the domain ontology. Ontology has the capability to interpret these advanced concepts in terms of relationships defined in the ontology and provide an accurate learning path. When consider the primary concepts conventional learning path defined by the content author would be suitable for a learner as the path generated by the system. Even though this is not the ideal solution for the personalization e-Learning this provides a

good foundation to improve upon to the research community.

7. Future Work

System currently serves the facility to represent the domain knowledge representation for a particular subject. But this can be extended to integrate several subject domains and ontologies provide necessary facilities to integrate different domain because ontology have the capability to import other ontologies as well. This kind of integration would be helpful to generate more expressive learning path because relationships between different domains can be interpreted also.

Currently system serves personalization by identifying learner's goal or objective from the given concept lists based on the domain. This can be extended to get the user inputs directly mentioning their goal of learning and then use natural language processing to semantically interpret the user's goal as needed by the system.

Currently domain expert who design the knowledge base must have some understanding of ontology when designing knowledge base. Even there is a user friendly tool for designing the knowledge base domain expert must aware of the concept of ontology. This can be extended by providing a user friendly highly interactive environment for lectures or content authors to design the knowledge base.

System has predefined competency level defined as beginner, intermediate and expert. Future work can be carried out to define these competency levels in a more dynamic way by assigning intermediate value between defined competency levels.

Future work can be carried out towards building the proposed solution as a plug in for any learning management system or it can be plugged in to the Moodle as well.

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