



# An ontology-based adaptive personalized e-learning system, assisted by software agents on cloud storage



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## ABSTRACT

E-learning and online education have made great strides in the recent past. It has moved from a knowledge transfer model to a highly intellect, swift and interactive proposition capable of advanced decision-making abilities. Two challenges have been observed during the exploration of recent developments in e-learning. Firstly, to incorporate e-learning systems effectively in the evolving semantic web environment and secondly, to realize adaptive personalization according to the learner's changing behavior. An ontology-driven system has proposed to implement the Felder-Silverman learning style model in addition to the learning contents, to validate its integration with the semantic web environment. Software agents are employed to monitor the learner's actual learning style and modify them accordingly. The learner's learning style and their modifications are made within the proposed e-learning system. Cloud storage is used as the primary back-end in order to maintain the ontology, databases and other required server resources. To verify the system, comparisons are made between the information presented and adaptive learning styles of the learner along with actions of agents according to learners' behavior. Finally, various conclusions are drawn by exploring the learner's behavior in an adaptive environment for the proposed e-learning system.

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## 1. Introduction

The emerging semantic web needs to develop an e-learning system which focuses on personalized and adaptive learning style of learners rather than just content delivery. Current E-learning system of read/write web (web 2.0) is facing some challenges to meet the requirements of semantic web (Web 3.0). Some issues of current e-learning system are to manage huge continuous growing e-learning content on the internet, searching an appropriate e-learning content as per the learner's requirement, represent knowledge in machine readable format with reasoning capability and also to allow reuse of e-learning material. All these issues are addressed by using ontologies for storing e-learning content and building an e-learning application for the semantic web. The ontology presents the course taxonomies in an unambiguous format which is its main resolution. Machine-readability and parsing capabilities of ontology makes it ideal for collaborative purposes. The knowledge base can be shared with other applications of similar intent. In our proposed e-learning system, the detail of personalization is stored appropriately in ontology, based on the Felder-Silverman model [1] and dynamic changes are notified by JADE agents. Ontology provides personalized e-learning content as the learner's requirements change

dynamically and the agents capture these changes in learning style and store this information in the ontology. The agents collaborate to thus provide accountability for adaptive learning. To store ontologies we require an expanded and secure environment, thus the entire system is deployed on DigitalOcean's remote cloud host. Cloud can store incremental e-learning content and also provides security by preventing unauthorized access of e-learning content. By overcoming these issues we can develop an effective and enlightening ontology driven personalized and adaptive e-learning system.

The rest of this paper is structured into 6 sections; initially we focus on introduction of paper in Section 1. In Section 2, foundation provides an overview of technologies used to propose our system, like, e-learning, ontologies, cloud computing for storing ontology and multi-agents architecture for interaction among agents. In Section 3, we explain the methodology details with the specification related to the actual technologies engaged on the basis of the foundation of the system. Methodology mentions the technologies used like Felder-Silverman learning model, ontology building tools and languages, DigitalOcean's cloud hosting and multi-agent architecture for development of proposed ontology driven adaptive & personalized e-learning system. Section 4 shows experimental results, which will affirm the content provided to the learner by the system, by imitating to the learner's learning style. It also mentions the agents' actions and their impact on the adaptive nature of personalization realized by the system. Followed by Section 5, in which Learner's dimension,

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Instructor dimension, Course dimension, Technology dimension and the Design dimension are used to evaluate the effectiveness of the proposed e-learning system. Finally, Section 6 draws conclusion and future research opportunities in the current e-learning scenario.

## 2. Foundations

### 2.1. E-learning and readiness

E-learning has gradually emerged as one of the most frequently used technologies in the modern era. The importance of e-learning is highlighted through emphasizing learning techniques as well as patterns. Hisham et al. has briefly defined it as a learning platform that utilizes information and communication technologies as well as electronic media. They also implied a number of alternative terms for e-learning such as technology enhanced learning, computer-based training, online-education, and others [2]. This definition quite immensely generalizes the utility of e-learning, which is of high importance, as the scope and approach of constructing an e-learning system is heterogeneous. Focus on a particular design of a system may vary completely from another design and heterogeneity in it leads to segregation of research areas within e-learning. Various segregations require different approaches to actualize the desired system.

A few studies have been reviewed in order to concisely comprehend the readiness of e-learning as a field. A study in 2004 conducted by the U.S. Coast Guard (USCG) focused on the validation of e-learning readiness and was achieved internally via checking the consistency of objects assigned to the development of self-assessment. Data obtained from it, was later employed as a guide for better enhancements that seemed fit for the development of numerous instruments working towards the cause. Respondents included members from the USCG within the age range of 17 to 34. Despite the study focusing on online learning, the respondents didn't have to actively use any online courses. The assessment of results confirms the potential in terms of validation and consistency, and it also shows indication of a good prediction tool in determining e-learning performance [3].

In 2005, Directors of Human Resource Department of, several companies in Turkey started an initiative to assess e-learning readiness in emerging countries. Top 100 companies in Turkey have been selected to become a part of a survey, by the Istanbul Chamber of Industry (ICI), from it's of 500 Major Industrial Enterprises of Turkey, published in 2001. While achieving a precise review of their e-learning readiness, they arrived at a conclusion to develop the companies' HR structure before proceeding with the integration of the online courses [4].

In 2006, a study focused to unravel the readiness among the teachers of an institute, rather than its students, was conducted by the academic staffs and deans of the International Islamic University Malaysia. The study underlined two factors, which played a crucial role in determining their readiness, e-learning training and confidence. However, it was suggested that their improvement hinged upon the infrastructure of the institute. The study also concurred that gender did not play a factor among its respondents [5].

In 2008, a study was conducted to review the feasibility in the health department, which was done by the nurses in Flemish hospitals in Belgium. The analysis also highlighted the necessity of training along with determining the importance of strict protocols involving work hours. It also emphasized the importance of transparency between communication involving the developers and people in charge of hospital policies [6].

In 2011, the focus of assessing e-learning readiness was to candidly determine its acceptance among students of different levels of proficiency in a subject. A group of undergraduate students studying English as a Foreign Language were selected from the King Khalid University in Saudi Arabia as respondents. The study showed a complete acceptance in e-learning integration in their environment [7].

In 2013, a study was conducted to determine the readiness of Ph.D. scholars in the Christian University of Thailand. Students were selected from various years into their research and the aspects taken into account, while quantifying their acceptance were technology access, online audio/video, importance to success, internet discussion, online skill and relationship, and motivation. As a whole, the study uncovered a great extent of e-learning readiness, wherein, technology access proved to be the most promising aspect while motivation was the least. The difference in demographics, according to their year in research or gender had no significance at the readiness level [8].

In 2015, Satpute et al. reviewed several prototypes engaged for educational needs and compared their usability to find the advantages of using Augmented Reality (AR). Web 2.0 tools were also examined to understand the combined use of the two technologies. They concluded by asserting better results in educational achievements come through by combining technologies. AR enhances immersion and engagement, whereas web 2.0 supports social interaction and collaboration [9].

### 2.2. Ontology – type, specification languages, development methodologies and various application areas

The learner personalization details as well as the taxonomy of learning resources will be maintained in ontology. There have been many attempts to define an ontology, though all of them have described the same concept but from different perspectives. However, in 1998, Studer et al. made an attempt to define the term while keeping in consideration, all the contemporary perspectives and stated that – “An ontology is a formal, explicit specification of a shared conceptualization” [10], the definition which needs a thorough explanation to decipher a comprehensive understanding. The word formal implies that the knowledge or content represented by the ontology is stored in a format understood by computers, which makes parsing the content, trivial. In the paper, DL Query<sup>1</sup> is used as the query language to parse the data. The explicit specification means that no relationships or concepts depicted by the ontology can be assumed or is implicit. Every property and relationship must be listed in its entirety, with none left to be assumed, which could result in multiple inferences. Finally, shared conceptualization reflects knowledge and its constituent conception to have a definition entirely agreed upon. This entails that the content represented by the ontology is universally accepted and only has a single perspective and context to understand. In the system, domain ontology is used, as the personalization to be demonstrated is done sufficiently through a localized batch of concepts pertaining to a specific domain. Elaboration is needed for the development of domain ontology to provide personalized e-learning.

#### 2.2.1. Ontology definition from the prospective of e-learning an application area

- Having a formal representation of knowledge is helpful in interoperability within heterogeneous e-learning environments.
- Explicit specification goes towards the enhancement of exhaustive learning by not making assumptions on the implicit nature of the information or the learner's style.
- Shared conceptualization ensures that the knowledge being stored and used, has no ambiguity or over its definition.

Elaboration is needed for the development of domain ontology to provide personalized e-learning. There have been few attempts at creating domain ontologies to meet the e-learning demands, even though its importance is substantial.

<sup>1</sup> DL Query, Protégé wiki - <http://protegewiki.stanford.edu/wiki/DLQueryTab>.

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