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A proposed paradigm for smart learning environment based on semantic web

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ABSTRACT

The current approaches of e-learning face challenges, in isolation of learners from learning process, and shortage of learning process quality. The researchers mentioned that the next generation of e-learning is e-learning ecosystem. E-learning ecosystem has many advantages, in which, learners form groups, collaborate with each other and with educators, and content designed for interaction. E-learning ecosystem faces some issues. It applies teacher-student model, in which, fixed learning pathway is considered suitable for all learners. Consequently, learners are presented with limited personalized materials. E-learning ecosystem needs to merge the personalization's concept. Semantic web ontology based personalization of learning environment plays a leading role to build smart e-learning ecosystem.

This paper previews a detailed study which addresses research papers that apply ontology within learning environment. Most of these studies focus on personalizing e-learning by providing learners with suitable learning objects, ignoring the other learning process components. This paper proposes and implements framework for smart e-learning ecosystem using ontology and SWRL. A new direction is proposed. This direction fosters the creation of a separate four ontologies for the personalized full learning package which is composed of learner model and all the learning process components (learning objects, learning activities and teaching methods).

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1. Introduction

Recently, the need for improving e-learning system is increasing continually (Pocatilu, Alecu, & Vettrici, 2010). E-learning systems face many challenges, including segregation of learners, lack of educators' feedback, shortage of learner collaboration in learning process, and shortage of learning process quality (technology, resources and support services) (Uden, Wangsa, & Damiani, 2007). The improvement and development of the e-learning solutions is necessary (Pocatilu et al., 2010). The researchers show that the solution lies in e-learning ecosystem (Dong, Zheng, Yang, Li, & Qiao, 2009). E-learning ecosystem has many advantages. It enables learners to form groups and collaborate with each other. The content in e-learning ecosystem designed for interaction. Though it faces challenges in adapting new tools and technologies, integrating new learning approaches, addressing learning process based on learners' various preferences and needs (Gütl & Chang,

2008). In addition to, the current approaches of e-learning ecosystems support one-to-many learning style. This approach mentions that there is a fixed learning pathway suitable for all learners, ignoring the many-to-one or many-to-many learning styles. (Chen, 2009; Rey-López et al., 2009).

The web includes large amount of learning content. The learners search the web to collect information and form knowledge about a specific topic (Azevedo & Aleven, 2013). The continuous growing of learning resources causes information overload problem. The problem increases when a large amount of irrelevant search results are generated from search engines based on keyword matching techniques. To fix this problem, the learner wants to receive search results about learning resources using semantic matching techniques. (Y.-F. Gu, 2013).

In recent years personalization is considered a crucial in many fields, like e-learning, e-commerce, digital libraries, tourism and cultural heritage, and travel planning (Carmagnola & Cena, 2009; De Oliveira, Bacha, Mnasser, & Abed, 2013). Personalization is a process that supplies the user with the best support in accessing, retrieving, and storing information based on various characteristics

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of the individual users. A simple comparison between traditional and personalized learning environment (Kurilovas, Kubilinskiene, & Dagiene, 2014) is shown in Table 1:

There is no doubt that the ontology is considered the future for the learning environment. Ontology represents the learning resources in a new manner that enables machines to interpret and process them (Torre, 2009). Ontology is considered a core component of semantic web which supports the learning process personalization and improves the competencies of e-learning systems (Huang, Liu, Tang, & Lu, 2011, pp. 258–267).

One of the most acceptable and well-known definitions of ontology is Gruber's: "ontology is an explicit specification of a conceptualization" (Alimam, Seghioeur, & Elyusufi, 2014). Researchers and developers of e-learning system become more interested in reusing and sharing educational content. In addition, they need a precise determination of learners' preferences and needs. Ontology is the solution. It supports more accurate and faster retrieval for educational material based on various learners' needs and preferences (X. Wang, Fang, & Fan, 2008, pp. 468–476).

One major drawback in sharing knowledge is the various systems use of various concepts for representing domains. These variations create a difficulty in sharing and reusing knowledge in another system (Luna et al., 2015).

Ontology determines explicitly and formally the concepts that belong to the learning domain, their properties and relationships. Furthermore, ontology is used as the backbone for different systems: it facilitates reusing of knowledge through sharing a common concepts. Constructing such reusable ontologies is a significant goal of ontology research (Bürger & Simperl, 2008; Vesin, Ivanović, KlačNja-MilićEvić, & Budimac, 2012).

Ontology supports the creation of new version of e-learning ecosystem adapted to the learners' various preferences and needs (Cheng, Du, & Ma, 2008). Ontology represents knowledge in a precise way. It introduces the relevant materials to the learner (Saleena & Srivatsa, 2015; Sun & Mushi, 2010). It changes the ways to design, develop and deploy educational systems (Malik, 2009).

Ontology motivates the e-learning ecosystem domain to adopt it for achieving many objectives, ranging from representing the learning objects as taxonomies, annotating and indexing them to improve collaboration, accessibility, and personalization functionalities (Brut, Buraga, Dumitriu, Grigoras, & Girdea, 2008; Capuano, Gaeta, Orciuoli, & Ritrovato, 2009; Huang, Ji, & Duan, 2010).

Learners have various preferences and needs like learning styles, a prior knowledge, performance, cognitive abilities, and learning goals (Baldoni, Baroglio, & Henze, 2005, pp. 173–212; Chrysaifiadi & Virvou, 2013; Dominic & Francis, 2015; Q. Gu & Sumner, 2006; Halimi, Seridi-Bouchelaghem, & Faron-Zucker, 2014; Jamuna, Ashok, & Palanivel, 2009; Kurilovas, Kubilinskiene, et al., 2014). Educational institutions should personalize their learning environment based on the various characteristics of their learners (Kurilovas, Zilinskiene, & Dagiene, 2014).

This paper introduces a detailed study which addresses most studies that apply ontology within e-learning systems. A

comparison between frameworks and algorithms that use ontology within learning environment is introduced. These studies and comparisons show that, the personalization concept in the e-learning systems focus only on providing individual learners with suitable learning objects, ignoring the other learning process components.

This paper suggests a smart framework using ontology. This framework makes the learning process much more intelligent and efficient. Each component in the framework will perform a specific role. Personalization in this paper addresses the suitability of all learning process components (learning objects, relevant learning/teaching methods and preferred learning activities) to different learners' characteristics. Applying ontology makes it easier to determine and understand the goal of each component accurately, supports interoperability between the components, achieves effective personalization, improves learning process, and supports of a precise and richer e-learning ecosystem structure (Hitzler, Krotzsch, & Rudolph, 2009; Vesin et al., 2012).

The reminder of the paper is articulated as follows. The history of e-learning ecosystem and the related work analysis on the personalization of learning environment is introduced in Section 2. The systematic literature review about applying ontology in e-learning domain is presented in Section 3. The suggested model is provided in Section 4. Conclusions are presented in Section 5, and future work is also offered in Section 5.

2. Research methodology

Ontology has become an important research field. There is a lot of academic researches focus on the role that the ontology plays to personalize learning environment. The research papers' classification on ontology will be verified by their publication year. The following leading scientific databases were searched to achieve a full bibliography of research papers on ontology and its role in personalizing the learning environment:

IEEE Library; Science Direct; and Springer Link.

The purpose of the search process is to find research papers that are related to ontology and its leading role in personalizing learning environment. This search process was performed on the leading MIS scientific databases. The search was performed based on three keywords: "ontology and personalization of learning environment", "ontology and personalization", and "ontology and personalization of e-learning". The papers that were truly related to our research are going to be employed.

The result of the search process about ontology and its leading role in the learning environment personalization was 108 articles selected from 3 leading scientific libraries. These papers published between 2004 and 2015, and then classified by the publication year, the scientific databases in which they appeared.

2.1. Classification of research papers

The selected papers are categorized based on the publications

Table 1
Comparisons between the traditional and personalized learning environment.

Criteria	Traditional learning environment	Personalized learning environment
Learning style	One-to-many	One-to-one or many-to-one (i.e. One, or many learning materials for one learner)
Flexibility	Put a number of constraints within the learning setting; (specific time place, and materials).	Introduces learning independent of location and time.
Learning Process	Is designed for the average learner.	The learning content depends on the characteristics of individual learners, i.e. prior knowledge, needs, skills, learning style, and preferences.
Learning materials	Is determined by the educator.	(Self-directed learning) depends on the learner's requirements.

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