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# Research Paper

# The Semantically Rich Learning Environments: A Systematic Literature Review

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**Abstract**
Purpose: The research is intended to extract repetitive themes in the field of semantic-rich learning and to express the basic opportunities and challenges therein.Method: The method applied was to review the articles published in the WOS database, during the years 2000 to 2020 by using the paradigm funnel technique; moreover the Nvivo software was used for document analysis and theme extraction.Findings: In the study, it was found that, establishing access to appropriate educational content, proper analysis and representation of knowledge, human capabilities enhancement, personalization of learning, and improving the quality of assessment, are the most important positive effects of using STs in learning; Also, in this study, nine themes and seven major challenges in the field of semantic-rich learning were identified.Conclusion: personalization and adaptation, and the development of various ontologies, are the most cited themes; and access to learning content and concerns about the design and development of learning systems are the most important challenges facing semantic-rich learning environments. We believe that in order to overcome the enumerated challenges, the combination of STs with other emerging cognitive and communication technologies, such as IOT, is necessary and could be the subject of future research in this field.

**Keywords:** Semantic technology, e-Learning, Educational semantic technology, Semantic Web, Ontology.

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## Introduction:

A semantic-rich e-learning environment as an Intelligent Learning system (ILE) is a 'personalized system that places the student at the center of the learning process, it is based on a seamless integration of shared knowledge according to the semantic web representations and ontologies' (Halimi & Seridi-Bouchelaghem, 2019). ILEs can be broadly defined as computer-based educational systems that rely on diverse Artificial Intelligence (AI) techniques to improve students learning experience, and help them reach their learning objectives (Jovanovic, Gasevic, Torniai, Bateman, & Hatala, 2009).

In computer science, semantics is "the theoretical study of meaning in systems of signs, or the meaning or relationship of meanings of a sign or set of signs (Kohlhase & Kohlhase, 2008); Therefore, ST is a set of methods and tools which provide an advanced means for categorizing and processing of data and also for discovering the relationship in various groups (Rouse, 2017). ST techniques applied in different fields like intelligent agents, data lakes, data governance and newly emerged cognitive programs.

Some part of ST stems in primary artificial intelligence and studies of expert systems; however, the tools which are created as a part of the semantic web movement are considered as a basis for modern ST. the Semantic Web is the evolution of the current Web, where in it, 'information is given well-defined meaning, better enabling computers and people to work in cooperation' (Carmichael & Tscholl, 2013; Jovanovic et al., 2009). The main idea of Semantic Web is to share data instead of documents (Anshari, Alas, & Guan, 2015); this idea, provides an appropriate response for the next generation of e-learning, that according to which, learners should be able to "find, share, and combine information more easily through Semantic Web" (Anshari et al., 2015).

Semantic technologies are touted as the next big wave in educational technology and as the solution to many problems in this arena (Kohlhase & Kohlhase, 2008). these technologies are also regarded as awareness of the kind and amount of the disability of handicapped people in interacting with electronic learning systems (Akin & Gokturk, 2019) and also as a "potential approach in helping the users in web-based learning" (Chang, Tseng, & Liu, 2013).

Despite "the stunning potential of this idea , especially in educational scenarios" (Kohlhase & Kohlhase, 2008), as Carmichael

and Jordan (Carmichael & Jordan, 2012) argue, the nature of semantic technologies (STs) has made them still an example of emerging technologies; The content of published studies about the use of STs in educational settings, also supports this claim. The emerging term probably reflects the fact that STs are not yet fully understood and there is a lack of research in this area. The present study, with regard to this gap, and with a glimpse of semantic-based learning, has identified the basic concepts, themes, and gaps, in this field.

**Objectives of the study**

This article aims to explore the current state of semantic-rich learning. To get the desired results the key objectives of this study are:

- To identify the emergent themes within the field of semantic-rich learning environments;
- To highlight the challenges and opportunities created by the STs in learning environments.

**Method**

Application of STs in learning environments is a new issue to which there is no agreement in its related concepts, tools of its assessment and ways to investigate ; therefore, in order to achieve the objectives of the study, it is appropriate to use the systematic literature review; the present research uses the paradigm funnel technique suggested by Berthon et.al (Berthon, Nairn, & Money, 2003). The reason for using this technique is the possibility of combining the observations and assumptions while assessing the methods and implied assumptions in the literature of the issue under investigation. In order to analyze the examined documents and extract the themes, version 12 of Nvivo software has been used.

**Search and select appropriate studies**

In order to reach the studies done concerning the topic of the present research, WOS database in the years between 2000 and 2020 A.D. was searched. we considered the following criteria for selecting studies: Studies are written in English, have full text access, and their topic is about the use of STs in teaching and learning; the list of keywords used included: *Semantic Technology (ST), semantic web (SW), Education, eLearning, educational technology (ET)*; in order to

retrieve the related studies more precisely, different combinations of keywords and their shortened forms were used.
This search yielded 229 articles. The retrieved articles were first review based on their relevance with the application of the Semantic in learning; this review was based on the abstract and keywords of the articles. at this stage, 76 articles were identified as related studies. these articles were carefully analyzed one by one. during this analytical review, 12 other articles were identified as irrelevant; therefore, the extraction of themes and challenges related to the research topic, is based on the remaining 64 articles.

**Using the paradigm funnel technique**

Paradigm funnel technique categorizes previous studies into four levels ranging from explicit and observable to implied and unobservable and provides the possibility of combining the observable assumptions and implied assumptions while assessing the methods based on the paradigm funnel technique. The results of investigations in the four levels are categorized as follows:

- **Empirical Research** (Level 1): Includes those articles that employed empirical observation to catalog and identify gaps in existing literature.
- **Analytical Methods** (Level 2): Includes those articles that focus on the use of specific analytical methods to examine the subject of research. The main purpose of this level is to select the appropriate methodology for studying the research topic.
- **Specific Theory** (Level 3): Includes those articles that have investigated the subject of research based on a particular theory.
- **Core Assumptions** (Level 4): includes articles that challenge the most basic ontological, epistemological, methodological, and axiological assumptions associated with semantic-rich learning.

## Results

### Overview of studies

Tables 1 and 2 show the general characteristics and nature of the articles selected for systematic review. According to Table 2, nearly 60% of the articles (38 articles) conducted their studies, based on the Design Science Research (DSR) Strategy; In other words, the dominant strategy for examining issues surrounding ST-based learning environments is DSR.

**Table 1: Details of articles related to semantically rich learning environments**

| | |
|---|---|
| Reviewed articles | 64 |
| Publication year | 2003 (1), 2004 (4), 2006 (2), 2007 (1), 2008 (1), 2009 (4), 2010 (1), 2011 (6), 2012 (11), 2013 (7), 2014 (4), 2015 (9), 2016 (2), 2017 (3), 2018 (3), 2019 (5). |
| Journals field | Interactive Learning Environments (7), Educational Technology & Society (7), Journal of Universal Computer Science (6), Transactions on Learning Technologies (4), Technology Pedagogy and Education (4), British Journal of Educational Technology (3), Knowledge-Based Systems (2), Computing and Informatics (2), Expert Systems with Applications (2), Journal of Computer Assisted Learning (2), Information Systems Frontiers (1), Automation in Construction (1), Computers in Human Behavior (1), Multimedia Tools and Applications (1), Educational Sciences-Theory & Practice (1), Journal of Ambient Intelligence and Humanized Computing (1), Ieee Transactions on Systems Man and Cybernetics Part C-Applications and Reviews (1), International Journal of Information Technology & Decision Making (1), Journal of Visual Languages and Computing (1), Information Sciences (1), British Journal of Educational Studies (1), Journal of Applied Research and Technology (1), Studies in Informatics and Control (1), Semantic Web (1), Education and Information Technologies (1), Program-Electronic Library and Information Systems (1), Behaviour & Information Technology (1), Informatica (1), International Journal of Educational Technology in Higher Education (1), Journal of the American Society for Information Science and Technology (1), Discourse-Studies in the Cultural Politics of Education (1), Ieee Access (1), Journal of Information Science and Engineering (1), Proceedings of the Ieee (1), Eurasia Journal of Mathematics Science and Technology Education (1). |

**Table 2: Research strategies/methods used in the reviewed articles**

| Research strategies/methods | Articles |
|---|---|
| Case study (4) | (Ounnas, Davis, & Millard, 2009), (S. H. Wang & Wang, 2012), (Tracy & Jordan, 2012), (Moreale & Vargas-Vera, 2004) |
| Conceptual (13) | (Anshari et al., 2015), (Carmichael, 2011), (Carmichael & Tscholl, 2013), (Jia, Huang, & Jiao, 2018), (Friesen & Anderson, 2004), (Aroyo et al., 2006), (Devedzic, 2003), (Carmichael & Jordan, 2012), (Jovanovic et al., 2009), (Lafuente, 2017), (Kohlhase & Kohlhase, 2008), (Aroyo & Dicheva, 2004), (Poore, 2014) |
| Design science (38) | (Gaeta, Mangione, Orciuoli, & Salerno, 2013), (Bajenaru, Smeureanu, & Balog, 2016), (Raju & Ahmed, 2012), (Cuong, Arch-Int, & Arch-Int, 2018), (Dascalu, Bodea, Tesila, Moldoveanu, & de Pablos, 2017), (Coccoli & Torre, 2014), (Y. Kim, Jung, Ji, Hwang, & Rho, 2019), (Pattuelli, 2011), (Canales-Cruz, Sanchez-Arias, Cervantes-Perez, & Peredo-Valderrama, 2009), (Tovar, Piedra, Chicaiza, Lopez, & Martinez-Bonastre, 2012), (Chi, 2009), (Romero, North, Gutierrez, & Caliusco, 2015), (Zablith, Fernandez, & Rowe, 2015), (Nguyen, Arch-Int, & Arch-Int, 2017), (Sanchez-Vera, Fernandez-Breis, Castellanos-Nieves, Frutos-Morales, & Prendes-Espinosa, 2012), (Castellanos-Nieves, Fernandez-Breis, Valencia-Garcia, Martinez-Bejar, & Iniesta-Moreno, 2011), (P. Kim, Ng, & Lim, 2010), (Rodriguez, Gago, Rifon, & Rodriguez, 2015), (Fernandez-Breis et al., 2012), (Borges & Silveira, 2019), (Halimi, Seridi-Bouchelaghem, & Faron-Zucker, 2014), (Iatrellis, Kameas, & Fitsilis, 2019), (Caravantes & Galan, 2011), (Jeremic, Jovanovic, & Gasevic, 2013), (H. C. Wang & Huang, 2013), (Henze, Dolog, & Nejdl, 2004), (Dzbor, Stutt, Motta, & Collins, 2007), (Piedra, Chicaiza, Lopez, & Tovar, 2015), (Dagiene, Gudoniene, & Burbaite, 2015), (Halimi & Seridi-Bouchelaghem, 2019), (Vesin, Klasnja-Milicevic, Ivanovic, & Budimac, 2013), (Romero, Saucedo, Caliusco, & Gutierrez, 2019), (Martinez-Garcia & Corti, 2012), (Shabajee, McBride, Steer, & Reynolds, 2006), (Baldoni et al., 2011), (Gasevic, Zouaq, Torniai, Jovanovic, & Hatala, 2011), (Rani, Nayak, & Vyas, 2015), , (Poulovassilis, Selmer, & Wood, 2012) |
| Experiment (4) | (Edwards & Carmichael, 2012), (Martinez-Garcia, Morris, Tscholl, Tracy, & Carmichael, 2012), (Harchay, Cheniti-Belcadhi, & Braham, 2015), (Dietze, Sanchez-Alonso, et al., 2013) |
| mixed method (2) | (Lozano, Gracia, Corcho, Noble, & Gomez-Perez, 2015), (Abbas, Ahmad, & Kalid, 2014) |
| survey (3) | (Dascalu, Bodea, Mihailescu, Tanase, & de Pablos, 2016), (Dietze, Kaldoudi, et al., 2013), (Pereira, Siqueira, Nunes, & Dietze, 2018) |

**paradigm funnel application**

In this section, the results obtained by applying the paradigm funnel on the selected articles will be explained. The aim of doing so is determining the position of the topic. Table 3, shows the list of articles related to each level of funnel. The number of articles in each level clearly shows the reason why the word 'funnel' is used in this approach.

In the first row, the list of articles related to the first level of paradigm funnel is shown. This list includes thirty-one articles which have investigated the existing gaps in semantic-rich learning environments, based on empirical observations.

the second row shows the articles related to the second level of the funnel. this list includes sixteen articles which have used a specific methodology in the field of semantic-rich learning. the few number of articles in this part can prove that the topic of the present research is up-to-date.

The third row shows the articles related to the third level of the funnel. This list includes eleven articles which have investigated semantic-rich learning, based on different theories. Connectivism, the learner as a knowledge producer, self-regulated learning, participatory design, technology-enhanced learning, constructive pedagogical models, turn to practice, problem-based learning, and case-based learning, are the most important theories, used in reviewed articles.

In the fourth row, a list of articles related to the fourth level of paradigm funnel is shown. This list includes six articles which challenge core assumptions related to semantic-rich learning. the content of articles at this level has been used mainly to identify gaps and challenges facing semantic-rich learning environments.

**Table 3: Articles related to each level of the paradigm funnel**

| Level | No. of articles | articles |
|---|---|---|
| 1: Empirical Research | 31 | (Y. Kim et al., 2019), (Pereira et al., 2018), (Jia et al., 2018), (Cuong et al., 2018), (Nguyen et al., 2017), (Dascalu et al., 2017), (Bajenaru et al., 2016), (Zablith et al., 2015), (Romero et al., 2015), (Rani et al., 2015), (Coccoli & Torre, 2014), (Gaeta et al., 2013), (S. H. Wang & Wang, 2012), (Tovar et al., 2012), (Sanchez-Vera et al., 2012), (Raju & Ahmed, 2012), |

| Level | No. of articles | articles |
|---|---|---|
| | | (Poulovassilis et al., 2012), (Martinez-Garcia et al., 2012), (Pattuelli, 2011), (Gasevic et al., 2011), (Castellanos-Nieves et al., 2011), (Carmichael, 2011), (Baldoni et al., 2011), (P. Kim et al., 2010), (Ounnas et al., 2009), (Chi, 2009), (Canales-Cruz et al., 2009), (Shabajee et al., 2006), (Aroyo et al., 2006), (Friesen & Anderson, 2004), (Devedzic, 2003). |
| 2: Analytical Methods | 16 | (Iatrellis et al., 2019), (Borges & Silveira, 2019), (Dascalu et al., 2016), (Rodriguez et al., 2015), (Piedra et al., 2015), (Harchay et al., 2015), (Dagiene et al., 2015), (Halimi et al., 2014), (H. C. Wang & Huang, 2013), (Jeremic et al., 2013), (Dietze, Sanchez-Alonso, et al., 2013), (Fernandez-Breis et al., 2012), (Caravantes & Galan, 2011), (Dzbor et al., 2007), (Moreale & Vargas-Vera, 2004), (Henze et al., 2004). |
| 3: Specific Theory | 11 | (Halimi & Seridi-Bouchelaghem, 2019), (Martinez-Garcia & Corti, 2012), (Romero et al., 2019), (Dietze, Kaldoudi, et al., 2013), (Jovanovic et al., 2009), (Abbas et al., 2014), (Carmichael & Jordan, 2012), (Lozano et al., 2015), (Carmichael & Tscholl, 2013), (Vesin et al., 2013), (Tracy & Jordan, 2012). |
| 4: Core Assumptions | 6 | (Edwards & Carmichael, 2012), (Kohlhase & Kohlhase, 2008), (Anshari et al., 2015), (Poore, 2014), (Aroyo & Dicheva, 2004), (Lafuente, 2017). |

## Prevalent themes regarding semantically rich e-learning

The analysis of the reviewed articles reveals nine themes related to educational environments enriched with STs. A list of these topics and related articles is shown in Table 4. The following is a description of each topic and the main issues raised around it.

**Table 4: Prevalent themes identified from studies (n=64)**

| Identified theme and No. of related articles | Articles |
|---|---|
| personalization and adaptation (29) | (Romero et al., 2015), (Rani et al., 2015) ,(Raju & Ahmed, 2012), (Nguyen et al., 2017), (Y. Kim et al., 2019) ,(Jia et al., 2018), (Gaeta et al., 2013), (Cuong et al., 2018) , (Canales-Cruz et al., 2009) ,(Baldoni et al., 2011) , (Bajenaru et al., 2016) ,(H. C. Wang & Huang, 2013), (Piedra et al., 2015), (Pereira et al., 2018) ,(Moreale & Vargas-Vera, 2004) ,(Jeremic et al., 2013) ,(Iatrellis et al., 2019) ,(Henze et al., 2004) ,(Halimi et al., 2014) , (Fernandez-Breis et al., 2012) ,(Dagiene et al., 2015) , (Vesin et al., 2013) ,(Romero et al., 2019) ,(Jovanovic et al., 2009) ,(Harchay et al., 2015), (Carmichael & Jordan, 2012), (Poore, 2014)) ,Aroyo et al., 2006), (Aroyo & Dicheva, 2004) |
| ontology building and development (27) | (Zablith et al., 2015) ,(S. H. Wang & Wang, 2012) ,(Tovar et al., 2012) ,(Romero et al., 2015) ,(Rani et al., 2015) , (Nguyen et al., 2017) ,(Y. Kim et al., 2019) ,(Jia et al., 2018), (Devedzic, 2003), (Bajenaru et al., 2016) ,(H. C. Wang & Huang, 2013), (Piedra et al., 2015), (Pereira et al., 2018) ,(Iatrellis et al., 2019) ,(Fernandez-Breis et al., 2012) ,(Dzbor et al., 2007) ,(Dascalu et al., 2016) ,(Vesin et al., 2013) ,(Romero et al., 2019) ,(Pattuelli, 2011) , (Jovanovic et al., 2009) ,(Harchay et al., 2015) ,(Gasevic et al., 2011) ,(Carmichael & Jordan, 2012) ,(Borges & Silveira, 2019) ,(Abbas et al., 2014), (Aroyo & Dicheva, 2004) |
| Design and development of intelligent learning Systems (26) | (S. H. Wang & Wang, 2012) ,(Raju & Ahmed, 2012) , (Poulovassilis et al., 2012) ,(Nguyen et al., 2017) ,(Y. Kim et al., 2019) ,(Gaeta et al., 2013), (Devedzic, 2003), (Cuong et al., 2018) ,(Coccoli & Torre, 2014) ,(Baldoni et al., 2011) ,(Rodriguez et al., 2015), (Pereira et al., 2018), (Halimi et al., 2014) ,(Vesin et al., 2013) ,(Romero et al., 2019) ,(Pattuelli, 2011) ,(Martinez-Garcia & Corti, 2012) , (Halimi & Seridi-Bouchelaghem, 2019) ,(Gasevic et al., 2011) ,(Edwards & Carmichael, 2012) ,(Dietze, Kaldoudi, et al., 2013) ,(Carmichael & Tscholl, 2013) ,(Carmichael & Jordan, 2012) ,(Poore, 2014) ,(P. Kim et al., 2010), (Aroyo & Dicheva, 2004) |

| Identified theme and No. of related articles | Articles |
|---|---|
| integration and interoperability (18) | (Raju & Ahmed, 2012) ,(Martinez-Garcia et al., 2012) , (Devedzic, 2003) ,(H. C. Wang & Huang, 2013), (Pereira et al., 2018), (Moreale & Vargas-Vera, 2004), (Dietze, Sanchez-Alonso, et al., 2013), (Dagiene et al., 2015) , (Caravantes & Galan, 2011), (Pattuelli, 2011), (Martinez-Garcia & Corti, 2012) ,(Jovanovic et al., 2009), (Gasevic et al., 2011), (Edwards & Carmichael, 2012) ,(Dietze, Kaldoudi, et al., 2013) ,(Carmichael & Jordan, 2012) , (Aroyo et al., 2006), (Aroyo & Dicheva, 2004) |
| Interaction between Human and ST (18) | (Tracy & Jordan, 2012), (Tovar et al., 2012), (Poulovassilis et al., 2012), (Nguyen et al., 2017) ,(Gaeta et al., 2013) , (Friesen & Anderson, 2004) ,(Jeremic et al., 2013) , (Romero et al., 2019) ,(Pattuelli, 2011) ,(Martinez-Garcia & Corti, 2012) ,(Jovanovic et al., 2009) ,(Halimi & Seridi-Bouchelaghem, 2019) ,(Edwards & Carmichael, 2012) , (Carmichael & Tscholl, 2013) ,(Carmichael & Jordan, 2012) ,(Poore, 2014) ,(Lafuente, 2017), (Anshari et al., 2015) |
| Learning Objects and Resources (13) | (Tovar et al., 2012) ,(Shabajee et al., 2006) ,(Rani et al., 2015) ,(Raju & Ahmed, 2012) ,(Coccoli & Torre, 2014) , (Chi, 2009) ,(Carmichael, 2011) ,(Canales-Cruz et al., 2009) ,(Rodriguez et al., 2015) ,(Piedra et al., 2015) , (Pereira et al., 2018) ,(Dietze, Sanchez-Alonso, et al., 2013), (Dagiene et al., 2015) |
| KM (12) | (Nguyen et al., 2017) ,(Chi, 2009) ,(Castellanos-Nieves et al., 2011) ,(H. C. Wang & Huang, 2013) ,(Fernandez-Breis et al., 2012) ,(Pattuelli, 2011) ,(Jovanovic et al., 2009) , (Carmichael & Tscholl, 2013) ,(Carmichael & Jordan, 2012) ,(Abbas et al., 2014) ,(Kohlhase & Kohlhase, 2008), (Anshari et al., 2015) |
| planning and management instruction (12) | (Tracy & Jordan, 2012) ,(Tovar et al., 2012) ,(Sanchez-Vera et al., 2012) ,(Romero et al., 2015) ,(Ounnas et al., 2009) ,(Martinez-Garcia et al., 2012) ,(Castellanos-Nieves et al., 2011) ,(Lozano et al., 2015) ,(Harchay et al., 2015) , (Edwards & Carmichael, 2012) ,(Carmichael & Tscholl, 2013), (Abbas et al., 2014) |
| Educational social semantic web (10) | (Nguyen et al., 2017) ,(Martinez-Garcia et al., 2012) ,(Jia et al., 2018) ,(Piedra et al., 2015) ,(Pereira et al., 2018) , (Jeremic et al., 2013) ,(Halimi et al., 2014) ,(Martinez-Garcia & Corti, 2012) ,(Jovanovic et al., 2009), (Carmichael & Jordan, 2012) |

- **personalization and adaptation:** Over the past few years, uch effort has been expended to enable personalization for e-learning by semantic web techniques (H. C. Wang & Huang, 2013). "personalization and adaption" is one of the main themes discussed in the articles under review and has been addressed in at least 29 articles. In this theme, topics such as: personal learning environments (PLEs), Personalization Services, Self-Regulation in learning, transformative potential of SW for education, the role of SW in Adaptive Web-based educational systems (AWBES), Adaptive Educational Hypermedia Systems, adaptation and improvement the learning by SW based LO design model, and semantic portal from a pedagogical perspective, have been mentioned many times.

- **ontology building and development:** More than 27 of the reviewed articles have dealt with this topic. In this theme, topics such as: domain modeling, adding meta data to learning objects, semantic web portals, ontology-based context representation, Successful instants of implemented ontologies, Challenges in ontology develop, and factors influencing ontology design, are discussed.

- **Design and development of intelligent learning Systems:** Design and implementation of intelligent learning systems and the requirements of this field form another recurring theme in the field of semantic-rich learning environments; In this regard, topics such as concerns in design of educational SW, pedagogical practice imprtance, AI and web2 experiences, domain analysis for using ontology in applications, educational standards, data mining and AI technologies, the separation of data from program logic, user-centered approach in ontology development, access to comprehensive repositories of learning content and metadata, educational STs affordances, accessiblity and usablity, flexible querying facilities, open access to digital resources, standardisation and flexibility in the development of STs, recommender systems in learning, implementation and development of e-portfolio, ambient learning, and semantic web of things, are discussed.

- **integration and interoperability**: In this field, topics such as: using STs to increase interoperability, solving interoperability problems using ontology, knowledge sharing, creating user models based on ontology, interoperability with other systems, semantic interoperability, common frameworks to increase interoperability, data and service interoperability, realizing educational semantic web, learning repository, data integration, heterogeneous web resource integration, digital repository, social semantic web educational systems and content providers, Ability to integrate with other web technologies, standardization and integration of learning environments, paradigm of integration and interaction between information, learners and experts, service and data integration, integration of distributed data in heterogeneous training repositories, Dealing with unstructured metadata, Metadata mediation and transformation, and Shifting focus towards educational context, are discussed.

- **Interaction between Human and ST**: In this context, topics such as: learner as a content producer, teacher and learner as designers and knowledge producers, discernmental role of teachers in use of SW to learning, people involved in the development of educational SW, preservation of cognitive resources for humans, social web as user-centric tools, ST as an actor, codes and standards, hidden aspects of STs, hidden curriculum, the administrative role of SW in education, advanced forms of social interactions, life-long learning, learning analysis, connectivism theory, Baudrillard's notion of the hyperreal, interactivity, participatory design, and educational resources, are discussed.

- **Learning Objects and Resources**: Topics related to this theme include: learning object development, educational content, learning content representation, Open Access philosophy, delivery of learning materials, and Use of recommender systems to identify educational resources.

- **Knowledge Management (KM)**: Topics related to this theme include: role of ontology in KM, knowledge representation,

knowledge sharing, Pervasive knowledge, knowledge engineering, and domain knowledge.

- **Planning and managing instruction**: Topics related to this theme include: teaching methods and strategies, case-based learning, pedagogical models (instructional or constructive), problem-based learning, Assessment and feedback, and learner group formation.

- **Educational social semantic web**: Topics related to this theme include: social semantic web paradigm, improving the interactivity of learning environments, social interaction platform, social web, and social semantic web.

**Key advantages/opportunities**

STs, though, as Lafuente)Lafuente, 2017) argues, may be promoting learning based on an accumulation of information into one's knowledge schemata, rather than learning based on the restructuration of those schemata; and may be promoting social networks that keep us in the comfort zone, rather than engaging us in intellectually challenging processes; But studies show that the use of these technologies has many advantages in the field of learning. In the following, the most important benefits of using STs in learning, from the perspective of the reviewed articles, will be pointed out.

**1.Access to appropriate learning content**

According to Carmichael and Tscholl (Carmichael & Tscholl, 2013), much of the research literature on the potential of STs in education has stressed their capacity to support learning through resource discovery, data linking, and aggregation, and by presenting large amounts of data using interactive visualization tools. Emphasis on content search and discovery is important because, considering the constant increasing of resources on the Web, it is almost impossible for the learners and instructors "to get an overview of all the available information relevant to their current needs, tasks, roles and goals. And even if they find some materials, which seem suitable, they are not able to assess completely whether the found content is entirely appropriate for their goals (for instructors) or current knowledge and cognitive state (for learners)" (Aroyo & Dicheva, 2004).

Educational portals have a special role in solving the problem of access to content by grouping information and facilitating access to different types of content and learning objects. Application of STs in these portals and implementation of educational semantic portals can provide meaningful integration of educational content and objects; An educational semantic portal, according to Borges and Silveira (Borges & Silveira, 2019), is an environment that organizes and stores educational resources, in which its users can share educational and material resources; navigate and fetch resources according to their interests, among other actions.

In addition to introducing educational semantic portals, with the aim of facilitating access to content, STs and ontologies are used for: "supporting access to data" (Pereira et al., 2018), "ubiquitous access to the knowledge and data " (Jovanovic et al., 2009), "improving discovery and access to digital content, … sharing, and reuse of knowledge across repositories" (Pattuelli, 2011) , and to "manage intricate information such as curriculum content sequencing problems" (Chi, 2009).

**2.Appropriate analysis and representation of knowledge**

ST has the potential to be used as a useful tool for analyzing vast amounts of information and countering what Lafuente calls "infoxication" (Lafuente, 2017); Because this technology deals with a huge amount of information to alert the user to what he needs or wants.

In this context, STs are used for representation of "knowledge"(Carmichael & Jordan, 2012), "context" (Jovanovic et al., 2009), "relationships between individuals" (Chi, 2009) and "key elements of intelligent learning analytics system" )Halimi & Seridi-Bouchelaghem, 2019); STs, also make it possible to develop a range of educational services, such as "interpretation, structure-visualization, support for argumentation, novel forms of content customization, novel mechanisms for aggregating learning material" (Dzbor et al., 2007), and "extract inferred knowledge out of the implicitly stated situations" (Jovanovic et al., 2009).

**3.Human enhancement**

ST has provided new educational opportunities for teachers and learners. A major application of these technologies in the learning

environment is the design of “administrative and pedagogical agents” (Poore, 2014). The intelligent administrative agent is an efficient and effective tool for educators in administrative tasks, such as enrollment, class planning, attendance, and "authentication" (Moreale & Vargas-Vera, 2004); and the intelligent pedagogical agent is a tool to improve the efficiency of teaching, designing, and delivering educational content to learners. STs, can also enhance human capabilities by helping to “understand relationships and dependencies between facts” (Kohlhase & Kohlhase, 2008) and “are used to improve individual knowledge while exploiting community knowledge” (Dascalu et al., 2017).

**4.Personalization of learning**

Almost unlimited access to a wealth of educational information can make it difficult to find meaningful content. The use of STs, especially in the form of recommender systems, can “help the users decide upon useful materials” (Dascalu et al., 2016), and “novel forms of content customization” (Dzbor et al., 2007). In addition, STs are used in “getting the best learning experiences according to their needs and preferences” )Halimi & Seridi-Bouchelaghem, 2019), “design and delivery of educational content to learners” (Poore, 2014), and “personalized training of managers” (Bajenaru et al., 2016). These technologies are “appropriated tools to achieve the goals of personalization and interoperability” (Romero et al., 2019).

**5.Improving the quality of evaluation**

For a systematic planning in education, the use of STs in the evaluation phase, will have the following benefits (Castellanos-Nieves et al., 2011; Sanchez-Vera et al., 2012):

- Ontologies can provide the precise semantic specification of the domain;
- Semantic annotations can be used for getting a precise semantic specification of the questions and the answers;
- Automatic feedback processes can be developed by combining course ontologies and semantic annotations.

**Key challenges**

The STs have provided new opportunities for intelligent learning environments and better management of education; So, these

technologies have taken learning to a new stage in their lives. Undoubtedly, STs will play a special role in the new generation of learning; But, like any other emerging phenomenon, it will face challenges. In this section, based on the concepts presented in selected articles, the most important challenges facing semantic learning environments and the topics discussed below each challenge are explained.

**Table 5: Key challenge identified from studies (n=64)**

| Key challenges and No. of related articles | Articles |
|---|---|
| Access to learning content (16) | (Martinez-Garcia et al., 2012), (Iatrellis et al., 2019), (Dascalu et al., 2017), (Friesen & Anderson, 2004), (Dietze, Sanchez-Alonso, et al., 2013), (Devedzic, 2003), (Pereira et al., 2018), (Pattuelli, 2011), (Henze et al., 2004), (Edwards & Carmichael, 2012), (Piedra et al., 2015), (Kohlhase & Kohlhase, 2008), (Dagiene et al., 2015), (Abbas et al., 2014), (Martinez-Garcia & Corti, 2012), (Jovanovic et al., 2009) |
| Design and development concerns (10) | (Romero et al., 2019), (Abbas et al., 2014), (Carmichael & Jordan, 2012), (Edwards & Carmichael, 2012), (Devedzic, 2003), (Friesen & Anderson, 2004), (Iatrellis et al., 2019), (Martinez-Garcia et al., 2012), (Gasevic et al., 2011), (Halimi & Seridi-Bouchelaghem, 2019) |
| Creation, development and maintenance of ontologies (7) | (Carmichael & Jordan, 2012), (H. C. Wang & Huang, 2013), (Pattuelli, 2011), (Pereira et al., 2018), (Devedzic, 2003), (Martinez-Garcia et al., 2012), (Gasevic et al., 2011) |
| Interoperability (6) | (Jovanovic et al., 2009), (Aroyo & Dicheva, 2004), (Abbas et al., 2014), (Pereira et al., 2018), (Dietze, Sanchez-Alonso, et al., 2013), (Iatrellis et al., 2019) |
| realization of Educational SW (4) | (Aroyo & Dicheva, 2004), (Carmichael & Jordan, 2012), (Dascalu et al., 2017), (Iatrellis et al., 2019) |
| understanding the human role (4) | (Poore, 2014), (Abbas et al., 2014), (Friesen & Anderson, 2004), (Lafuente, 2017) |
| Shortcomings of STs (3) | (Poore, 2014), (Carmichael & Jordan, 2012), (Raju & Ahmed, 2012) |

- **Access to learning content**: According to the reviewed articles, access to appropriate data, information and knowledge is the most important challenge of semantic learning environments. In this regard, the following topics are further emphasized: the need to create a learner profile to improve

learning, extract information from social networks, the quality of educational data, collect meaningful and well-defined data for different sectors, knowledge sharing, production of Semantically enriched learning objects, and limitations in the representation of domain knowledge.

- **Design and development concerns:**limitations in the design and development of semantic-based learning systems are another challenge in this area. In this regard, the following topics are further emphasized: need for continuous observation and evaluation of the student, need to support learning at all the levels of the Bloom's taxonomy, Support for data mining and AI technologies, The need for simplicity to support useful learning experiences, assessments of the potential for adoption of SW, The complexities of STs development, Challenges presented by lifelong learning, practical and cost considerations, Components required for development of an intelligent tutoring system, issue of privacy, Complexity in the development of Internet technologies, use of technologies that associated with the earlier failed experiment of AI, requirements of the semantic infrastructure, and Adaptable and personalized LP.

- **Creation, development and maintenance of ontologies:** In this regard, the following topics are further emphasized: building and developing ontologies, lack of empirical validation indicating significant e□ciency of using ontology, Lack of use of consensus ontology for personalization, need to build domain ontologies for different target domains, Multiple Ontologies Support, and based education by categories.

- **Interoperability:** In this regard, the following topics are further emphasized: Dealing with continuous change in web, Enrichment and interlinking of unstructured metadata, Metadata mediation and transformation, realization of Educational Semantic Web, Data interoperability, requirements of ILEs, and profile developing in intelligent tutoring systems.

- **realization of Educational Semantic Web:** In this regard, the following topics are further emphasized: dependence on educational settings, Dependence on pragmatism, situatedness and context-specificity for educational SW, unified authoring support, requirements of the semantic infrastructure, learning path modeling, and find the right platform.

- **understanding the human role:** In this regard, the following topics are further emphasized: understanding the student behavior, understanding the purpose of education and the roles of teachers and students, acquisition of argumentation skills through technology, pedagogical activity, change patterns of interaction and cooperation between public and private educational institutions, and administrative and policy challenges.

- **Shortcomings of the STs:** In this regard, the following topics are further emphasized: Human needs and STs shortcomings, invisibility of STs and failure to gain public imagination, Lack of widespread use in the delivery of learning objects, and need to theoretical frame for development of educational SW.

**Concluding comments**

STs promise great things for the future, especially in the field of educational technologies. The volume of research conducted in recent years on the application of these technologies to solve social and educational problems shows the importance of these technologies and the need to address the issues surrounding them.

This research has been conducted with the aim of identifying the main themes in the field of semantic-rich learning and the basic opportunities and challenges ahead. In order to achieve the objectives of the research, using the paradigm funnel technique, a systematic review of studies in this field was conducted and the results were categorized and presented in the form of key themes, opportunities, and challenges.

Based on the results of applying the paradigm funnel, most of the studies conducted in the field of semantic-rich learning, have been carried out based on design science research strategy; These studies, mainly by modeling and implementing an instant of learning systems

based on STs, have identified the effects, challenges and opportunities arising from the use of the product in the learning environment. Also, modern theories of learning such as problem-based learning, case-based learning, connectivism theory, learner as a producer of knowledge, and constructive pedagogical models, have been used in researches.

In the study, it was found that, establishing access to appropriate educational content, proper analysis and representation of knowledge, human capabilities enhancement, personalization of learning, and improving the quality of assessment, are the most important positive effects of using STs in learning; Also, in this study, nine themes and seven major challenges in the field of semantic-rich learning were identified. Accordingly, personalization and adaptation, and the development of various ontologies, are the most cited themes; and access to learning content and concerns about the design and development of learning systems are the most important challenges facing semantic-rich learning environments. We believe that in order to overcome the enumerated challenges, the combination of STs with other emerging cognitive and communication technologies, such as IOT, is necessary and could be the subject of future research in this field.

**References:**

Abbas, M. A., Ahmad, W. F. W., & Kalid, K. S. (2014). Semantic Web Technologies for Pre-School Cognitive Skills Tutoring System. *Journal of Information Science and Engineering, 30*(3), 835-851. Retrieved from <Go to ISI>://WOS:000340075300018

Akin, N. T. A., & Gokturk, M. (2019). Comparison of the Theory of Mind Tests on the Paper, 2D Touch Screen and Augmented Reality Environments on the Students With Neurodevelopmental Disorders. *IEEE Access, 7*, 52390-52404. doi:10.1109/access.2019.2902836

Anshari, M., Alas, Y., & Guan, L. S. (2015). Pervasive Knowledge, Social Networks, and Cloud Computing: E-Learning 2.0. *Eurasia Journal of Mathematics Science and Technology Education, 11*(5), 909-921. Retrieved from <Go to ISI>://WOS:000366174600001

Aroyo, L., & Dicheva, D. (2004). The new challenges for e-learning: The Educational Semantic Web. *Educational Technology & Society, 7*(4), 59-69. Retrieved from <Go to ISI>://WOS:000224855500005

Aroyo, L., Dolog, P., Houben, G. J., Kravcik, M., Naeve, A., Nilsson, M., & Wild, F. (2006). Interoperability in personalized adaptive learning. *Educational Technology & Society, 9*(2), 4-18. Retrieved from <Go to ISI>://WOS:000238974000002

Bajenaru, L., Smeureanu, I., & Balog, A. (2016). An Ontology-Based E-Learning Framework for Healthcare Human Resource Management. *Studies in Informatics and Control, 25*(1), 99-108. Retrieved from <Go to ISI>://WOS:000372945700011

Baldoni, M., Baroglio, C., Brunkhorst, I., Henze, N., Marengo, E., & Patti, V. (2011). Constraint modeling for curriculum planning and validation. *Interactive Learning Environments, 19*(1), 81-123. doi:10.1080/10494820.2011.528893

Berthon, P., Nairn, A., & Money, A. (2003). Through the Paradigm Funnel: A Conceptual Tool for Literature Analysis (Vol. 13).

Borges, P. R. S., & Silveira, I. F. (2019). Adding and Segmenting Educational Videos: Experiences of Teacher Users in an Educational Portal. *IEEE Access, 7*, 87996-88011. doi:10.1109/access.2019.2924946

Canales-Cruz, A., Sanchez-Arias, V. G., Cervantes-Perez, F., & Peredo-Valderrama, R. (2009). Multi-agent system for the

making of intelligence and interactive decisions wit hin the learner's learning process in a web-based education environment. *Journal of Applied Research and Technology, 7*(3), 310-322. Retrieved from <Go to ISI>://WOS:000272541300005

Caravantes, A., & Galan, R. (2011). Generic Educational Knowledge Representation for Adaptive and Cognitive Systems. *Educational Technology & Society, 14*(3), 252-266. Retrieved from <Go to ISI>://WOS:000294410900021

Carmichael, P. (2011). RESEARCH CAPACITY BUILDING IN EDUCATION: THE ROLE OF DIGITAL ARCHIVES. *British Journal of Educational Studies, 59*(3), 323-339. doi:10.1080/00071005.2011.599788

Carmichael, P., & Jordan, K. (2012). Semantic web technologies for education - time for a 'turn to practice'? INTRODUCTION. *Technology Pedagogy and Education, 21*(2), 153-169. doi:10.1080/1475939x.2012.696788

Carmichael, P., & Tscholl, M. (2013). Cases, simulacra, and Semantic Web technologies. *Journal of Computer Assisted Learning, 29*(1), 31-42. doi:10.1111/j.1365-2729.2011.00459.x

Castellanos-Nieves, D., Fernandez-Breis, J. T., Valencia-Garcia, R., Martinez-Bejar, R., & Iniesta-Moreno, M. (2011). Semantic Web Technologies for supporting learning assessment. *Information Sciences, 181*(9), 1517-1537. doi:10.1016/j.ins.2011.01.010

Chang, C. J., Tseng, J. M., & Liu, C. C. (2013). The effect of semantic technologies on the exploration of the web of knowledge by female and male users. *Electronic Library, 31*(3), 376-398. doi:10.1108/el-08-2011-0122

Chi, Y. L. (2009). Ontology-based curriculum content sequencing system with semantic rules. *Expert Systems with Applications, 36*(4), 7838-7847. doi:10.1016/j.eswa.2008.11.048

Coccoli, M., & Torre, I. (2014). Interacting with annotated objects in a Semantic Web of Things application. *Journal of Visual Languages and Computing, 25*(6), 1012-1020. doi:10.1016/j.jvlc.2014.09.008

Cuong, N. D. H., Arch-Int, N., & Arch-Int, S. (2018). FUSE: A Fuzzy-Semantic Framework for Personalizing Learning Recommendations. *International Journal of Information*

*Technology & Decision Making, 17*(4), 1173-1201. doi:10.1142/s0219622018500220

Dagiene, V., Gudoniene, D., & Burbaite, R. (2015). Semantic Web Technologies for e-Learning: Models and Implementation. *Informatica, 26*(2), 221-240. doi:10.15388/Informatica.2015.46

Dascalu, M. I., Bodea, C. N., Mihailescu, M. N., Tanase, E. A., & de Pablos, P. O. (2016). Educational recommender systems and their application in lifelong learning. *Behaviour & Information Technology, 35*(4), 290-297. doi:10.1080/0144929x.2015.1128977

Dascalu, M. I., Bodea, C. N., Tesila, B., Moldoveanu, A., & de Pablos, P. O. (2017). How social and semantic technologies can sustain employability through knowledge development and positive behavioral changes. *Computers in Human Behavior, 70*, 507-517. doi:10.1016/j.chb.2017.01.026

Devedzic, V. B. (2003). Key issues in next-generation Web-based education. *Ieee Transactions on Systems Man and Cybernetics Part C-Applications and Reviews, 33*(3), 339-349. doi:10.1109/tsmcc.2003.817361

Dietze, S., Kaldoudi, E., Dovrolis, N., Giordano, D., Spampinato, C., Hendrix, M., . . . Yu, H. Q. (2013). Socio-semantic Integration of Educational Resources - the Case of the mEducator Project. *Journal of Universal Computer Science, 19*(11), 1543-1569. Retrieved from <Go to ISI>://WOS:000327375100004

Dietze, S., Sanchez-Alonso, S., Ebner, H., Yu, H. Q., Giordano, D., Marenzi, I., & Nunes, B. P. (2013). Interlinking educational resources and the web of data A survey of challenges and approaches. *Program-Electronic Library and Information Systems, 47*(1), 60-91. doi:10.1108/00330331211296312

Dzbor, M., Stutt, A., Motta, E., & Collins, T. (2007). Representations for semantic learning webs: Semantic Web technology in learning support. *Journal of Computer Assisted Learning, 23*(1), 69-82. doi:10.1111/j.1365-2729.2007.00202.x

Edwards, R., & Carmichael, P. (2012). Secret codes: the hidden curriculum of semantic web technologies. *Discourse-Studies in the Cultural Politics of Education, 33*(4), 575-590. doi:10.1080/01596306.2012.692963

Fernandez-Breis, J. T., Castellanos-Nieves, D., Hernandez-Franco, J., Soler-Segovia, C., Robles-Redondo, M. D., Gonzalez-Martinez,

R., & Prendes-Espinosa, M. P. (2012). A semantic platform for the management of the educative curriculum. *Expert Systems with Applications, 39*(5), 6011-6019. doi:10.1016/j.eswa.2011.11.123

Friesen, N., & Anderson, T. (2004). Interaction for lifelong learning. *British Journal of Educational Technology, 35*(6), 679-687. doi:10.1111/j.1467-8535.2004.00426.x

Gaeta, M., Mangione, G. R., Orciuoli, F., & Salerno, S. (2013). Ambient e-Learning: a metacognitive approach. *Journal of Ambient Intelligence and Humanized Computing, 4*(1), 141-154. doi:10.1007/s12652-012-0111-5

Gasevic, D., Zouaq, A., Torniai, C., Jovanovic, J., & Hatala, M. (2011). An Approach to Folksonomy-Based Ontology Maintenance for Learning Environments. *Ieee Transactions on Learning Technologies, 4*(4), 301-314. doi:10.1109/tlt.2011.21

Halimi, K., & Seridi-Bouchelaghem, H. (2019). A Web3.0-based Intelligent Learning System Supporting Education in the 21st Century. *Journal of Universal Computer Science, 25*(10), 1373-1393. Retrieved from <Go to ISI>://WOS:000499089000009

Halimi, K., Seridi-Bouchelaghem, H., & Faron-Zucker, C. (2014). An enhanced personal learning environment using social semantic web technologies. *Interactive Learning Environments, 22*(2), 165-187. doi:10.1080/10494820.2013.788032

Harchay, A., Cheniti-Belcadhi, L., & Braham, R. (2015). A Context-aware Approach for Personalized Mobile Self-Assessment. *Journal of Universal Computer Science, 21*(8), 1061-1085. Retrieved from <Go to ISI>://WOS:000365385300005

Henze, N., Dolog, P., & Nejdl, W. (2004). Reasoning and ontologies for personalized e-Learning in the semantic web. *Educational Technology & Society, 7*(4), 82-97. Retrieved from <Go to ISI>://WOS:000224855500007

Iatrellis, O., Kameas, A., & Fitsilis, P. (2019). EDUC8 ontology: semantic modeling of multi-facet learning pathways. *Education and Information Technologies, 24*(4), 2371-2390. doi:10.1007/s10639-019-09877-4

Jeremic, Z., Jovanovic, J., & Gasevic, D. (2013). Personal learning environments on the Social Semantic Web. *Semantic Web, 4*(1), 23-51. doi:10.3233/sw-2012-0058

Jia, B. X., Huang, X., & Jiao, S. (2018). Application of Semantic Similarity Calculation Based on Knowledge Graph for Personalized Study Recommendation Service. *Educational Sciences-Theory & Practice, 18*(6), 2958-2966. doi:10.12738/estp.2018.6.195

Jovanovic, J., Gasevic, D., Torniai, C., Bateman, S., & Hatala, M. (2009). The Social Semantic Web in Intelligent Learning Environments: state of the art and future challenges. *Interactive Learning Environments, 17*(4), 273-309. doi:10.1080/10494820903195140

Kim, P., Ng, C. K., & Lim, G. (2010). When cloud computing meets with Semantic Web: A new design for e-portfolio systems in the social media era. *British Journal of Educational Technology, 41*(6), 1018-1028. doi:10.1111/j.1467-8535.2010.01055.x

Kim, Y., Jung, S., Ji, S., Hwang, E., & Rho, S. (2019). IoT-based personalized NIE content recommendation system. *Multimedia Tools and Applications, 78*(3), 3009-3043. doi:10.1007/s11042-018-5610-8

Kohlhase, A., & Kohlhase, M. (2008). Semantic knowledge management for education. *Proceedings of the IEEE, 96*(6), 970-989. doi:10.1109/jproc.2008.921606

Lafuente, M. (2017). Getting looped in to the web: characterizing learning processes and educational responses. *Interactive Learning Environments, 25*(1), 72-84. doi:10.1080/10494820.2015.1116014

Lozano, E., Gracia, J., Corcho, O., Noble, R. A., & Gomez-Perez, A. (2015). Problem-based learning supported by semantic techniques. *Interactive Learning Environments, 23*(1), 37-54. doi:10.1080/10494820.2012.745431

Martinez-Garcia, A., & Corti, L. (2012). Supporting student research with semantic technologies and digital archives. *Technology Pedagogy and Education, 21*(2), 273-288. doi:10.1080/1475939x.2012.704320

Martinez-Garcia, A., Morris, S., Tscholl, M., Tracy, F., & Carmichael, P. (2012). Case-Based Learning, Pedagogical Innovation, and Semantic Web Technologies. *Ieee Transactions on Learning Technologies, 5*(2), 104-116. doi:10.1109/tlt.2011.34

Moreale, E., & Vargas-Vera, M. (2004). Semantic services in e-Learning: an argumentation case study. *Educational Technology*

*& Society, 7*(4), 112-128. Retrieved from <Go to ISI>://WOS:000224855500009

Nguyen, C. D. H., Arch-Int, N., & Arch-Int, S. (2017). SEMAG: A NOVEL SEMANTIC-AGENT LEARNING RECOMMENDATION MECHANISM FOR ENHANCING LEARNER-SYSTEM INTERACTION. *Computing and Informatics, 36*(6), 1312-1334. doi:10.4149/cai_2017_6_1312

Ounnas, A., Davis, H. C., & Millard, D. E. (2009). A Framework for Semantic Group Formation in Education. *Educational Technology & Society, 12*(4), 43-55. Retrieved from <Go to ISI>://WOS:000271028400005

Pattuelli, M. C. (2011). Modeling a Domain Ontology for Cultural Heritage Resources: A User-Centered Approach. *Journal of the American Society for Information Science and Technology, 62*(2), 314-342. doi:10.1002/asi.21453

Pereira, C. K., Siqueira, S. W. M., Nunes, B. P., & Dietze, S. (2018). Linked Data in Education: A Survey and a Synthesis of Actual Research and Future Challenges. *Ieee Transactions on Learning Technologies, 11*(3), 400-412. doi:10.1109/tlt.2017.2787659

Piedra, N., Chicaiza, J., Lopez, J., & Tovar, E. (2015). Seeking Open Educational Resources to Compose Massive Open Online Courses in Engineering Education An Approach Based on Linked Open Data. *Journal of Universal Computer Science, 21*(5), 679-711. Retrieved from <Go to ISI>://WOS:000358988400004

Poore, M. (2014). The Next G Web. Discernment, meaning-making, and the implications of Web 3.0 for education. *Technology Pedagogy and Education, 23*(2), 167-180. doi:10.1080/1475939x.2013.802992

Poulovassilis, A., Selmer, P., & Wood, P. T. (2012). Flexible Querying of Lifelong Learner Metadata. *Ieee Transactions on Learning Technologies, 5*(2), 117-129. doi:10.1109/tlt.2011.38

Raju, P., & Ahmed, V. (2012). Enabling technologies for developing next-generation learning object repository for construction. *Automation in Construction, 22*, 247-257. doi:10.1016/j.autcon.2011.07.008

Rani, M., Nayak, R., & Vyas, O. P. (2015). An ontology-based adaptive personalized e-learning system, assisted by software

agents on cloud storage. *Knowledge-Based Systems, 90*, 33-48. doi:10.1016/j.knosys.2015.10.002

Rodriguez, A. C., Gago, J. M. S., Rifon, L. E. A., & Rodriguez, R. P. (2015). A Recommender System for Non-traditional Educational Resources: A Semantic Approach. *Journal of Universal Computer Science, 21*(2), 306-325. Retrieved from <Go to ISI>://WOS:000352143200007

Romero, L., North, M., Gutierrez, M., & Caliusco, L. (2015). Pedagogically-Driven Ontology Network for Conceptualizing the e-Learning Assessment Domain. *Educational Technology & Society, 18*(4), 312-330. Retrieved from <Go to ISI>://WOS:000362516300024

Romero, L., Saucedo, C., Caliusco, M. L., & Gutierrez, M. (2019). Supporting self-regulated learning and personalization using ePortfolios: a semantic approach based on learning path. *International Journal of Educational Technology in Higher Education, 16*, 16. doi:10.1186/s41239-019-0146-1

Rouse, M. (2017). DEFINITION semantic technology. Retrieved from https://searchdatamanagement.techtarget.com/definition/semantic-technology

Sanchez-Vera, M. D., Fernandez-Breis, J. T., Castellanos-Nieves, D., Frutos-Morales, F., & Prendes-Espinosa, M. P. (2012). Semantic Web technologies for generating feedback in online assessment environments. *Knowledge-Based Systems, 33*, 152-165. doi:10.1016/j.knosys.2012.03.010

Shabajee, P., McBride, B., Steer, D., & Reynolds, D. (2006). A prototype Semantic Web-based digital content exchange for schools in Singapore. *British Journal of Educational Technology, 37*(3), 461-477. doi:10.1111/j.1467-8535.2006.00616.x

Tovar, E., Piedra, N., Chicaiza, J., Lopez, J., & Martinez-Bonastre, O. (2012). OER Development and Promotion. Outcomes of an International Research Project on the OpenCourseWare Model. *Journal of Universal Computer Science, 18*(1), 123-141. Retrieved from <Go to ISI>://WOS:000301282200008

Tracy, F., & Jordan, K. (2012). Students as designers of semantic web applications. *Technology Pedagogy and Education, 21*(2), 171-188. doi:10.1080/1475939x.2012.696789

Vesin, B., Klasnja-Milicevic, A., Ivanovic, M., & Budimac, Z. (2013). APPLYING RECOMMENDER SYSTEMS AND ADAPTIVE HYPERMEDIA FOR E-LEARNING PERSONALIZATION. *Computing and Informatics, 32*(3), 629-659. Retrieved from <Go to ISI>://WOS:000321677400009

Wang, H. C., & Huang, T. H. (2013). Personalized e-learning environment for bioinformatics. *Interactive Learning Environments, 21*(1), 18-38. doi:10.1080/10494820.2010.542759

Wang, S. H., & Wang, H. (2012). Organizational schemata of e-portfolios for fostering higher-order thinking. *Information Systems Frontiers, 14*(2), 395-407. doi:10.1007/s10796-010-9262-0

Zablith, F., Fernandez, M., & Rowe, M. (2015). Production and consumption of university Linked Data. *Interactive Learning Environments, 23*(1), 55-78. doi:10.1080/10494820.2012.745428

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