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Using Semantic Web (Web 3.0) in Education

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Abstract: The World Wide Web has brought a revolutionary change in the way Internet users benefit from the multitude of tools that allow them to search for information, exchange data, collaborate and interact with each other. In the field of education, education systems should no longer be limited to the narrow confines of formal processes and programmes, but should incorporate new technologies. Motivated by this trend, this paper provides an overview of the Semantic Web and examines its potential pedagogical uses and benefits in the field of education, taking into account various research challenges, models and structures.
Keywords: Semantic web, e-learning, Ontologies, Linked Data.

Introduction

Research on online education systems and e-learning has been going on for a long time and has played a key role in improving the quality of educational services, the quality of educational content, pedagogical approaches and technological frameworks.

There is no doubt that the Internet and the World Wide Web have been a revolution in the field of information, as their use has minimized geographical barriers and connected the whole planet into a network for the circulation of information. In particular, the use of the Internet in education is twofold: either as a means for delivering organized educational programmes (e-learning) or as a source of information, since it contains a large volume of information of varying subject matter and form which, with the appropriate processing, can contribute to the creation of timely and effective learning/teaching content. (Brooks et al., 2006).

Although the Internet is one of the most important sources of information, it has significant limitations in terms of the ability to extract the information itself. The public nature of the Internet has led to the creation of a large and constantly changing volume of information, resulting in its lack of uniformal form and structure. The solution to these problems was provided by the creator of the World Wide Web himself, Tim Berners-Lee, who came up with the next generation of the Internet, the Semantic Web (Web 3.0) (Berners-Lee et al., 2001).

The Semantic Web (SW) is an extension of the current Web (Web 2.0) with technologies that help automate the actions related to the search, retrieval and processing of information, thus providing a common framework for collaboration between humans and computers.

More specifically, the SW is a promising technology that gives online content a clear semantic, turning the vast amount of information posted on the Internet into knowledge. SW takes us from the traditional web of hyperlinks and simple publishing of documents and data to the creation of structured documents and their linking. It enables the description of information at a semantic instead of a merely syntactical level, where by using knowledge representation vocabularies (ontologies), the information can be tracked directly and accurately with the help of advanced applications. (Antoniou & Harmelen, 2009).

In the field of education, the SW can greatly contribute to learning, particularly in regards to the way information is searched for, the organization of results and the creation of a learning programme.

Students can access online libraries, educational resources, smart learning systems, virtual communities, online games and, through virtual reality, make use of SW technologies to better prepare for the workplace.

This paper aims to describe SW, the technologies it offers and how those can be used in the field of education. It consists of four sections:

- The first section introduces the SW and its technologies.
- The second section presents an overview of SW in education.
- The third section deals with the uses and applications of SW in education
- The fourth section presents the conclusions of the research.
- The fifth section provides the Bibliographical References.

Methodology

Nowadays, computers and smart communication devices are an integral part of students' everyday life and thus it is becoming inevitable that new methods of online teaching and learning will come to the foreground and, with the computer as their axis, contribute to adequately preparing students for the challenges of the 21st century.

The Internet as well as computers and new smart communication devices are nowadays used as tools to enhance the learning and teaching process. Traditional teaching methods with teachers lecturing in front of a blackboard and students watching them are no longer effective.

The use of ICT in the educational process has transformed the role of the teacher into an intermediary link for the discovery and acquisition of knowledge by students who are now actively involved in the educational process and engage in activities that require collaboration, critical thinking and understanding to think through and address a problem. (Kalogiannakis, 2010).

The use of the World Wide Web has made it possible for teachers to use new educational tools, access a wealth of educational material and to be able to easily and quickly obtain information and formulate teaching scenarios for their students throughout the educational process.

This article aims to describe the technologies of the SW and its uses in the field of education, in the face of the challenges of the 21^{ου} century. The questions it aspires to answer are:

- To what extent are the technologies and applications of the SW effective and beneficial in modern education?
- What are the advantages and disadvantages of using the SW in education?

The research method used is data collection techniques and literature review; while research fields related to SW technologies are presented.

The Semantic Web

The SW is not a new World Wide Web, but an extension and improvement of the current web in the direction of structuring information so that it is accessible by computer programs. In the SW, digital documents (web pages) are replaced by entities where they can be described in a structured way and linked to other entities, creating a giant global network of concepts and data. In this way, information acquires well defined meaning, enabling more effective collaboration between humans and computers, since there is now a common language of communication between them, that of semantic description.

The World Wide Web Consortium (W3C), which aims to drive the Web to its full potential by developing technology standards (specifications, guidelines, software and tools) describes the Semantic Web as "a vision for the future of the Web, in which information is given explicit meaning by making it easier for machines to automatically process and integrate information available on the Web".

The W3C maintains specifications for a stack of technologies with which the Semantic Web can be implemented. This stack is shown in Figure 1. (Wikipedia, 2022)

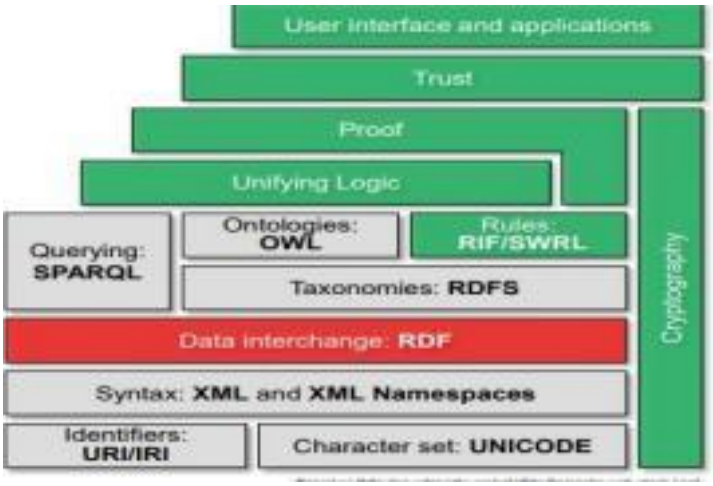

Figure 1: The layers of the SI architecture

Unicode is the standard used to represent any character and URIs (Uniform Resource Identifier) which are strings that uniquely identify an entity (a Web site, a property, a person, a thing, etc.). The XML markup language allows users to add arbitrary structure to their documents without defining the semantics of that structure.

The RDF framework is used to represent data and share knowledge ιn the Internet. The RDF Schema provides a predefined, basic modeling scheme for describing classes and resource properties based on the RDF model.

The OWL language is used to create and distribute ontologies, supporting advanced Internet search, software agents and knowledge management. While an ontology provides a way to describe terms and relationships around a domain of interest, offering a more robust syntax than RDF and RDF Schema as well as more robust logic-based semantics.

The SPARQL query and search language is used for RDF data, and for Linked Data in general. Logic and Proof is an automatic reasoning system and the last level of the structure addresses issues of trust in order to better guarantee the quality of the information found online and build a degree of trust in the source providing this information. (Aghaei et al., 2012).

Ontologies, the RDF standard, the OWL language and the SPARQL query and answer language are the key elements of the semantic web. They have the ability to encode semantics and provide

automated reasoning, merging and sharing of information from different sources. Figure 2 illustrates all the areas that SW technologies affect.

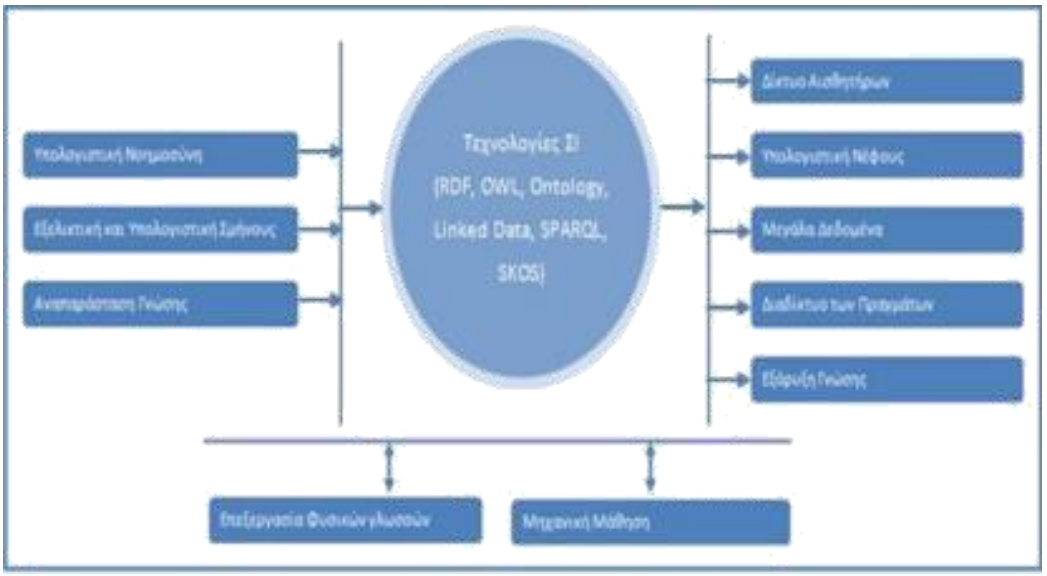

Figure 2: Areas related to the SW

The incoming arrows show how this domain enhances the development of the semantic web and outgoing arrows show the use of SW in this particular domain, while bi-directional arrows show these domains keep pace with SW. (Patel & Jain, 2019)

SW and its technologies have the potential to organize and connect data through the World Wide Web in a consistent and coherent way and solve various problems in many domains. The long-term goal is to "infuse" the Web with meaning by providing easy ways to describe the available resources and the links between them. The key to achieving this goal is metadata, or meta-information.

Metadata is data referring to other data and is a key element of SW, which is made up of linked statements consisting of a triple subject, predicate, object, each identified by a single resource identifier.

In particular, they contain part of the meaning of the data, which justifies the term "semantic". On the other hand, ontologies describing the real world play a vital role in establishing the SW. Inference rules and classification into classes are the most basic features of ontologies.

The term ontology was first used and defined by Tom Gruber in the 1990s. In his view, an ontology "is an explicit specification of a conceptualization. (Gruber, 1995). Ontologies contain important data and are intended to bridge the differences between different systems, languages and formats. They also provide a fertile ground for understanding, capturing, representing and interpreting the concepts of a domain. (Stojanovic, & Studer, 2003).

However, creating the SW is not an easy undertaking, as it requires cross-functionality, standardization and harmonization, tasks difficult to achieve. So far, the groups involved in creating standards do not work closely together and one of the biggest challenges of the Semantic Web is to create a common language that could be understood by all kinds of technology, computers, mobile phones, tablets, etc.

Semantic web and education

With the advent of the web in everyday life, many things have changed, especially the way we communicate and learn. Until recently, the educational process was defined by three basic characteristics: the teaching content, the order in which the teaching took place and the simultaneous presence of the teacher and the student in the same physical space.

In this way, education had a generalized character that did not always fit the needs and particular characteristics of the students. The challenges of the modern era are to improve Web-based education, providing more adaptability and intelligence. Developments in SW are contributing to this direction (Clark et al., 2004).

New SW technologies play an important role in changing educational practice and pedagogical approaches in school environments, where teachers and students can generate new knowledge and design their own learning practices. (Carmichael & Jordan, 2012).

The advantages of semantic technologies for learning and teaching and the benefits they offer in the fields of digital libraries, knowledge management and e-learning have been topics of debate over the last few years.

SW and Linked Data technologies can support and enhance everyday teaching practice, while engagement with these technologies also helps in developing new teaching and learning environments, in the search for and delivery of new resources by teachers and students and in the management of routine tasks by teachers. (Anderson & Whitelock, 2004).

SW in Education is a developing and futuristic vision. As such, it has many supporters and an equal number of skeptics. Proponents of SW foresee its use in new, very powerful applications in almost all disciplines, most critically social and economic. Teaching, learning, collaboration, assessment and other educational activities in the semantic web occur with the help of intelligent agents (Devedzic, 2004).

Ontologies are the backbone for structuring linked data and play an important role in defining links within a dataset and between datasets and other linked data. The development of ontologies in the field of digital libraries is a promising solution to the problem of different models and representation structures by establishing a commonly accepted model, thus promoting interoperability between libraries and helping students in their search for knowledge.

Finally, the knowledge graphs are also essential for the SW. The term "Knowledge graph" was invented by Google in 2012 and is intended for any knowledge-based graph such as DBpedia, Freebase, Open Cyc, wikidata, YAGO etc. Integrated knowledge bases like DBpedia and Wikidata can play a significant important role in educational process and practice in the context of the information overload problem.

Uses and applications of the semantic web in education

Nowadays, students' constant exposure to the Internet and digital media has sculpted a new way for learning and receiving information. The advent of SW in the field of education has facilitated the integration of new technologies into the educational knowledge bases and modernized the way in which teachers and students manage information (Yee-King et al, 2019). Reviewing the literature, we find that many researchers propose educational systems for e-learning based on ontologies and SW technologies (Tapia-Leon et al. 2018), (Yago et al., 2018), (Grivokostopoulou et al., 2019), (Stancin et al., 2020)

The use of ontologies in different areas of education offers a higher quality of learning and helps to search for data and information on new knowledge (Aróstegui et al., 2004). It allows the organization of SW-based knowledge and the integration of data from different sources (Isotani et al. 2013). It also helps shape the representation of a learning domain and supports the creation of a new generation of

intelligent learning systems that are personalized and tailored to the preferences and needs of learners. (Jensen, 2017), (Ibrahim et al., 2019)

Furthermore, ontologies can assist with creating concept maps and assessing students' understanding, as well as annotating answers to open-ended questions in various e-learning courses. (Castellanos-Nieves et al., 2011), (Icoz et al., 2014). For example, an ontology that has been developed and can be used in the field of music education is Music Ontology. It is used to represent and publish information about music, create music websites and enrich search engines around music tracks, artists, musical works, etc. (Rainmond, 2010).

In such a context, several personal learning environments (PLEs) and virtual learning environments (VLEs) have emerged with somewhat different definitions and common features including: facilitating online interaction with other people around a common content, control by the learners themselves of the learning process, bringing together all the different interests of the learner and simplifying their management, possibility of creating a framework of understanding through interaction with different existing resources. (Halimi, & Seridi Bouchelaghem, 2019)

On the other hand, Linked Open Data (LOD) Sets are now accessible to students and teachers and help in knowledge discovery. Wikipedia also covers a wide variety of topics where students can search for information and implement various projects. (Nikolaidou et al., 2011).

There are many applications where Linked Data is used in education with a clear pedagogical goal. One example is the MeLOD mobile app, which uses data residing in an Open Data cloud to provide relevant and up-to-date information based on the location of students. (Taibi et al., 2014) (Piedra et al. 2015)

Virtual Reality is also a technology that simulates an environment with which we can interact using appropriate equipment. (Bian, 2016). This technology can be used to virtually tour a place (museums, ancient civilizations), but also to learn musical instruments. (Guclu et al., 2021).

Artificial Intelligence is also contributing to the field of education by developing intelligent algorithms to extract knowledge from digital libraries. AI provides access to a completely new and demanding reality where students have the possibility to impersonate other people using Avatar. This opens up new perspectives in teaching and encourages collaboration, role-play and teamwork, making learning more interesting and different from traditional education.
(Bates et al., 2020).

Recent developments on the Internet as well as advances in technology-enhanced pedagogical methods have laid the foundations for the important role of games in education. Games no longer serve a merely entertaining purpose , but offer a powerfully dynamic learning environment.

Today's students have grown up around computer games. In addition, their constant exposure to the internet and digital media has shaped the way they receive information as well as the way they learn. There are many features of games that often make them considered pedagogical learning environments. A significant number of schools are using games as add-ons to enrich the traditional learning environment with encouraging results (Oblinger, 2004).

Finally, the SW provides access to a large number of open resources so that students can improve their knowledge in various fields of knowledge, as well as enroll in Open Massive Open Online Courses (MOOCs). It also provides the appropriate tools for the development of Smart Learning Environments where the triptych, *Anywhere, Anytime, Any Distance*, is implemented.

Conclusions

The implementation of Web 3.0 and its benefits in education will soon become visible. Ontologies, virtual worlds, open educational resources and Open Linked Data will help students to organize their own learning, set their own learning goals and obtain the knowledge appropriate for their personal learning.

SW will undoubtedly benefit students even if education in general is forced to change in order to match developments in Information and Communication Technology. In the end, the models and standards of SW will become interoperable, the software will provide accurate translations and the use of multimedia will provide the wealth of information that students seek.

Unfortunately, the web was built for human use and not for use by a machine. Regardless of the shortcomings of current standards, SW is part of the development of the web and if some people are currently not comfortable with the elements that enable its application, new generations will overcome this challenge.

The next generation of learning is e-learning, where SW technologies offer several benefits to students and teachers such as access to educational resources without geographical and time constraints. On the other hand, there are several challenges associated with e-learning through SW, such as managing large volumes of data, information overload, knowledge extraction costs, data security as well as legal or copyright issues.

In short, we are at the very beginning of a new revolution where people and computers have more collaboration and data management tools at their disposal. While it is difficult to predict the specifics, but one thing is certain: if SW becomes as ubiquitous as the Web 2.0, the results will be exciting!

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