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Ontological Search for Academic Resources

Ángel Fidalgo-Blanco
Geological and Mining Engineering
Technical University of Madrid
Madrid Spain
angel.fidalgo@upm.es

María Sánchez-Canales
Technical University of Madrid
Madrid Spain
maria.scanales@upm.es

María Luisa Sein-Echaluce
Applied Mathematics
University of Zaragoza
Zaragoza Spain
mlsein@unizar.es

Francisco J. García-Peñalvo
GRIAL Research Group,
Research Institute for Educational Sciences
University of Salamanca
Salamanca Spain
fgarcia@usal.es

ABSTRACT

Active methodologies promote students´ elaboration of knowledge-based resources susceptible to being used as a learning tool. However, due to their quantity, variety and the technology used, it is difficult to manage them, mainly as regards the consultation and identification of the most appropriate resources to carry out a specific training action. A possible solution would be to develop (1) a repository that offers an overview of all resources generated, regardless of the technology, variety and types; (2) an ontology, which permits their classification; and (3) a semantic search system that allows a user to make a quick and effective retrieval. This research-based paper shows the results obtained using a content manager, which centralizes the resources created by the students in some technologies. Also, two tools have been developed: an ontology, which permits resources of a subject to be classified, and a plugin for WordPress, which allows the ontologies are building through the use of tags and categories, as well as to provide them with a semantic search engine through inferences between ontology-related elements—. Through a result cross-check, students' perception of the repository use has been measured. It has been found that, on the one hand, the system proposed is adequate to manage the resources generated by the students; and, on the other, their availability has been useful for them.

CCS CONCEPTS

• Applied computing →Education→Learning management systems

KEYWORDS

Active methodologies, Repository, Ontological search, WordPress plugin.

1 INTRODUCTION

In recent years, with the development of the ICT possibilities for communication, the interest of using them no longer for individualized learning but also as a support for group learning and the joint creation of knowledge. In this way, ICTs open up new perspectives for group learning, in collaboration. Relevant authors in the education field [4,16,26,27] considered that learning is an activity located in a context that gives it intelligibility, according to which the decontextualization of learning is impossible since all acquisition of knowledge is contextualized in some type of social activity.

Despite the different definitions and approaches of cooperative learning [3,14,15], in general, authors considered it as a teaching methodology based on the certainty that learning increases when students develop cooperative skills to learn, solve problems and perform activities[2]. In this perspective, learning constitutes a social action that results from the interaction between people. However, to work cooperatively, it is necessary that the exchange in the groups leads to the elaboration of new ideas[18].

e generation of content by students is related to the application of active methodologies [5] several studies have shown the usefulness of the materials created by students as learning resources[22,24]. In some cases, the problem is to get students a ached to the knowledge-building activity. Recognition and respect from peers can be a strategy to solve this problematic [21]. In other cases, when students are very participative during the application of collaborative work, the resources generated by them are enormous and their use is practically impracticable. In that case, a content manager becomes essential.

It is necessary to answer specific questions to manage knowledge, such as: what is to be managed, for what, how, etc., that is, analyze how knowledge should be treated so that it can be useful to people and the organization. The answer to these questions is also known as knowledge modalities applicable to the formation of organizational capacities[13]. These knowledge modalities can be managed at different levels: search for information; structuring, archiving and distribution of information; and, finally, the creation, participation, and management of information[20].

The term repository assumes the extension of the characteristics of preservation and conservation of the archives, since in addition to storing the information; the repository has other functionalities such as supply, management, recovery, visualization and reuse of digital documents[10,19]. Including resources generated by students in digital repositories, the experience of collaborative work not only remains in knowledge generation of an academic course but also can be reused by students of later courses.

However, to find the most relevant information becomes to be difficult when there is a large amount of information, like on the Internet. Searches yield millions of references and the most relevant ones are difficult to find. The same happens in repositories that contain a large amount of content and very similar[7], any search yields almost all content. In this context, Ontology [8] is becoming relevant as a solution for several search problems, for example when different terminology is used to refer to the same concept or the same term involves various concepts[11].

In the Internet framework, one of the main objectives of Web 3.0 is to give meaning to the Internet information, in this way searches find easier the relevant information. A way to give sense to the information is by adding metadata to it [17] . Also, to facilitate the search for pertinent information, inferences between metadata can be used[12].

The primary goal of this research work is to develop a plugin that provides a content manager with semantic search capabilities through inferences between elements of its ontology. This development will be applied to a repository — created with the content generated both by students and teachers— in the context of a university subject.

2 CONCEPTUAL MODEL

The developed model was based on CSORA method [7] which uses tags with different functionalities such as classification, search, organization of results and relationship with the object identified:

- Classification: tags are used to have identified and related all the repository´s contents. Classification is usually made based on robust ontologies or weak ontologies. The first type uses standard and globally recognized classifications — i.e., UNESCO Nomenclature for fields of science and technology [25]. The second one is arising from the application, in a specific context, of the repository´s contents, such as tags defining the classification of blog content.
- Searches: made by inferences between tags to ensure the usefulness of obtained results after a search. These labels can be the same as those used for classification or specific ones for searches.
- Organization of results: done by regrouping obtained results based on lists defined by label sets.
- Relationship with the object identified: Through the so-called relationship tags other objects similar to previously identified one can be found.

The CSORA method has been validated not only in different institutional repositories i.e. University of Zaragoza [1,23] or University of Salamanca [9]— and in thematic repositories [6].

Tags —following the CSORA model— were used to classify and organize all the repository´s contents by establishing ontologies. The ontology used should allow identifying, classifying and relating the whole subject knowledge.

Through inferences in the different elements of the ontology logical expressions by using tags are established. Logical expressions are used to identify the contents whose tags match with the used expression used for the search done.

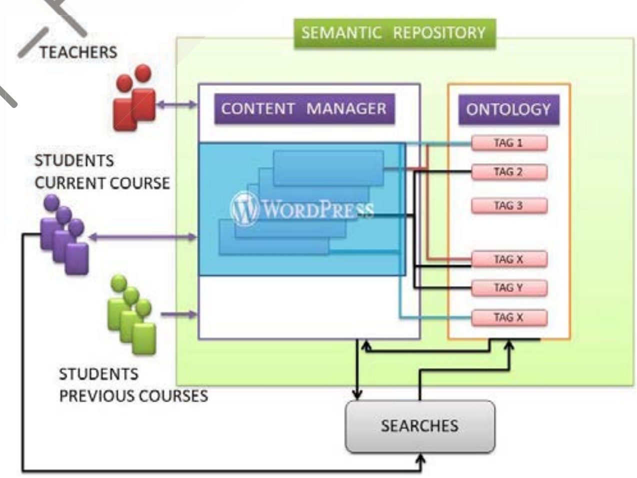

Figure 1. Scheme of the repository previously created and weak-ontology-based tags used for searches.

In this paper, several tags —based on weak ontologies— have been added to classify contents of a repository previously created. Also, these weak-ontology-based tags were used for searches through inferences between them, as shown in Figure 1.

Three different user groups introduced contents in the created repository: teaching staff, students of previous courses and current students.

In this work, a WordPress plugin has been developed. The choice was motivated by its global reach since 30% of the web pages worldwide are made with this content manager. Likewise, whether web pages made exclusively with content managers are considered, WordPress has a 60% share worldwid[28].

As it is shown in Figure 2, two types of contents are managed by WordPress: post and pages. In terms of structure, both cases can be considered as pages within a web. In order to establish an ontology, WordPress uses both tags and categories. The categories are similar to tags; the difference lies in only categories maintain a hierarchical structure.

Figure 2 Types of contents managed by WordPress: post and pages

Thus, the classification and organization of the contents could be done through an ontology with WordPress, however, to make inferences between the elements of the ontology does not allow.

In this work, a plugin for WordPress has been developed, which allows establishing a hierarchical ontology using both WordPress tags and categories (Figure 3). The ontology has been carried out through the following structure: Group, Branch Parent and Tag/Category.

An ontology includes some Group, each one of them with several Branch Parent. Each Branch Parent, in turn, can be composed of numerous hierarchical elements—WordPress tags or categories.

The plugin developed allows marking Tags, and through them, it makes a logical expression with the following criteria: using "or" between all the tags of the same Branch Parent but "and" with tags of different Branch Parent.

In a real search, shown in Figure 4, using the plugin developed, all pages and post would be found whose related tags meet the following inference:

(Grade.Biotechnology) and (Feedback Positive or negative) and (Stage. Results).

All the content found in WordPress —that responds to the inference mentioned above— are shown on the le side.

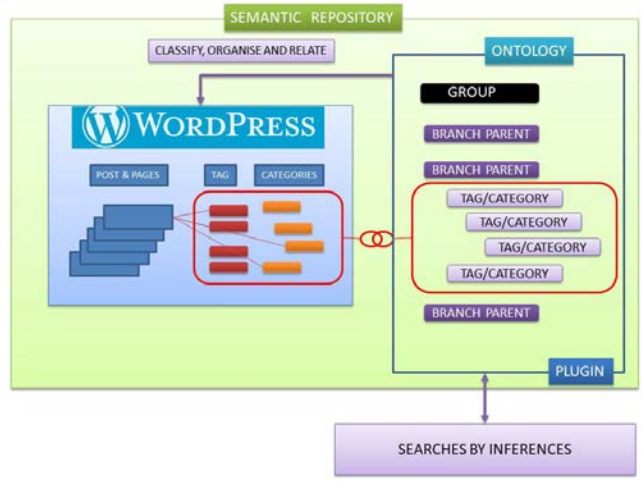

Figure 3 The developed plugin for WordPress allows establishing a hierarchical ontology using both tags and categories

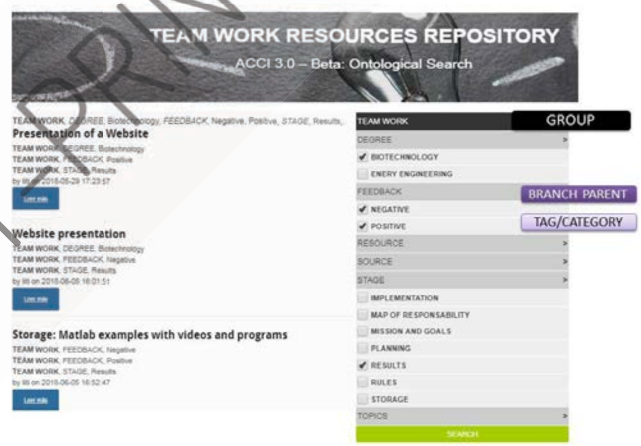

Figure 4 Screenshot showing a real search using the developed plugin

3 APPLICATION CONTEXT

The repository was used during the second semester of the 2017-2018 academic year, in the subject of "Computer Science and Programming." This subject is belonging to the first year of Energy Engineering degree in the Polytechnic University of Madrid.

A total of 144 students have participated in the experience. Three groups of students were established following the pre-existing groups in the subject: two-morning groups' —GIE1 and GIE2— with 66 and 60 students respectively, and an afternoon group —GIE3— including 18 participating students.

The repository was nurtured, as mentioned above, by three different user groups. Firstly, the contents coming from teaching staff are learning resources of the subject mentioned above and learning resources of another subject —"Foundations of programming" of the first course of the Biotechnology degree, taught during the first semester of the course 2017-2018.

Secondly, resources coming from the students of the above subject of Biotechnology were also added to the repository, which means that they were contents contributed by students of another subject and course.

Finally, contents generated by GIE1 group during the development of the subject of "Computer Science and Programming" were incorporated into the repository. The 66 students of the GIE1 group were grouped into 11 teams for the generation of the above-mentioned contents.

The repository, composed of the contents three mentioned groups, was used by all the students of the subject of "Computer Science and Programming" during the final step. This last phase of the experiment corresponds to the accomplishment of teamwork by the 144 students. With this work, individual competences —such as responsibility, participation, commitment— and group competences —i.e. the completion of the teamwork stages— are measured. The results were also measured with the final work.

It should be noted that for the elaboration of the teamwork mentioned above, the GIE1 and the GIE2 groups were given the repository without any prior training, while the GIE3 group was explained their usefulness and management in class.

4 RESULTS

At the end of the course, a survey of students participating in the experiment was conducted. One of the questions (Q13) analyzed the perception of the students in the use of the repository (see Figure 5).

Q13 - Assess the extent to which you agree about the repository used to share resources.
Likert scale (1=totally disagree to 5=totally agree).

Q13.1 – I have a vision of the different resources in the repository.
Q13.2 – I can recover the information quickly.
Q13.3 - I think that the experience of surfing the repository was good.
Q13.4 - I recommend using the repository for other subjects.

Figure 5 Questions asking to students about the repository used

Participation in the survey was 60.6% in the GIE1 group —40 out of 66— and 61.7% in the GIE2 group —37 out of 60. However, for the GIE3 group, of the 18 students, a total of 15 responded to the survey that corresponds to 83.3%.

Table 1 Participation in the survey by student group

Student group	Population (Nº students)	Sample (Nº students)	Survey participation
GIE1	66	40	60.6%
GIE2	60	37	61.7%
GIE3	18	15	83.3%

For each of the sub-questions that made up question Q13, the mean and standard deviation of the answers obtained were analyzed. The results are shown in the following table:

Table 2 Mean and standard deviation for Q13.1 – "I have a vision of the different resources in the repository"

Q13.1.	Mean	sd
GIE1	3.350000	0.9001424
GIE2	3.027027	0.8542422
GIE3	3.466667	0.6324555

Table 3 Mean and standard deviation for Q13.2 – "I can recover the information quickly"

Q13.2.	Mean	sd
GIE1	3.100000	0.9001424
GIE2	3.216216	0.8542422
GIE3	3.400000	0.6324555

Table 4 Mean and standard deviation for Q13.3 – "I think that the experience of surfing the repository was good"

Q13.3.	Mean	sd
GIE1	2.975000	0.9001424
GIE2	2.729730	0.8542422
GIE3	3.666667	0.6324555

Table 5 Mean and standard deviation for Q13.4 – "I recommend using the repository for other subjects"

Q13.4.	Mean	sd
GIE1	3.125000	0.9001424
GIE2	3.027027	0.8542422
GIE3	3.666667	0.6324555

For all sub-questions and groups, mean was more than 2.5 out of 5. For Q13.1, Q13.2, and Q13.4, the three groups have a mean within 3 - 3.5. However, for sub-question Q13.3, both the GIE1 and the GIE2 have a mean between 2.5 and 3. The higher mean was for the GIE3 for both Q.13.3 and Q13.4 sub-questions.

5 CONCLUSIONS

For all the groups and in all the sub-questions that make up the question Q13, mean exceed a value of 3 —or are close to 3— out of 5. Therefore, in general, all the students have used the repository together with the search engine by inferences between elements of the ontology. Likewise, it is deduced that their together use has been useful for all students.

More specific conclusions have been obtained following.

5.1 Different resources in the repository

The best results have been getting from both groups with a preview of the repository contents ─GIE1─ because of creating and uploading resources to the repository, and ─GIE3─ for receiving an informative class about the materials and use of the repository. However, the GIE2 results have been lower, due to lack of information or previous experience with the contents of the repository.

Hence, for better results, students should have prior knowledge of the different types of resources available in the repository. This is because there are available for students a large number of resource types as lessons learned from the students, videos made by the students, notes, doubts, reflections, exercises, among others.

5.2 Recovering information quickly

The results in the speed of information retrieval are similar between the GIE1 and the GIE2. Although the GIE3 results are slightly higher than GIE1 and GIE2, they can also be considered analogous. This similarity in the results of the three groups can be explained by the fact that the search depends on the inferences between the elements of the ontology. Therefore, it is independent of whether the types of content that exist in the system are known since the ontology generates a complete view of the system.

5.3 Surfing the repository

The results obtained on navigation through the repository have been the lowest in both the GIE1 and the GIE2 ─with similar results in both groups─. However, the highest values of the entire survey were obtained in the GIE3 group. These results may be due to only the GIE3 received prior training in the use of the repository.

The repository navigation is entirely different from the navigation that can be done through a social network, website or any other technology ─wiki, google drive, YouTube, among others─ that students have used during the course. Therefore, the first few times surfing the repository might be confusing, especially if the user did not receive prior orientation. As a result of this, it can be concluded that the first few times of use of the repository can be confusing to handle due to the student's lack of habit. Therefore, an explanation about it in advance can be very beneficial for all students.

5.4 Using in other subjects

Regarding the recommendation of the repository used in other subjects, in all groups, the average response is over 3. The value obtained by the GIE1 group is very similar to the GIE2 group. However, the GIE3 group obtained a significantly higher value.

Based on these results, it can be assumed that the students recommend the repository used in other subjects. Therefore, the transferability of the developed repository to other subjects has been verified.

Also, from the significantly higher values in results of the sub-questions Q13.2, Q13.3 and Q13.4 in the GIE3 group, it can be concluded that the previous explanation of the use of the repository is beneficial for users.

5.5 Software developed

Active methodologies application allows students to generate content that can be considered useful for the subject. This content might be made by students of other courses and subjects or by the students of the current course. In this context, where vary and multiple materials are generated, an adequate organization lets to have a vision of all types of resources available in the repository. With these premises, the searches will be effective, and navigation will be easy to perform.

The adaptation of the CSORA method to a document manager provides those characteristics. The software developed can easily be incorporated into any web page that has already been created with WordPress or any new page that is going to be made with WordPress. Competing with tools to make repositories is not the goal, but having the possibility of a new application of WordPress as a repository in academic contexts is one of the objectives. Similarly, complementing web pages made with WordPress with a plugin that allows building a repository with the contents of the Web page itself is another aim.

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REFERENCES

[1] Abadía, A.R., Beltrán, F., Bueno, C., Fidalgo Blanco, Á., Julián, J.A., Lerís, D., Lidón, I., R. and R., Rivero, P., and Sein-Echaluce Lacleta, M.L. *Repositorio de Buenas Prácticas de Innovación Docente de la Universidad de Zaragoza.* Á. Fidalgo Blanco, M.L. Sein-Echaluce Lacleta and F.J. García-Peñalvo, Madrid, 2015.

[2] Cabero, J. Principios pedagógicos, psicológicos y sociológicos del trabajo colaborativo: su proyección en la telenseñanza. In F. Martínez, ed., *Redes de comunicación en la enseñanza. Las nuevas perspectivas del trabajo cooperativo.* Paidós, Barcelona, 2003, 131–156.

[3] Dillenbourg, P. *Collaborative learning: cognitive and computational approaches.* Pierre Dillenbourg, Amsterdam, 1999.

[4] Engeström, Y. and Cole, M. Situated Cognition in Search of an Agenda. In D. Kirshner and J.A. Whitson, eds., *Situated Cognition Social, Semiotic, and Psychological Perspectives.* Lawrence Erlbaum Associates, London, 1997, 301–309.

[5] Fidalgo-Blanco, Á. La innovación docente y los estudiantes. *La Cuestión Universitaria 0*, 7 (2016), 84–91.

[6] Fidalgo-Blanco, A., Sein-Echaluce, M.L., and Garccía-Peñalvo, F. Epistemological and ontological spirals: From individual experience in educational innovation to the organisational knowledge in the university sector. *Program 49*, 3 (2015).

[7] Fidalgo, Á. and Ponce, J. Método CSORA: La búsqueda de conocimiento; CSORA Method: The search for knowledge. *ARBOR Ciencia 187*, Extra 3 (2011), 51–66.

[8] García-Peñalvo, F.J., Colomo-Palacios, R., García, J., and Therón, R. Towards an ontology modeling tool. A validation in software engineering scenarios. *Expert Systems with Applications 39*, 13 (2012), 11468–11478.

[9] García-Peñalvo, F.J., Sein-Echaluce, M.L., and Fidalgo Blanco, Á. Educational Innovation Management. A Case Study at the University of Salamanca. *Proceedings of the Third International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM'15)*, ACM (2015), 151–158.

[10] GARCÍA PEÑALVO, F.J. The Future of Institutional Repositories. *Education in the Knowledge Society (EKS) 18*, 4 (2017), 7–19.

[11] Guarino, N. Ontologies and knowledge bases: towards a terminological clarification. In N.J.I. Mars, ed., *Towards Very Large Knowledge Bases*. IOS Press, Amsterdam, 1995, 25–32.

[12] Haghshenas, H., Kabir, H., and Khademi, M. Some Properties of Semantic Web in e-Learning. *International Journal of Innovation, Management and Technology 4*, 2 (2013), 189–191.

[13] Huang, K., Lee, Y.W., and Wang, R. *Calidad de la información y gestión del conocimiento*. AENOR. Asociación Española de Normalización y Certificación, 2000.

[14] Johnson, D.W. and Johnson, R.T. Conflict in the classroom: controversy and learning. *Review of Educational Research 49(1)*, (1979), 51–70.

[15] Johnson, D.W. and Johnson, R.T. *Learning together and alone : cooperative, competitive, and individualistic learning*. Allyn and Baco, Boston, 1999.

[16] Leontiev, A.N. *Actividad, Conciencia y Personalidad*. Ediciones Ciencias del Hombre, Buenos Aires, Argentina, 1978.

[17] Memeti, A., Imeri, F., and Xhaferi, G. Reusing Learning Objects and the Impact of Web 3.0 on e-Learning Platforms Council for Innovative Research. *International Journal of Computers & Distributed Systems 4*, 3 (2014), 64–68.

[18] Mercer, N. *The guided construction of knowledge. Talk amongst teacher and learner*. Multilingual Matter, Clevedon, 1995.

[19] Pinfield, S. Journals and repositories: an evolving relationship? *Learned Publishing 22(3)*, (2009), 165–175.

[20] Rosenberg, M.J. *E-learning. Strategies for delivering knowledge in the digital age*. Mc Graw Hill, Bogotá, 2001.

[21] Scardamalia, M. and Bereiter, C. Computer support for knowledge-building Communities. *Journal of the Learning Sciences 3(3)*, (1994), 265–283.

[22] Sein-Echaluce Lacleta, M.L., Fidalgo Blanco, Á., and García Peñalvo, F. Metodología de enseñanza inversa apoyada en b-learning y gestión del conocimiento Flip Teaching Methodololgy supported on b-learning and knowledge management. *Actas del III Congreso Internacional sobre Aprendizaje, Innovación y Competitividad. CINAIC*, Fundación General de la Universidad Politécnica de Madrid (2015), 464–468.

[23] Sein-Echaluce, M.L., Abadía-Valle, A.R., Bueno-García, C., and Fidalgo-Blanco, A. Interaction of knowledge spirals to create ontologies for an institutional repository of educational innovation best practices. *International Journal of Human Capital and Information Technology Professionals 8*, 2 (2017).

[24] Sein-Echaluce, M.L., Fidalgo-Blanco, A., Esteban-Escaño, J., and García, F. The learning improvement of engineering students using peer-created complementary resources. *International Journal of Engineering Education 33*, 2 (2017).

[25] UNESCO. *Informe del director general sobre las actividades de la Organización en 1973*. París, Conferencia general de la Unesco 18ª reunión, 1974.

[26] Vygotsky, L.S. *Mind in society: The development of higher psychological processes*. Harvard University Press, Cambridge, 1978.

[27] Wenger, E. *Communities of Practice: Learning, Meaning, and Identity*. Cambridge University Press, 1999.

[28] Usage Statistics and Market Share of WordPress for Websites, August 2018. 2018. https://w3techs.com/technologies/details/cm-wordpress/all/all.