A Social Semantic Repository for Special Needs Education

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Abstract—The main problem that characterises the context of Special Education is the availability of a large amount of available information and its real, pertinent usability. The use of software systems for the semantic annotation and retrieval of teaching resources for this field appears to be still little explored, also due to the lack of specific semantic models for information description. This paper introduces the Knowledge Hub, a semantic repository of educational and information resources for Special Education, which is able to assist practitioners and teachers in finding the most interesting and useful digital resources for each special need by combining recommendation techniques with Semantic and Social Web models and tools. The paper also describes the encouraging results of a system experimentation with real users.

Keywords—Special Needs Education, Semantic Repository, Recommender Systems.

I. INTRODUCTION

The distributed nature of information, the large amount of available information sources and the potential wealth of knowledge enclosed in social networks and communities of interest highlight the need to seek out new paths and new environments which are specifically functional to Special Needs Education (SNE) and which are able to overcome the so-called “horizon restriction” as well as to improve resource searching in a deeper way [1].

Many people see knowledge management technologies and semantic searching technologies as the starting point for building the answers to these problems. In particular they seem to facilitate what is known as natural browsing, i.e. the process of knowledge extraction and formalisation, the aim being not only to make this knowledge accessible to the whole user base but also to exploit the interaction between users and the system so that users themselves contribute to refining and increasing the knowledge base.

Although there have been many proposals of systems for the recording and semantic retrieval of didactic resources, the opportunities offered by these technologies in SNE have yet to be thoroughly explored, particularly as regards their potential for improving the teaching and learning processes of homebound (HB) disabled subjects and for fostering the synergies among all the actors involved in such processes.

II. RELATED WORK

The evolution of the use of Internet as a social space and the dynamics related to Social Computing have led to the establishment of a new communicative paradigm based on collaboration, horizontal information and knowledge sharing. Users have taken on a new role; after having been consumers of information, they now share content, build connections, assess cultural artefacts and produce digital content [2].

In this scenario, the various forms of knowledge to be filed and documented, above all to counteract problems of information overload, can find a possible solution in the semantic technologies. Thanks to the Semantic Web [3] which enables systems to interpret the meaning of structured documents, it is possible to carry out searches that go beyond the presence of keywords in the document, as well as other specialised operations such as building networks of relations and connections among documents, and so forth [4].

The scientific research sector invests in the assets of information and of open and distributed knowledge, and highlights the advantages that an efficient space for the retrieval and updating of the shared information base can
have on a knowledge community. The concrete launching of an online research activity within specific interest groups such as those connected to Special Education can be helped by a skilful, rational integration of knowledge repositories, allowing users to retrieve, construct and share information from distributed and heterogeneous action contexts.

The classic learning repositories such as MERLOT\(^1\) are centralised repositories which contain only metadata and indicate the remote location of learning objects. Others such as CAREO\(^2\) present resources with the relative metadata records. This guarantees the result of the research on the basis of a fixed structure of stored knowledge. On the other hand however, these repositories necessarily make use of formalised meaning structures.

An approach which several authors agree might remedy the lack of formal semantics in knowledge repositories which makes both the retrieval process and the population of the database difficult, is that of the Semantic Web. It introduces the concept of semantic metadata, which enable the user to associate special descriptions with information or knowledge resources\([5]\).

These descriptions favour the generation of logical links to a certain number of classes and properties defined in special ontologies. The semantic metadata are machine-understandable and can be used by the applications to obtain full semantic interoperability and effective retrieval.

**Semantic Learning Object Repositories (SLOR)** \([6]\) use tools for the formal representation of knowledge, in the form of ontologies. Their aim is to enable their users to carry out advanced searches and to benefit from mechanisms for identifying and retrieving resources.

Examples of SLOR include ELENA\(^3\), a system based on Web Services which offer personalisation functions that exploit the semantic annotations of the learning objects. The central element of the architecture is the personal learning assistant service that provides a search interface interacting with an ontology both to construct the queries and to specify queries based on concepts not included in the ontology.

An additional service extends the user’s query, inserting further limitations and variables not present in the original formulation. On the basis of heuristic principles, semantic links were created between didactic resources, bearing in mind the information contained in the user’s profile.

MILOS\(^4\) supports the storing and retrieval of learning objects using several methods. Besides formulating queries based on the metadata of the resources, it allows to carry out research on the contents of the resources\([7]\). The system also supports a hypertextual access based on the semantic associations among resources, and a semantic access based on various information obtained through profiling.

The WIKINGER project\(^5\) is working on semantic repositories which support the collaborative generation of a network of the topics, so as to facilitate the creation of a critical mass within the contexts of the interest or scientific communities\([8]\). The result is a semantic network which provides a representation of the knowledge contained in the data, assessed by domain experts.

As far as the domain of SNE is concerned, it should be pointed out that the specific repositories are very few. We cite as an example ePKhas\(^6\), developed in the Malay archipelago for the creation, sharing and retrieval of digital resources for SNE. The system presents resources anchored to specific digital lesson plans and does not adopt advanced solutions for searching for material which can help sector stakeholders and the members of the interest communities to find solutions for their specific needs.

Another Web repository is Teacher Gateway to Special Education\(^7\) where the resources have been organized along three main lines: **Student Needs, Formal Exceptionalities Determined by IPRC and Diagnosed Medical/Psychological Conditions**. The resources are organized using a specific taxonomy and are anchored to special needs offering prompt and cues the system doesn’t allow a personalized search.

The KH, designed and developed by research activities described in this article, is a knowledge repository endowed with an intelligent browsing system which helps a user to search for resources in the SNE field. To do this, the KH combines methodologies from Adaptive Hypermedia with Recommendation Systems and the Semantic Web.

### III. MODELLING RESOURCES FOR SNE

The KH is a semantic repository of educational and information resources for SNE that can be retrieved through browsing or complex search features. To be employed by the system, the managed resources must be formally described with a specific semantic model. The following paragraphs describe the components of such model.

#### A. Resource categories

The KH manages different categories of SNE-linked information resources, including:

- **projects**, i.e. interventions connected to SNE which have specific resources and a definite duration, created to achieve goals in specific contexts;
- **experiences**, i.e. good practices connected to SNE, not related to specific projects;
- **communities**, i.e. formal associations, informal groups, institutional communities or networks of subjects operating in SNE or connected fields;
- **educational processes**, i.e. educational models and processes which involve homebound subjects, developed at both national and international levels;
- **bibliographical resources**, i.e. documents of interest, connected or in some way pertinent to SNE themes.

The resources are interconnected so as to allow their semantic navigation. Figure 1 shows the interdependences of the managed resources.

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\(^1\) [http://www.merlot.org/](http://www.merlot.org/)

\(^2\) [http://careo.netera.ca](http://careo.netera.ca)

\(^3\) [http://www.elena-project.org](http://www.elena-project.org)

\(^4\) [http://vice.isti.cnr.it/](http://vice.isti.cnr.it/)

\(^5\) [http://www.iais.fraunhofer.de/wikinger.html](http://www.iais.fraunhofer.de/wikinger.html)

\(^6\) [http://epkhas.ses.usm.my/](http://epkhas.ses.usm.my/)

B. Resource metadata

In the KH, a resource may consist of a document, a file or a link to a Web resource. Each resource is associated with a metadata composed of a group of pairs (field/value), where field belongs to a specific scheme varying according to the category of resource, and value is chosen from the values which are acceptable for each specific descriptor [9].

For each KH resource, several descriptors have been identified for representing the information core in the most exhaustive and simplest way. Many descriptors come from user modelling and, for the different types of resources, only those characterising their specificity have been selected.

A full description of the defined metadata model is provided in [10]. It reproduces the main features resources identified in the mapping stage using a formalised language. The model is structured into a series of descriptors, presented through a formalism compliant with the LOM 1.2 standard8, and includes information about the compulsory nature of the fields, the data types and the dimensions.

C. The homebound profile

The KH allows a process of automatic selection of content and information on the basis of users’ specific needs, characteristics and requests, so as to provide the most pertinent contents at the most opportune moment and in the most suitable way. At the basis of the personalisation process there is a formal representation of the characteristics of the user accessing the system, known as user model.

In the user model, all the relevant information related to a specific user is stored so as to personalise the interaction with the system. A model instance, known as profile, is a record of structured data containing information connected with the user, including identifiers, features, skills, needs, interests and preferences, and previous behaviour in relevant contexts which may predict and influence future behaviour.

Ideally speaking, a profile should thus include all the information regarding the user which might be useful for improving the process of content personalisation. Some information regards user’s stable and unalterable properties, such as name, gender, age etc.; others may change with time, e.g. new preferences or skills acquired during interactions.

A specific category of these metadata sets has been devoted to describing the “referential HB characteristics and context”. So, once the whole set of metadata composing the user-model was determined, for each specific typology of resource stored in the KH we identified the user descriptors which could be useful to describe and to search for them.

The defined user-model is based on the international specifications IMS-LIP9 and consists of 5 categories of descriptors: (1) User identification and affiliation; (2) User’s role and characteristics; (3) Referential HB’s characteristics and context; (4) User preferences; (5) Information needs.

Only the last category is automatically inferred from user tracking, while other information is gathered directly from the user registered in the system. Descriptors belonging in categories 1, 2 and 4 concern the generic user, while the ones of category 3 are aimed at describing the referential HB (the user himself/herself or the user’s son, brother, student, etc.).

This category of descriptors is the actual added value of the user-model, since it allows to personalize the user experience with the system according to the characteristics of the referential HB. It is important to note that this specific set of descriptors has been derived from a mapping against the ICF classification10 of the World Health Organisation [11].

IV. RECOMMENDING RESOURCES FOR SNE

Recommender Systems (RS) are aimed at providing personalised recommendations on the utility of a set of objects belonging to a given domain, starting from the information available on users and objects. The KH uses RS techniques to provide recommendation and personalised search functions on SNE resources.

After introducing the problem of recommendation and principal RS approaches, this section describes the RS techniques we defined to generate suitable recommendations of SNE resources, based on the analysis of user behaviour within the system.

A. Approaches to the recommendation problem

A formal definition of the recommendation problem can be expressed in these terms [12]: C is the set of users of the system, J the set of objects that can be recommended, R a totally ordered set whose values represent the utility of an object for a user and u: C × J → R a utility function that measures how a given object i ∈ J is useful for a particular user c ∈ C. The purpose is to recommend to each user c the object i that maximises the utility function so that:

\[ \hat{r}_{c} = \arg \max_{i \in J} u(c, i) \]

8 http://ltsc.ieee.org/wg12/
9 http://www.imsglobal.org/profiles/
10 http://www.who.int/classifications/icf/
The central problem of the recommendations is that the function \( u \) is not completely defined on the space \( C \times I \); in fact, in typical applications of such systems, a user never expresses preferences about each object of the available catalogue. An RS shall then be able to estimate the values of the utility function also in the space of data where it is not defined, extrapolating from the points of \( C \times I \) where it is known.

Several RS techniques exist in literature. In **cognitive approaches** [13], the value of the utility function \( u(c, i) \) is predicted considering the values \( u(c, i) \) assigned to items found similar to \( c \). Each object \( i \in I \) is associated with a profile i.e. a vector \( \text{content}(i) = (w_{i1}, \ldots, w_{ik}) \) where \( w_{ij} \) is the weight of the \( j \)-th attribute or an indication of how the \( j \)-th attribute is able to characterise \( i \).

As for objects, users are also associated with a profile based on the attributes of the objects preferred in the past. The profile is defined as \( \text{profile}(c) = (w_{c1}, \ldots, w_{ck}) \), where each weight \( w_{cj} \) denotes the importance of the \( j \)-th attribute for the user \( c \). The profile for \( c \) can be obtained averaging all profiles of the objects for which \( c \) has expressed a rating and weighting them on the basis of the rating itself. Once the profiles that characterise objects and users have been defined, the utility of an object \( i \) for the user \( c \) is calculated basing on the similarity between the two profiles. Several similarity measures can be used for this purpose: one of the most common is the so-called **cosine similarity** based on the calculation of the cosine between two vectors using the following equation:

\[
    u(c, i) = \frac{\sum_{j=1}^{k} w_{cj} w_{ij}}{\sqrt{\sum_{j=1}^{k} w_{cj}^2} \sqrt{\sum_{j=1}^{k} w_{ij}^2}} \quad (1)
\]

In **collaborative approaches**, unknown values of \( u(c, i) \) are estimated from those made available by people similar to \( c \) [14]. The basic idea is that users who evaluated the same objects in the same way are likely to have the same tastes. Such methods calculate the utility \( u(c, i) \) as aggregation of the utility expressed for \( i \) by users similar to \( c \):

\[
    u(c, i) = \text{aggr}(c \in C', u(c', i))
\]

where \( C' \) is the set of users considered most similar to \( c \).

A typical aggregation function is the average of ratings given to \( i \) by users of \( C' \) weighted on the similarity of such users with \( c \):

\[
    u(c, i) = \frac{\sum_{c' \in C'} u(c', i) \text{sim}(c, c')}{\sum_{c' \in C'} \text{sim}(c, c')} \quad (2)
\]

where \( \text{sim}(c, c') \) is the similarity between \( c \) and \( c' \) calculated using similarity measures like equation (1) applied to vectors \( (w_{c1}, \ldots, w_{ck}) \) that characterise users, where \( w_{c,j} = u(c, i) \), if defined.

The main advantage of collaborative approaches is that they are able to provide less obvious advice with respect to cognitive ones. On the other end cognitive approaches are able to provide useful recommendations also with only one assessment made by the user while collaborative ones need a substantial number of assessments available.

As we detail in the following sub-sections, in the KH we have adopted a hybrid approach [15] to exploit both the metadata associated to resources (cognitive component) and the preferences of similar users (collaborative component).

### B. Profile and utility of a resource for SNE

The first step in applying a recommendation algorithm for KH resources consists of building the profile of each of these resources and of defining the corresponding utility function. Based on this, it will be possible to estimate the utility of each available resource for each system user.

As described in section III, KH resources may belong to different categories. Each resource also has an associated metadata that, apart from a core of common fields, varies depending on the category. Moreover, several metadata fields allow free text. This limits the possibility of applying a cognitive approach only to non-textual fields which are common to any category. Table 1 lists these fields.

<table>
<thead>
<tr>
<th>Field</th>
<th>Feasible Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Project, Community, Experience, Training Process</td>
</tr>
<tr>
<td>Activity</td>
<td>Training, Information, Research, Assistance</td>
</tr>
<tr>
<td>Context</td>
<td>Formal, Non formal, Informal</td>
</tr>
<tr>
<td>Clinical Diagnosis</td>
<td>Principal chapters of the ICF standard</td>
</tr>
<tr>
<td>Technology</td>
<td>On-site without technology, On-site with technology, distance</td>
</tr>
</tbody>
</table>

On the basis of the selected fields, it is possible to build the profile of any KH resource. Let \( F = \{f_1, \ldots, f_n\} \) be the set of selected fields and \( S_i = \{s_{i1}, \ldots, s_{ik}\} \) the set of allowable values for each metadata field \( f_i \), then we can define the profile of a given resource \( i \) as:

\[
    \text{content}(i) = (w_{i1}, \ldots, w_{i1,s_{i1}}, \ldots, w_{ip}, \ldots, w_{ip,s_{ip}})
\]

where \( w_{ij} = 1 \) if \( f_i \) takes the value \( s_{ij} \) for the resource \( i \) (allowing multiple selections), while \( w_{ij} = 0 \) otherwise.

The utility that the user \( c \) attributes to a given resource \( i \) is expressed by \( u(c, i) \) and can take a real value between 0 and 1. It consists of three components inferred from the analysis of user actions within the KH.

The first component \( u_1(c, i) \) takes the value of the rating expressed by the user (an integer between 1 and 5 where the evaluation is expressed, 0 otherwise). The second component \( u_2(c, i) \) takes the value 4 if \( i \) was tagged by \( c \), 0 otherwise. The third component \( u_3(c, i) \) takes the value 3 if the user \( c \) participated in a discussion on \( i \), 0 otherwise.

Once the 3 components have been calculated, if at least one of them is different from 0, it is possible to calculate the utility \( u(c, i) \) as follows:
\[ u(c, i) = \begin{cases} 
\frac{u_1(c, i) - 1}{4} & \text{if } u_1(c, i) \neq 0 \\
\max(\frac{u_2(c, i) u_3(c, i) - 1}{4}) & \text{otherwise}
\end{cases} \]

If, for a given pair, all three components are equal to zero, \( u(c, i) \) remains undefined for that pair.

C. Unknown utility estimation

In cognitive approaches the value of the utility function of a resource \( i \) for the user \( c \) is calculated on the similarity between the profile of \( c \) and the profile of \( i \). By denoting with \( u'(c, i) \) the cognitive component of the utility for KH resources, it can be estimated using the equation (1).

For the construction of the resource profile the ad-hoc techniques defined in the previous subsection are used. The profile of a user \( c \) is instead calculated by averaging all the profiles belonging to the objects for which \( c \) has expressed an assessment, weighted on the expressed evaluation itself with the following equation:

\[ \text{profile}(c) = \frac{1}{|I|} \sum_{i \in I} u(c, i) \cdot \text{profile}(i) \]

where \( I \) is the set of all resources for which the user \( c \) has provided, implicitly or explicitly, an evaluation.

Once profiles that characterise both objects and users have been defined, the cognitive component of the utility of an object \( i \) for the user \( c \) is calculated according to (1).

For the calculation of the collaborative component, a user-to-user recommendation algorithm is used. It infers the utility \( u''(c, i) \) as aggregation of the utility expressed for \( i \) by users similar to \( c \). To calculate this value we start from the user-to-item matrix where each element \( u(c, i) \), if defined, is the assessment made (implicitly or explicitly) by the user \( c \) for the resource \( i \).

From this matrix, the user-to-user similarity matrix is calculated. Each element \( \text{sim}(c, c') \) of this matrix is obtained by calculating the cosine similarity (equation 1) between the columns corresponding to users \( c \) and \( c' \) in the user-to-item matrix considering only columns for which both \( c \) and \( c' \) have an evaluation.

Once the similarity matrix is calculated, to estimate the unknown utility \( u''(c, i) \) for a given resource \( i \), it is sufficient to isolate and combine, applying the equation (2), the utility expressed for \( i \) by the users most similar to \( c \).

Let \( u'(c, i) \) and \( u''(c, i) \) be the utilities of the resource \( i \) for the user \( c \) estimated respectively according to cognitive and collaborative approaches; the estimate of \( u(c, i) \) is made by combining the two values with the following equation:

\[ u(c, i) = \alpha u'(c, i) + (1-\alpha) u''(c, i) \]

where \( \alpha \) is the hybridisation coefficient i.e. a real number ranging from 0 (highest priority to collaborative component) to 1 (highest priority to cognitive component).

The advantage of providing recommendations based on a hybrid approach that combines cognitive and collaborative components consists of being able to mix the advantages of both techniques [15]. As for cognitive approaches the system can provide useful recommendations even if available data is minimal. As for collaborative approaches, the system can generate interesting and non-obvious recommendations with a high level of serendipity.

The recommendations provided to system users evolves over time and take into account any new interactions between users and system, any new implicit or explicit feedback provided by any user as well as information about new resources that are included within the system.

V. THE KNOWLEDGE HUB

This section describes the functions and architecture of the KH, which applies the models and techniques defined in the previous sections. The KH is designed for the management and retrieval of educational and information resources for SNE.

We describe below the functions offered for the management, retrieval and recommendation of resources. Particular emphasis is also given to the social functions offered, including social tagging, rating and moderated discussions associated with each resource.

A. Management of the editing flow

Visiting users (who do not have credentials) access the system anonymously. They can consult (and use) the resources and information of the KH but cannot propose new ones. After the registration process, a profile is associated with each user, this being main for KH resources.

There are also special users with the role of Moderator. They are the only ones able to add new resources to the system, certifying the quality and completeness of the information offered. Figure 2 shows the editing flow used by the KH. It can be modified to be smoothly integrated within specific business processes of adopting organizations [16].
can decide to delete it or accept it if he/she retains it to be valid and complete. If it is not complete, he/she may decide to complete it autonomously or to directly ask the user who proposed it to make the necessary changes. The process is thus reiterated until the moderator transforms the proposal into a resource or decides to trash it definitively.

B. Search and recommendation features

The KH has several search modes for accessing the resources of the repository, which proceed along different paths. Base search is the simplest search mode and can be accessed from every page of the portal. It allows retrieval of all resources containing one or more of the keywords specified in a text box.

Advanced research allows the user to specify one or more research criteria which act on single metadata descriptors. For each selected descriptor it is possible to establish a value or a group of values to be searched for. Depending on the acceptable values of the descriptor, the search keys can be specified with free text or selected from a list or taxonomy.

The advanced search can be applied to one or more types of resource at the same time. Since the different types have different metadata schemes, if more than one type is selected at the same time the system allows specification of criteria only for the common descriptors.

The system is able to carry out personalised searches based on the application of the recommendation algorithms described in Section IV. A specific section of the KH lists for each user the resources retained to be of major interest for his/her profile, with an indication of the estimated degree of relevance given by means of star rating (see Figure 3).

The usefulness estimated by the recommendation algorithms for the registered users is also used to improve the results of the base and advanced searches. The user in fact has the chance to reorder the results of these searches on the basis of their estimated usefulness, thus achieving more rapid access to the really relevant results obtained by the searches carried out.

In particular, the user is able to:

- express an assessment for each resource of the repository using star rating, and visualise the average assessment both in the search results and at the visualisation stage;
- apply free tags to the resources, share the tags defined with other users and visualise, for each resource, all the public tags associated with them;
- access the resources using tag clouds, selecting a tag from a “cloud” representation (where the fonts increase in size as the tags become more frequent) and obtaining all the results connected to those tags;
- comment on the resources of the repository, participating in organised discussions associated with each of them and moderated by the creator of the resource him/herself.

D. KH Architecture

Figure 4 shows a logical view of KH, describing the components and their interactions with stakeholders and external systems. The Application Framework layer provides basic functions related to user management, collaboration, information sharing, process and document management. It is implemented on top of Microsoft SharePoint 2010.

The Portal layer customises the Application Framework for the KH needs so as to manage resource metadata and user profiles. It identifies the types of resources and groups them into special collections, it defines the types of users and their permissions, it defines and implements the resource editing and publication process, it implements the available search types and configures the collaboration tools.

The Profiler component exploits the models and techniques described in Sections III and IV to provide recommendation features. It updates the information needs included within user profiles according to users’ behaviour and their interactions with the system. It receives information from the Portal layer, processes it and returns the result.

The Adapters are additional components that deal with the connection of external repositories and allow the (semi)automatic generation of new resource proposals linked to external content. The Web Service Interface allows to query the search and filtering engine of the KH from external systems and search engines so that the KH resources can be smoothly accessed by third parties.
VI. EXPERIMENTATION

Is the KH an environment which is able to foster a rich, personalised and dynamic search activity on the resources pertaining to the field of Special Needs Education? In order to answer this question, an experimentation was carried out with the intention of implementing improvements on the basis of the empirical data collected.

A description of the experimentation methodology used and the results obtained is given herewith.

A. Experimentation methodology

The experimentation was carried out with 17 professionals with an average age of about 42 years, in a face-to-face meeting. Expert figures in the field of Special Needs Education were chosen in order to favour the heterogeneity of the experiences and to adequately represent the main reference user base of the system.

The group consisted of 13 educators, mainly support and home education teachers; 2 educational social health workers, i.e. teachers from hospital schools; and 2 university researchers who were sensitive to the themes of Special Education by dint of their specific studies.

Some operational scenarios were defined for the experimentation which could best represent the goals the KH was designed to achieve. The approach, starting from a particular case and the definition of an objective, effectively stimulated users’ motivation to learn KH functioning. The strategy for the definition of the scenarios took the following principles into account:

1. definition of the objective; a story was presented and a precise suitable objective was defined to test the chosen function;
2. attention to motivation; the scenario was constructed so as to be interesting and pertinent for the user;
3. selection of the activities: a group of actions requiring users to act in the system to be tested was constructed around a particular scenario;
4. population with resources: the system was populated so as to guarantee a knowledge base which was functional to the search processes which had to be performed;
5. attention to feedback: users had the opportunity to receive system feedback about the actions carried out and the results achieved, as well as human feedback from the classroom tutors themselves.

Each scenario was constructed to provide the user group with sufficient opportunities to perform the required actions for obtaining relevant information. Moreover, each scenario included navigation of the area or the key functions to be tested, and the compilation of a survey questionnaire. This allowed structured and systematic collection of the group’s evaluations during the exploration of the system and its separate areas.

On the basis of the data collected it was possible to obtain measurements of the appreciation of the KH search functions concerning both of validity, i.e. ability of the environment to meet the particular user needs for which it was developed and the user-friendliness of the system itself.

Some transversal indicators, functional to the assessment, were defined for both validity and usability. For validity, educational needs, accuracy of the contents, self-reflexivity and motivation were considered. For usability, ease of navigation, enjoyment, effectiveness of the interface and accessibility were analysed [17].

B. Experimentation results

The experimentation showed that the KH was perceived as a useful, innovative service for those involved in the world of SNE. The findings demonstrated the coherence of the environment and showed adequate planning and integration of its components.

As can be seen in Figure 5, the participants expressed very positive results regarding the validity of each function presented. The summary scores presented in the figure were calculated by aggregating the scores obtained in the single items pertaining to the validity of the function under consideration. Moreover, no significant differences were found among the functions, the scores for which were all in the range 4.40 to 4.36.

The variety of resources present in the KH and the possibility of accessing them through various search paths was found to be the most highly appreciated element for those interacting with the system for the first time.

Also from the point of view of user-friendliness, the KH environment obtained good assessments: the scores were above 4 (from 4.14 to 4.33) in a scale from 0 to 5. Thus in this case too there were no significant differences among the various functions considered, as can be seen from Figure 4.

The fact that the findings on KH user-friendliness were positive needs to be considered with some caution, since step-by-step accompaniment and the presence of continuous support during the experimentation meant that participants were able to test the system in a protected and guided environment.

Generally speaking, the positive evidence confirms the innovative contribution of this tool for the reference context. The KH is seen to be an environment which is able to extend the search concept to scenarios where the investigable space consists not only of document repositories, but also of distributed, dynamic bodies of information which express human resource skills in a more or less structured manner.

![Figure 5. Results on validity and usability of the KH](image)
VII. CONCLUSIONS AND FUTURE WORK

This article has presented the Knowledge Hub, an information repository of semantically-described resources for SNE, whose added value, as compared to other existing repositories, is the possibility of assisting a user in searching for the most adequate resources combining recommendation techniques with techniques from the worlds of the Semantic and Social Web.

It is precisely in the Semantic and Social Web that some possible lines of evolution can be identified for the KH. The stack of the Semantic Web, as it has been defined by the W3C, might even be used to model the KH resources of the relative metadata, using languages such as RDF, RDFS, OWL/OWL2.

This would make it possible to formulate and carry out more complex queries, to perform inferences according to Description Logics, to guarantee interoperability with other systems which would not be limited to the purely syntactical but also the semantic aspects, to correlate KH resources to taxonomies, ontologies, data sets and resources deriving from other repositories, in such a way as to exploit the advantages of Open Linked Data [18].

In this way, KH resources would be correlated to external data sets such as DBLP, PubMed or Geonames, semantically linking scientific (pertinent) articles with KH resources, or geographically contextualising said resources so as to enrich the search results on the one hand and the querying and filtering capacities on the other.

A further advantage of adopting the Semantic Web would be the possibility of modelling the whole search community using SWRC, thus guaranteeing greater support not only for the search for and filtering of resources, but also for collaboration activities [19].

The second development prospect for KH concerns collaborative and social aspects. The Social Web would allow KH resources to be perceived as social objects to be shared and enriched in different-sized communities. The folksonomies generated by social tagging activities could in turn be represented with semantic schemes such as SCOT and MOAT, in order to guarantee sophisticated searches on the tags and management of the meaning of said tags [20].

The folksonomies might also be used as sources for the enrichment of the existing taxonomies and as a support for automatic linking with external data sets. In this scenario, the participants of the community themselves will make a contribution to the linked data using common actions like tagging, thus improving the quality of the search results in the KH space and the capacity for correlation between internal KH resources and external resources.

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REFERENCES


11 http://www.wisefirb.it