IKHarvester – Informal eLearning with Semantic Web Harvesting*

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Abstract. Only recently, researchers and practitioners alike have begun to fully understand the potential of eLearning and have concentrated on new tools and technologies for creating, capturing and distributing knowledge. Focusing on the area of informal learning, this paper describes this emerging domain and assesses current semantic and Web 2.0 tools used in this field. Contributing to the body of research, the limitations of both sets of technologies are documented highlighting areas of definite improvement. Finally, semantic web harvesting technology as a solution is explored in the form of the IKHarvester tool.

1 Introduction

Obtaining sustainable competitive advantage weighs heavily on an organizations learning capability [3]. Just like many other industries, the learning and education industry has not been immune to eCommerce and Internet-driven change [4]. Even though there has been extensive research on knowledge management related to information technology [3], relatively little attention has been given to the area of eLearning [18].

eLearning has been identified as a growing market, a direct result of increased demand for training [26]. It has been forecasted that world wide eLearning license revenue will grow at a compound rate of 15.6% each year creating a market worth over $685 million in 2009 [13]. Organizations have been investing more and more on training to respond to a growing need for new information and knowledge required to facilitate organizational changes such as mergers and acquisitions, new business models, re-engineered and reinvented organizational forms [26]. Satisfying this demand, eLearning is seen as a revolutionary way to empower a workforce with the skills and knowledge it needs to turn change into an advantage [30]. Nevertheless, although considerable progress has been made, educators have just begun to exploit the transformational power of the Internet [18].

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In addition, the bulk of eLearning research is mainly around the area of formalized learning where users learn in a highly structured environment with minimal interaction or collaboration. Even though large sums of corporate revenue are put into formally educating employees each year, a lot of knowledge is gained through informal learning. Examples of informal learning include: conversations at the coffee machine or printer, assistance by more experienced employees to newcomers, collaborative services, such as wikis, blogs, fora, and instant messengers. These are just some of the existing ways in which employees can quickly share their experience within the organization. Unfortunately, organizations are unable to harness the potential benefit of informal learning as many of the tools employed are primarily focused on formal learning.

1.1 Use-case Scenario

Currently, users utilize eLearning (see Fig. 1) functions through very structured Learning Objects, which come from an organizations Learning Management System (LMS). However, as the content within the Learning Objects is static, and not interactive, users turn to other informal sources for additional information. For instance, students in the last weeks/days before an exam will often gather to learn together. Students often find it easier to understand and learn things when explained by their peers. It is also likely that different students will have focused more on different parts of the course, thus by collaborating informally they get greater coverage of the overall course.

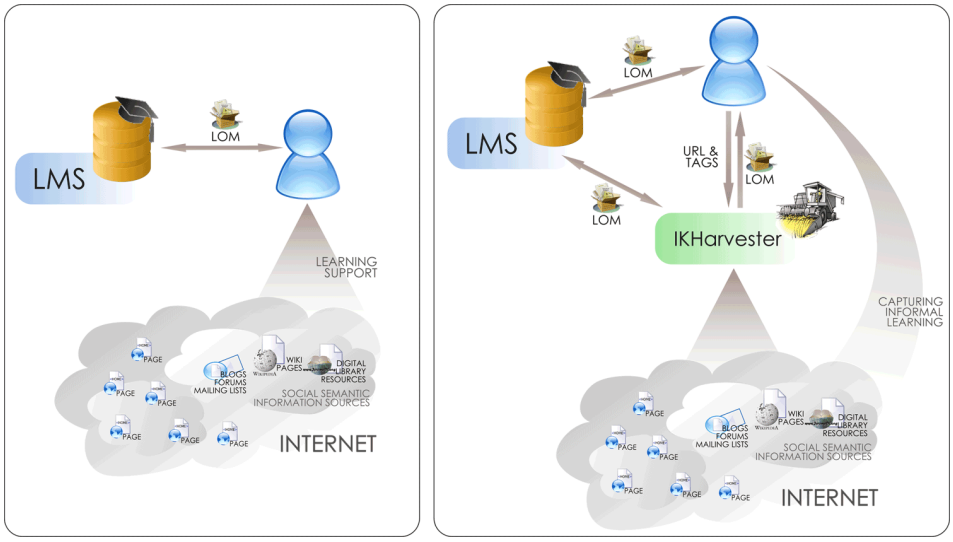

Fig. 1. Use-case scenario of capturing informal learning with IKHarvester

From an eLearning perspective, what is required is a service where knowledge, coming from different sources can be submitted and shared through the LMS. The purpose of IKHarvester is to incorporate these sources of information and integrate them into an organizations LMS, where they can give additional flexibility to eLearning functions. IKHarvester captures the informal sources of knowledge and converts them into an LMS compatible format (LOM). As a result this can be then integrated into the LMS.

1.2 Outline of the paper

This article is structured as follows. The next Section presents existing tools for capturing and managing information that can be collected from web pages. In Section 3, we introduce IKHarvester, our project for utilizing metadata for online resources for further usage. Finally, Section 4 recaps the results of the research in the field of informal learning and describes future research.

2 State of the Art

In this section, we present existing tools for capturing, tagging, and browsing online resource or metadata for them. We have divided them into two sections: Web 2.0, and the Semantic Web tools.

2.1 Web 2.0

Even though current eLearning applications have brought great benefit to organizations, they have been too rigid to tap the knowledge generated by current Web 2.0 tools.

Web 2.0 is the Web where people meet, collaborate and share anything that is popular, which forms social networks (online communities). The term Web 2.0 refers to second generation of Internet-based services: blogs, wikis, and other communication frameworks.

Web 2.0 tools have become very popular due to their: *(i)* immediacy, *(ii)* interactivity, and *(iii)* informality. The immediacy of these tools allows new content to be shared quickly, and older content to stay active through frequent updates. The interactivity of Web 2.0 gives readers a chance to respond to published information through various means of communication and collaboration [25]. Finally, the fluidity of these tools engenders natural/casual content that is different from the formal "corporate speak".

del.icio.us[3] One such Web 2.0 tool that has taken hold in organizations is the social bookmarking system, *del.cio.us*. This technology allows users to store lists of Internet resources that they find useful. These lists can be accessible to the public by users of a specific network or website. Other users with similar

[3] Del.icio.us: http://del.icio.us/

interests can view the links by topic, category, tags, or even randomly. *Del.cio.us* is an example of such a collaborative tagging system for web bookmarks that its creator, Joshua Schachter, calls a "social bookmarks manager" [9]. Much in the same way users save bookmarks within their browsers, they can save bookmarks in *del.cio.us*, instead. The benefit of doing so is that once ones bookmarks are on the web, they are accessible from any computer, not just the users own browser [15]. In addition, public users can see these links and also how many times a link has been bookmarked (tagged) by other users and then explore the links of these users.

This type of collaborative tagging is most useful when there is nobody in the librarian role or there is simply too much content for a single authority to classify; both of these traits are true of the web [14]. The strategy of tagging, without regard to categorical constraints seems like a recipe for disaster, but as the Web has shown us, you can extract a surprising amount of value from large unstructured data sets. Moreover, this kind of collaborative tagging offers an interesting alternative to current research efforts with Semantic Web ontologies [27].

2.2 Semantic Web

One of the problem of online communities is that they are dispersed over the Internet. Although their content is valuable, it is difficult to track. Current solutions allow mainly text based searching, so a user must browse many web pages to find what he/she looks for.

The Semantic Web encompasses efforts to build a new World Wide Web architecture that enhances content with formal annotations. It is supposed to create a universal medium for exchanging information in a way understood by computers [17]. Consequently, browsing and searching in the cyberspace is simplified.

One of the most important advantages of the Semantic Web is flexibility. Different kinds of data can be used together and diverse types of analysis can be applied over it [31]. For instance, a book can be described with Dublin Core [11] annotations whereas information about the author can be expressed by using the FOAF (Friend-of-a-Friend) vocabulary [10].

SIOC (Semantically-Interlinked Online Communities) is an initiative that is supposed to overcome the above mentioned problem; its goal is to interconnect and track online communities [6]. SIOC can be used in published or subscribed mechanisms, as it stores community-like metadata such as information about the post's author, enclosed links, the creation time, connection with other web pages.

PingTheSemanticWeb.com[4] is a service for sharing RDF documents. Its engine looks for RDF data either in the content of the resource with the specified URL or in documents this resource links to. If such data is found, it is saved

[4] PingTheSemanticWeb.com: http://pingthesemanticweb.com/

to the shared repository. *PingtheSemanticWeb.com* supports FOAF, SIOC, and DOAP ontologies, and other RDF documents.

The pinging feature is invoked either by typing a URL on the service's home page or using specially prepared browser buttons. Moreover, *PingtheSemanticWeb.com* benefits from Semantic Radar[5], an add-on for Firefox web browser; whenever Semantic Radar detects RDF data on a web page, it informs *PingtheSemanticWeb.com* about that fact so it can be added to the repository. Software agents can request the service for a list of stored RDF documents and use that information for crawling the Semantic Web.

SIMILE Project[6] Semantic Interoperability of Metadata and Information in unlike Environments provides tools for metadata managers and common end-users.

Piggy Bank, an add-on for Firefox, changes the browser into a mush-up platform, by allowing to capture metadata for online resources and mix them together. Collected data can be stored locally, tagged, searched, and browsed. *Piggy Bank* can capture RDF documents a web page links to and from any web pages that are supplied by "screen scrapers". A "screen scrapers" is a little program for collecting metadata for, also, non-semantic web pages. It is written in another *SIMILE* tool, *Solvent*. If a user wants to share his collection of metadata, he/she publishes it to the *Semantic Bank*, a communal repository of RDF data.

Zotero[7] is an add-on for Firefox web browser. It helps with collecting, managing, and citing research material, mainly bibliographic resources. *Zotero* extracts RDF injected into XHTML documents; it works with a few standards and microformats [20]: embedded RDF, COinS, Dublin Core [11], and Marc [1]. *Zotero* informs a user it has discovered some mark up by showing a special button in the browser toolbar. Clicking the button starts capturing process.

A user can easily edit the data saved by *Zotero* and append additional information, such as notes, tags, and related files. Moreover, Zotero can be integrated with Microsoft Word and WordPress. Captured data can be searched and browsed both online and offline.

2.3 Limitations

All the above mentioned tools are good metadata harvesters. However, they work differently, and have different possible usages.

By providing Web Services, *PingtheSemanticWeb.com* allow gathering semantic annotations for online resources in a shared space. This information can be used for instance by crawlers while searching for specific piece of data. But,

[5] Semantic Radar: http://sioc-project.org/firefox/
[6] SIMILE Project: http://simile.mit.edu/
[7] Zotero: http://www.zotero.org/

PingtheSemanticWeb.com does not come up with the possibility to browse stored data besides viewing raw RDF documents, which is unacceptable for a common user. Also, it does not work with non-semantic sources, like Wikipedia.

Zotero is a powerful tool for researchers and students because it facilitates bibliographic resources management. With *Zotero* it is easy to browse saved information about books and articles, search and cite them. However, it only reads embedded RDF; there is no support for pure RDF data, which passes more knowledge.

Piggy Bank is capable of reading whole RDF documents that a web page links to. Moreover, although it does not support non-semantic web pages itself, it is possible to write "screen scrapers" that can do that. In spite of that, it has little support for eLearning platform; there is no standardized way to use captured data by eLearning frameworks, like Learning Management Systems.

Finally, *del.cio.us* is one of the most successful Web 2.0 services for collecting and sharing boomarks. However, there is no "pure" semantics. Therefore, it is difficult to employ software agents for collecting tags out of it.

Analysis of existing knowledge management tools, resulted with a set of significant characteristics that such a tool must be distinctive with. Not only should it work with semantic sources of information but also it must operate on non-semantic web pages, like Wikipedia. It must be easy to extend it so that it supports more types of websites. Then, a user should be supplied by supportive tools for data capturing, like browser buttons or add-ons.

Also, we have discovered that captured data can considerably boost informal learning; it can be used in new eLearning frameworks that use both learning material prepared by specialists and collected by an information harvester.

3 IKHarvester - Capturing and Delivering Informal eLearning

We have described informal learning and claimed considerable amount of relevant information can be collected from them. Then, we have presented existing solutions for capturing metadata and pointed out their limitations. In this section, we present IKHarvester and our approach for managing informal learning available on the Internet.

IKHarvester[8] (Informal Knowledge Harvester) is a web service that is characterizes by two core features: harvesting data, and providing it for eLearning frameworks. It benefits from the Semantic Web principles that demands rich descriptions of resource to be available online. Thus, the content of web pages is understandable not only with machines but also by machines.

[8] IKHarvester deployed on *notitio.us* service: http://notitio.us/ikh/

3.1 Data harvesting

IKHarvester captures RDF data from Social Semantic Information Sources (SSIS). The current version works with semantic blogs, semantic wikis, and JeromeDL (the Social Semantic Digital Library) [24].

IKHarvester looks for RDF documents related to the given resource, which is indicated by a special HTML entry:

```
<link rel="meta" type="application/rdf+xml" title="SIOC"
href="http://dobrzanski.net/index.php?sioc_type=post&amp;sioc_id=20"/>
```

The above notation informs a web browser that there is an RDF document related to currently viewed page, and it is available at the location defined by `href` attribute (here, `http://dobrzanski.net/index.php?sioc_type=post&sioc_id=20`).

Besides reading pure RDF data, IKHarvester uses Microformats which allow embedding RDF into HTML documents. Moreover, IKHarvester is capable of creating RDF descriptions for non-semantic information sources, like Wikipedia[9]. For that reason, it scrapes the HTML code of an article in order to collect some data (for instance, a title, external links, see also links, references) from it.

In general, data captured from online communities, like blogs, wikis, bulletin boards, can be described with SIOC ontology, whereas JeromeDL and MarcOnt ontologies are employed for describing bibliographic resources. The read or created RDF document for an online resource is saved to the informal knowledge repository.

3.2 Data providing

Once the informal knowledge repository is filled with data, it can be used by possible clients, like Learning Management System (LMS). Therefore, IKHarvester provides informal learning material in the form of Learning Objects (LOs) [28]. In general, a LO is something you can acquire, manage and use; LOs are reusable, modular, flexible, portable and compatible. We have followed SCORM CAM (Content Aggregation Model) instructions in defining the way of creating and managing LOs. This standard suggests using Learning Object Metadata (LOM) for describing learning material.

There are nine categories of this information, each of which focus on different aspects [19]:

- General – general information about the LO as a whole
- Lifecycle – features related to the history and current state of the LO and those who have affected it during its evolution
- Meta Metadata – information about the metadata instance itself
- Technical – groups the technical requirements and technical characteristics of the LO

[9] Wikipedia: http://wikipedia.org/

– Educational – educational and pedagogic characteristics of the LO
– Rights – intellectual property rights and condition of use the LO
– Relation – group of features defining the relationship between the LO and other related LOs
– Annotation – comments on the educational use of the LO and information on the author of the comment and time when it was written
– Classification – describes the LO in relation to a particular classification system

LOM standard describes LOs very thoroughly with plenty of attributes. However, only part of them can be assigned with values taken directly from the description of the resource. Some attributes that pass educational, pedagogical and technical information for LMSs are bound with default values, specific for each type of resources. We set those attributes to established default values, basing on the analysis of the type of the resource.

In Table 1, we present how attributes of a post (first column) are mapped to SIOC ontology predicates (second column), and then to LOM attributes (third column). We do similar mapping of attributes for other types of resources.

3.3 Extensibility

Current version of IKHarvester operates on three types of resources: blogs that enable SIOC, wikis that use MediaWiki engine, and JeromeDL. However, there are plenty of types of web pages that capture learning material. Therefore, IKHarvester has been built in a way that enables adding extensions for those websites (see Fig. 2).

We hope that more and more extensions will be provided in the future to cover more sources of informal knowledge, which do not expose metadata explicitly.

3.4 Service-Oriented Architecture

According to He [16], SOA is an architectural style that aims at loose coupling among interacting software agents. There is a number of services that do a unit of work to fulfill the service consumer's needs. The services are independent; they do not rely on the context and state of other services. The architecture demands using interfaces based on the Internet protocols like HTTP, FTP, SMTP; all messages, except from binary data attachments, must be described in XML.

REST (REpresenational State Browser) Web Services, likewise the Semantic Web, are based on the concept of a resource - anything that is characterized with a URI (Uniform Resource Identifier). Therefore, they best fit to IKHarvester. In fact, REST is used commonly nowadays, in the World Wide Web and Web 2.0 [12].

REST interfaces provide representation of a resource in XML. There are four possible HTTP methods:

Table 1. Mapping between attributes of informal knowledge and LOM.

Attribute	**Predicate**	**LOM**
-	sioc:Post	Educational.LearningResourceType="BlogPost"
URI	-	Technical.Location & General.Identifier.Catalog="URI" & General.Identifier.Entry & Meta-Metadata.Identifier.Catalog="URI" & Meta-Metadata.Identifier.Entry
title	dc:title	General.Identifier.Title
creator	sioc:has_creator	Lifecycle.Contribute.Role="Author" & Lifecycle.Contribute.Date="Date of creation" & Lifecycle.Contribute.Entity="Personal info." & Meta-Metadata.Contribute.Role="Author" & Meta-Metadata.Contribute.Date="Date" & Meta-Metadata.Contribute.Entity="Personal info."
creation date	dcterms:link	Lifecycle.version="Date"
description	sioc:content	General.Description & Educational.Description & Classification.Description
rich content (HTML)	content:encoded	-
topic*	sioc:topic	General.Keyword & Classification.Keyword
reply*	sioc:has_reply	Annotation.Entity="About author" & Annotation.Date="Date" & Annotation.Description="Content"
external link*	sioc:links_to	Relation.Kind="references" & Relation.Resource.Identifier.Catalog="URI" & Relation.Resource.Identifier.Entry & Relation.Resource.Description="references"
language	-	General.Language & Educational.Language & Meta-Metadata.Language

- GET - for obtaining a stateless representation of a resource
- POST - for updating or creating a representation of a resource
- PUT - for creating a representation of a resource
- DELETE - for removing a representation of a resource

Table 2 presents the specification of Web Services for accessing IKHarvester features, as exposed by the `http://notitio.us/` service (see Sec. 3.6).

3.5 Benefits

To recap, there are few solutions for capturing managing semantic annotations (metadata) for online resources useful in learning process: *PingtheSemanticWeb.com*, *Piggy Bank*, and *Zotero*. Although their goal is similar, they achieve

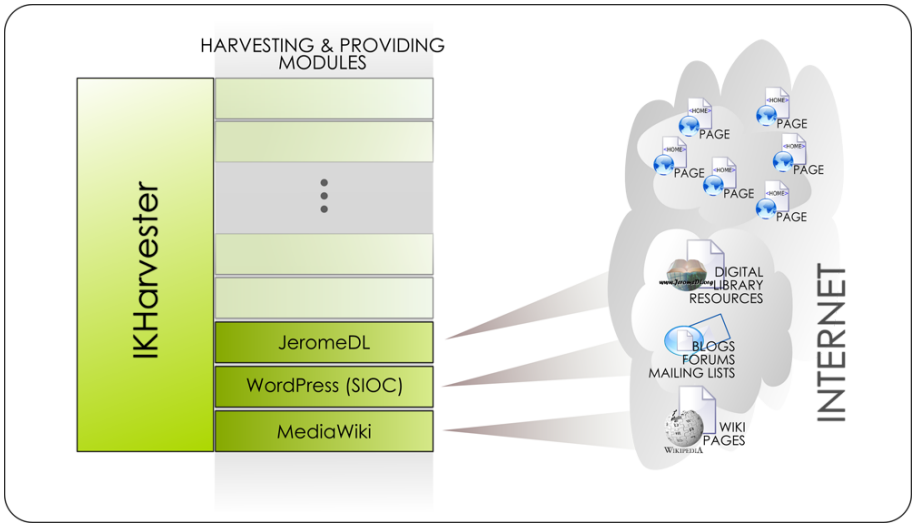

Fig. 2. Extending IKHarvester

it in different ways. The table presented on the Fig. 3 explicitly shows the difference between the above mentioned solutions, indicating the level of support for each of the feature.

Integration with web browsers is crucial for such systems. The more web browser the system supports, the better; such a tool should not demand using a specific browser. Since *Piggy Bank* and *Zotero* are Firefox add-on, they are perfectly integrated only in this browser. IKHarvester, *PingtheSemanticWeb.com* and *del.icio.us* also support Internet Explorer and Opera by providing special buttons for capturing data. Moreover, some features of IKHarvester and *del.icio.us* can be invoked by using a special add-ons for Firefox.

All compared tools, except from *Zotero* and *del.icio.us*, are able to collect sufficient amount of metadata for online resources available on web pages, by reading RDF documents that those pages link to. By sufficient, we mean more information than the URL or the title of the resource. For instance, there should be some information about the author of the resource or related resources. IKHarvester distinguishes itself as it collects metadata also from non-semantic web pages, like Wikipedia which is a treasury of informal knowledge. In addition, IKHarvester and *Zotero* can capture pure RDF data from separate documents and semantic markups, like RDFa [2] and microformats [21] embedded into HTML and XHTML. Finally, IKHarvester utilizes GRDDL, a mechanism for Gleaning Resource Descriptions from Dialects of Languages [7], which makes use of microformats by linking a page containing such mark up with transforming algorithms, like XSLT, in order to extract this data from the document [8].

To make much more use of metadata for learning purposes, it should be shared and made available for all. For that reason, it is necessary to access it

Table 2. REST-based Web Services specification for IKHarvester

URL	Method	Description
http://notitio.us/ikh/soa/[type]	GET	Returns the list of all LOs, or LOs of specified type if *type* parameter is set.
http://notitio.us/ikh/soa/URI/manifest	GET	Returns the manifest of the LO with specified *URI*
http://notitio.us/ikh/soa/URI/content	GET	Returns the content of the LO with specified *URI*
http://notitio.us/ikh/soa/URI	PUT / POST	Add/Update the LO with specified *URI*
http://notitio.us/ikh/soa/URI	DELETE	Removes the the LO with specified *URI*

with Web Services as it improves its accessibility and reusability. Also, tagging helps managing collected information and facilitates searching and browsing. Again, IKHarvester acquits itself well. All shared data can be retrieved, saved, and tagged by calling REST Web Services.

Beyond that, IKHarvester has a considerable eLearning background. It treats online resources as learning material (informal Learning Objects), and uses captured data as its description. Moreover, IKHarvester delivers these metadata in a form in accordance with LOM standard. This rich information is used by eLearning LMSs, to perform accurate reasoning and provide well tailored courses.

3.6 Success stories

Didaskon IKHarvester has been designed as a SOA layer for Didaskon[10], a system designed for eLearning purposes. Didaskon delivers a framework for composing an on-demand curriculum from existing learning objects provided by eLearning services (formal knowledge) [28]. In addition, it benefits from SSIS - sources of informal learning [29].

Didaskon creates a learning path which best fits a specific learner. To achieve that, the system uses initial information (preconditions) like a student's needs, skills, learning history etc., anticipated resulting skills and knowledge (goals), and technical details of the clients platform.

notitio.us[11] is a service for collaborative knowledge aggregation and sharing. It employs IKHarvester for retrieving RDF information about Web resources bookmarked by the users. Therefore, it is capable of indexing rich metadata, coming from various types of resources. In contrary to bookmarking services, such as

[10] Didaskon: http://didaskon.corrib.org/
[11] notitio.us: http://notitio.us/

Feature \ Tool	IKHarvester	Ping the Semantic Web.com	Piggy Bank	Zotero	del.icio.us
Integration with browsers	buttons: FF, Opera, IE; add-on for FF	buttons: FF, Opera, IE	FF an add-on itself	FF an add-on itself	yes
Support for Semantic MediaWikis	full (also additional information besides from RDF)	full	full	none	no
Support for Wikipedia	some	none	weak	none	no
Support for JeromeDL	full	some	full	weak	no
Tagging	yes	no	yes	yes	no
Is remote service	yes	yes	no, but works with Semantic Bank	no	yes
Accessible with Web Services	yes	yes	no	no	yes
Allows data sharing	yes	yes	partially - sharing with Semantic Bank	no	yes
Support for new document types (extensibility)	yes - writing new "blades"	no - dependency on the authors of the tool	yes – writing new "screen scrapers"	no - dependency on the authors of the tool	N/A

Fig. 3. Comparison of tools for collecting informal data

del.icio.us, notitio.us keeps rich, semantically interconnected metadata shared by the users using Social Semantic Collaborative Filtering [23]. The resources not only can be shared with a bookmarking interface (SSCF), but also, based on the rich metadata, they can be searched and browsed using TagsTreeMaps[12], a tags browser based on treemaps rendering algorithm, and MultiBeeBrowse [22], a collaborative browsing components. These components improve user browsing experience, utilizing metadata delivered by IKHarvester. One of modules delivered by IKHarvester allows to expose aggregated metadata in LOM [5] standard, which turns notitio.us into a valuable source of learning objects based on informal knowledge, delivered by IKHarvester.

4 Conclusions and Future Work

The water cooler effect can play a substantial part in the education of employees, students and individuals. Capturing this informal learning is a major challenge.

Within the eLearning domain, the water cooler is replaced with reference tools such a Wikipedia, digital libraries and social tools such as blogs and bulletin boards. Current Web 2.0 and semantic tools go some way toward capturing this knowledge. However, no current tools are targeted for the eLearning domain. IKHarvester is a tool specifically designed to capture and track informal eLearning. Working in conjunction with a Learning Management System, IKHarvester allows the user to manage their informal learning activity by capturing Social Semantic Information Sources and creating RDF description for non-semantic information. This information is then provided to the LMS using the SCORM

[12] TagsTreeMaps: http://sf.net/projects/tagstreemaps/

standard. Once this information is captured, it can then be shared using collaborative tools such as Didaskon and notitio.us.

At present, IKHarvester has been implemented in two systems, the Didaskon LMS, and the notitio.us collaborative knowledge tool. Initial trials within these systems have provided positive results for the capture of informal eLearning and a full usability survey is planned.

Future plans include extending IKHarvester to operate on more types of online resources. We also plan to increase support for more wiki engines, such as MoinMoinWiki[13], JSPWiki[14] and IkeWiki[15]. Also, we find it crucial to operate on blogs hosted on Blogger[16] as it is the second most important blogging platform, aside from WordPress. Finally, we intend to support further digital libraries, for instance BRICKS[17] and Fedora[18].

References

1. MARC (MAchine Readable Cataloging) and SGML/XML. http://xml.coverpages.org/marc.html, 2002.
2. B. Adida and M. Birbeck. RDFa primer 1.0 - embedding RDF in XHTML. World Wide Web Consortium, Working Draft WD-xhtml-rdfa-primer-20070312, Mar. 2007.
3. M. Alavi and D. E. Leidner. Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly*, 25(1), 2001.
4. M. Beller and E. Or. The crossroads between lifelong learning and information technology, A challenge facing leading universities. *J. Computer-Mediated Communication*, 4(2), 1998.
5. J. Brase, M. Painter, and W. Nejdl. Completing LOM - how additional axioms increase the utility of learning object metadata. In *ICALT*, page 493. IEEE Computer Society, 2003.
6. J. Breslin, A. Harth, U. Bojars, and S. Decker. Towards semantically-interlinked online communities. volume 3532, pages 500–514, June 1993. Proceedings of the 2nd European Semantic Web Conference (ESWC '05), Heraklion, Greece.
7. D. Connolly. Gleaning resource descriptions from dialects of languages (GRDDL). World Wide Web Consortium, Working Draft WD-grddl-20070302, Mar. 2007.
8. I. Davis and Talis. (GRDDL) primer. World Wide Web Consortium, Working Draft, Oct. 2005.
9. Del.icio.us., 2005.
10. L. Dodds. An Introduction to FOAF. http://www.xml.com/pub/a/2004/02/04/foaf.html, February 2004.
11. DublinCore Initiative, http://dublincore.org/documents/dces/. *Dublin Core Metadata Element Set, Version 1.1: Reference Description.*

[13] MoinMoinWiki: http://moinmoin.wikiwikiweb.de/
[14] JSPWiki: http://www.jspwiki.org/
[15] IkeWiki: http://ikewiki.salzburgresearch.at/
[16] Blogger: http://www.blogger.com/
[17] The BRICKS Community: http://www.brickscommunity.org/
[18] Fedora: http://www.fedora.info/

12. R. T. Fielding. Architectural styles and the design of network-based software architectures, 2000.
13. Gartner. Forecast: E-learning suites and management systems software, worldwide, 2005-2009. Technical report, SumTotal Systems, Inc, 2005.
14. S. A. Golder and B. A. Huberman. Usage patterns of collaborative tagging systems. *Journal of Information Science*, 2005.
15. V. Grover and T. H. Davenport. General perspectives on knowledge management: Fostering a research agenda. *Journal of Management Information Systems*, 18(1):5–21, 2001.
16. H. He. What is service-oriented architecture, September 2003. Online, accessed April 7, 2007, `http://webservices.xml.com/pub/a/ws/2003/09/30/soa.html`.
17. J. Hendler and O. Lassila. The semantic web. *Scientific American Magazine*, May 2001.
18. C. Holsapple and A. Lee-Post. Defining, assessing, and promoting e-learning success: An information systems perspective. *Decision Sciences Journal of Innovative Education*, 4(1):67–85, 2006.
19. IEEE. Draft standard for learning object metadata. Technical report, Institute of Electrical and Electronics Engineers, Inc., http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf, 2002.
20. R. Khare. Microformats: The next (small) thing on the semantic web? *IEEE Internet Computing*, 10(1):6875, 2006.
21. R. Khare and T. Çelik. Microformats: a pragmatic path to the semantic web. In L. Carr, D. D. Roure, A. Iyengar, C. A. Goble, and M. Dahlin, editors, *WWW*, page 865866. ACM, 2006.
22. S. R. Kruk. Multibeebrowse - collaborative faceted navigation on ontologies. In *Proceedings to Faculty Research Day, NUIG, 2007*, 2007.
23. S. R. Kruk, S. Decker, A. Gzella, S. Grzonkowski, and B. McDaniel. Social semantic collaborative filtering for digital libraries. *Journal of Digital Information*, Special Issue on Personalization, 2006.
24. S. R. Kruk, S. Decker, and L. Zieborak. JeromeDL - Adding Semantic Web Technologies to Digital Libraries. In *Proceedings of DEXA'2005 Conference*, 2005.
25. H. Rollett, M. Lux, M. Strohmaier, G. Dosinger, and K. Tochtermann. The web 2.0 way of learning with technologies. *Int. J. of Learning Technology*, 3:87107, Feb. 07 2007.
26. S. Seufert. E-learning business models, framework and best practice examples. In *In: Raisinghani, M (Hrsg) Cases on Worldwide E-Commerce*, pages 70–94. Idea Group, New York, 2001.
27. C. Shirky. Ontology is overrated: Categories, links and tags, 2005.
28. D. team. Didaskon project documentation. Technical report, Digital Enterprise Research Institute (DERI), http://didaskon.corrib.org/, 2006.
29. A. Westerski, S. R. Kruk, K. Samp, T. Woroniecki, F. Czaja, and C. O'Nuallain. E-learning based on the social semantic information sources. In *Proceedings to LACLO'2006*, 2006.
30. R. H. Wild, K. A. Griggs, and T. Downing. A framework for e-learning as a tool for knowledge management. *Industrial Management and Data Systems*, 102(7):371–380, 2002.
31. D. N. Z. Bjelogrlic. The a-semantic platform: Solving basic semantic web problems in security-related fields.