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Ecology of social search for learning resources

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Abstract

Purpose – This paper deals with user-generated interest indicators (ratings, bookmarks and tags). The authors aim to answer two research questions: Can search strategies based on social information retrieval (SIR) make the discovery of learning resources more efficient for users? Can Community search help users discover a wider variety of cross-boundary resources?

Design/methodology/approach – Cross-boundary is defined as that the user and resource come from different countries and that the language of the resource is different from that of the user's mother tongue. The authors focus on a portal that accesses a federation of multilingual learning resource repositories. The authors collect users' attentional metadata based on a server-side logging scheme and use this empirical data to answer two hypotheses.

Findings – The search-play-annotation ratio is more efficient with social information retrieval strategies, but community browsing alone does not help users to discover more cross-boundary resources.

Practical implications – By social tagging and bookmarking resources from a variety of repositories, users create underlying connections between resources that otherwise do not cross-reference, for example, via hyperlinks. This is important for bringing them under the umbrella of SIR methods. Future studies should include testing wider range of SIR methods to leverage these user-made connections between resources that originate from a number of countries and are in a variety of languages.

Originality/value – The use of attentional metadata to model the ecology of social search adds value to the actors of learning object economy, e.g. educational institutions, digital libraries and their managers, content providers, policy makers, educators and learners.

Keywords Learning, Information retrieval, Digital libraries

Paper type Research paper

1. Introduction

Learning resource repositories and libraries make educational material and/or its metadata available in digital format, the sharing of which is their core *raison d'être*. Their reuse has been touted for enabling cost savings because the creation of high quality material is costly, hence the focus on standards that enable interoperability (Campbell, 2003) even across repositories (Ternier *et al.*, 2008). Traditionally, metadata and/or web directories are used for searching and exploring the content items. Currently, novel exploratory search systems are developed for learning resources to assist users in obtaining information to meet their information needs. Such systems include social navigation and collaborative recommender systems, both of which belong to the family of techniques called social information retrieval (Goh and Foo, 2007).

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Social navigation involves using the behaviour of other people to help navigate online. It is driven by the tendency of people to follow other people's footprints when they feel lost (Dieberger *et al.*, 2000). Such footprints in an online environment are what Claypool *et al.* (2001) define as implicit and explicit interest indicators and can be acquired either directly from the user (e.g. rating) or indirectly (e.g. time spent on an object). Collaborative recommender systems, on the other hand, use explicit ratings to find like-minded users (Adomavicius, 2005). Evaluation of recommender systems traditionally focuses on the algorithms and their performance (Herlocker *et al.*, 2004), similar to exploratory search systems (White *et al.*, 2008). Evaluating recommenders from the user perspective has received less attention (McNee, 2006).

Within the field of technology enhanced learning (TEL) such systems exist. Rafaeli *et al.* (2005) introduced a system to harness the social perspectives in learning where the learner could choose from whom to take recommendations (friend or algorithm). Koper (2005) used indirect social interaction in choosing a path that allows successful competition of a learning task. Drachsler *et al.*(2008) took this research further showing that users employing a recommender system that offers navigation support in self-organised learning networks, were more efficient time-wise in completing an equal number of learning activities. Farzan and Brusilovsky (2005) studied social navigation and found that adding the time spent reading each page provides more precise insight into the intention of the group of users and more accurate information about pages selected from search results. Jung *et al.* (2007) studied implicit click data to increase both precision and recall of the feedback data on a university search portal. Tang and McCalla (2009) studied the pedagogical value while using collaborative filtering to recommend papers for learners, and Manouselis *et al.* (2007) used multi-criteria ratings to recommend resources to teachers.

Both the field of recommender systems and social navigation, however, suffer from the same problems: how can interest indicators be gathered without being too intrusive, and yet, at the same time, remain accurate enough in guiding users in their choice of product or navigational path. The sparse data and new items often are problematic too (Herlocker *et al.*, 2004; Adomavicius, 2005; Rafaeli *et al.*, 2005). Social bookmarking and tagging systems overcome these problems: they allow users to describe their interest by using tags that lead to the social nature of information sharing. The underlying structures by the triple (user, content, annotations) create relationships between resources, users, and tags (Golder and Huberman, 2006; Marlow *et al.*, 2006; Sen *et al.*, 2007). Social bookmarking systems thus take advantage of both social navigation and collaborative recommender systems by linking like-minded users. The idea of social tagging and bookmarking has been implemented in the TEL context (Maier and Thalmann, 2008; Vuorikari and Poldoja, 2008), in digital libraries (Puspitasari *et al.*, 2007) and for scientific papers (Farooq *et al.*, 2007).

Millen *et al.*(2007) studied the use of social bookmarking at the enterprise level and suggest that integrated with traditional search engines, it has the potential to solve commonly known enterprise search problems, e.g. content from heterogeneous repositories that do not cross-reference via hyperlinks (Mukherjee and Mao, 2004). We study a similar implementation for multilingual learning resources within a federation that has social bookmarking and tagging features. Our aim is to study such a hybrid system to understand how it is used, how different variables are interconnected and,

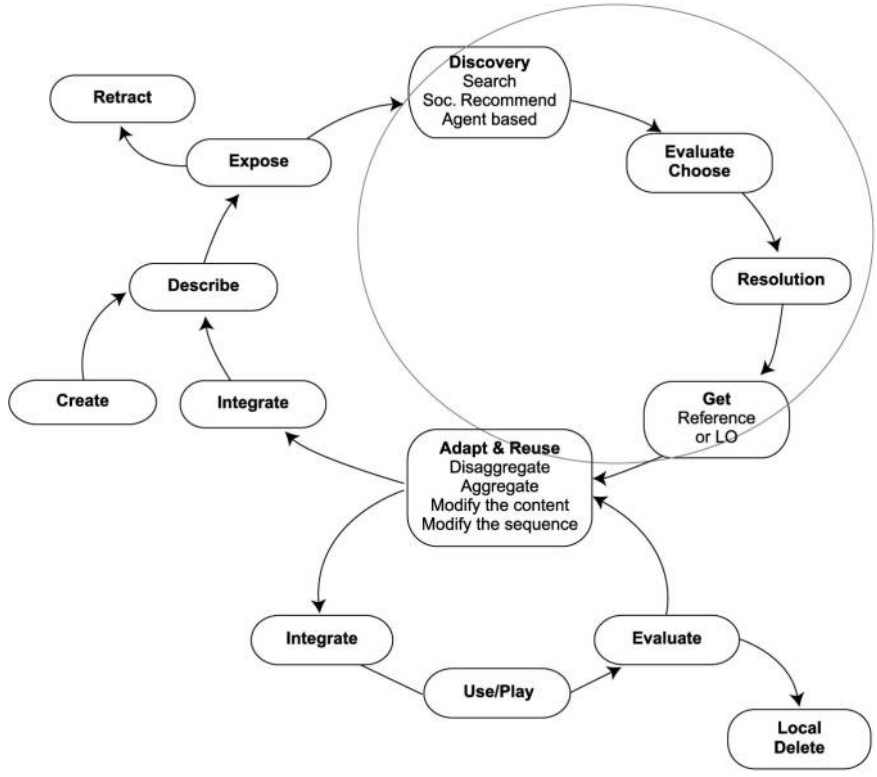
finally, how the behaviour of previous users could be leveraged to support and enhance the discovery process of educational resources for all users of the system.

From previous studies (McGormick *et al.*, 2004; Vuorikari and Koper, n.d.) we have evidence that users of educational content use cross-boundary resources to a certain extent, but their reuse remains rather low (equal or half of the normal reuse, around 10 per cent).

In this study our specific questions focus on the efficiency of resource discovery and how we can support the users in discovering cross-boundary resources. We have defined our two hypotheses as following:

H1. The search methods that take advantage of Social Information Retrieval yield more relevant resources with less effort from the users than the methods based on conventional text based search.

H2. The users who take advantage of community browsing discover more cross-boundary learning resources than those who use conventional text base search.



Source: Van Assche and Vuorikari (2006)

Figure 1.
Learning resource lifecycle

We focus on a specific moment in the lifecycle of a learning resource, namely when the user discovers the learning resource and evaluates whether it matches with the information seeking need at hand (Figure 1).

In the following section we introduce the study methodology and the data set. The next section focuses on the results followed by the discussion. The paper is concluded with an outlook for future work.

2. Context of the study and its method

The portal that we study makes open educational resources available from 19 content providers from Europe and elsewhere. These resources exist in different languages and conform to different national and local curricula. The portal, developed in the MELT project (Figure 2), offers three different categories of searches (Millen *et al.*, 2007):

(1) *Explicit search*. Comprises the traditional search box with text and filtering options. "Find by subject" offers browsing through pre-defined categories. The results are shown on the search result list (SRL) with metadata and annotations about the resources. Resource-related tags allow pivotal browsing.

(2) *Community browsing*. Includes browsing the tagcloud, tags, other people's Favourites. Figure 2 shows part of the tagcloud, and the lists of "travel well" and most bookmarked resources.

(3) *Personal search*. Looking for bookmarks from one's own personal collection of bookmarks (MyFavourites).

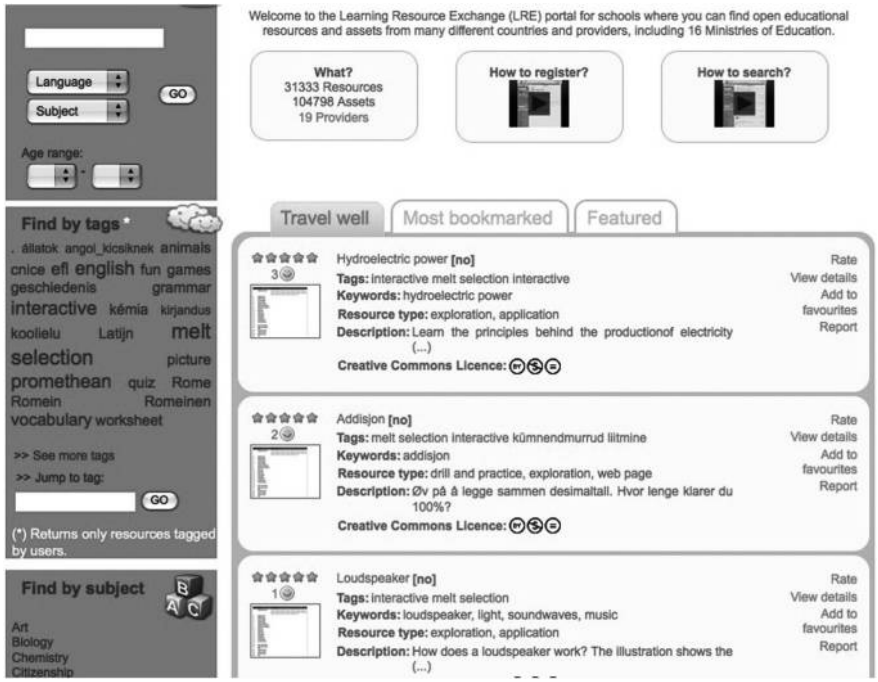


Figure 2.
Melt portal

In this study, social information retrieval comprises community browsing features and other retrieval of resources that contain user-generated interest indicators. By clicking on the link users play resources and generate click-through. An annotation is a public contributing action and happens when the user makes an explicit interest indicator on the resource, e.g. a rating (usefulness, scale 1-5) or a bookmark with tags (called favourites). We use the term "cross-boundary discovery" when the user bookmarks or rates resources that come from different country than she does and that are in a language other than that of the user's mother tongue.

We use the following metric for relevance: when a resource is added in the favourites, or the resource is rated with the value of 3 or greater. Such relevance represents the relationship between the object and the information need, as perceived by the user. We do not focus on the other types of relevance, such as the query and object match or topical relevance (Borlund, 2003). With "less effort from the user" we mean that users will play and annotate more relevant resources with less search effort (e.g. the number of executed searches).

2.1 Description of the data

We have defined our own logging scheme for users' attentional metadata, which can be exported in a contextual attention metadata compliant format (Najjar *et al.*, 2007). It was first used on the calibrate pilot in 2007. We redefined the scheme to cover a range of contributing actions and social search. Table I describes the scheme that includes three main units: the data about the resources, about the users and what the user does on the portal. The latter includes three main categories: search, click and contributing actions.

Server-side logs were collected from the period of 1 October to 18 December 2008. After excluding the project staff, we were left with 168 users, out of which 163 had initiated searches and 82 had clicked on a resource on the portal at least once. Table II presents the data used for this study that include unregistered and registered users.

Table I.
Logging scheme on the portal to capture users' attentional metadata

	Unique ID	Languages	Location	Time stamp	Other metadata
1. Resources	×	×			LOM LRE Application profile
2. Users	×	×		×	Country, school, interested topics
3. Actions					
3.1 Session	×			×	User ID if logged in
3.2 Search				×	Type of search: advanced, browse topics, tag search
3.3 Click			×	×	The item clicked (LO, tag, rating, other user)
3.4 Bookmark	×		×	×	User ID, LO ID
3.5 Tag	×	×	×	×	User ID, LO ID
3.6 Rate	×	×	×	×	User ID, LO ID, value, comment

Table II.
Data description

	Session	Search	Play	Distinct resources	Distinct resources annotated
Unregistered users	2,036	7,846	1,854	1,746	Not available
Registered users (82)	310	1,863	974	687	394

The registered users, mostly primary and secondary teachers, were invited to use the portal after an initial pilot. They came from 11 different European countries (Austria, Belgium, Estonia, Finland, France, Germany, Greece, Hungary, Slovenia, Sweden and the UK).

During the pilot, a selection of more than 30,000 distinct resources were made available. A total of 565 resources (less than 2 per cent of all resources) had been annotated prior to the period of study. Figure 3 shows that the growth of new users and tags follow one another. Farooq *et al.* (2007) explain that linear tag growth suggests that the tag vocabulary is still maturing and has not yet reached its relatively stable stage, a view that we also adopt for our system.

2.2 Data processing

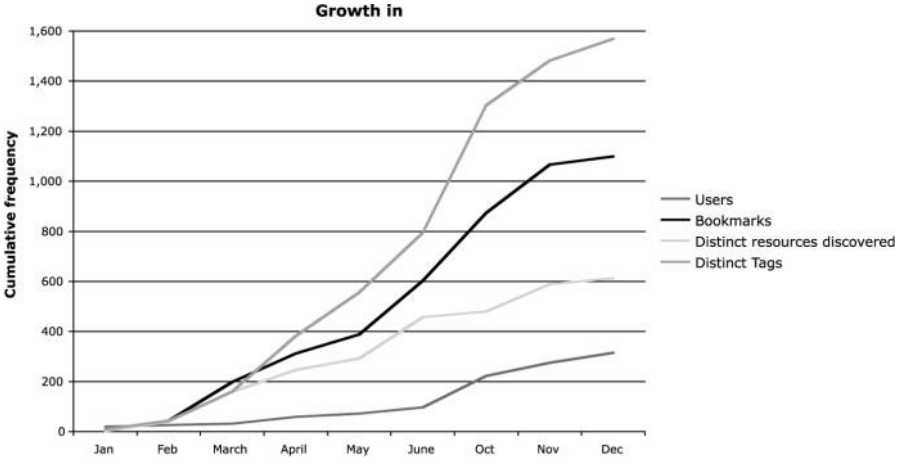
We tested the normality of our data using the Kolmogorov-Smirnov test, which indicates a highly significant deviation from normality. As the assumption of normality was not tenable, we used methods for non-parametric data (e.g. Kendal tau). As for testing the association between the type of search and the number of actions that followed, we used Pearson Chi-Square test ($p < 0.001$).

3. Results

We first give descriptive results on our three main actions: how do users search, play and contribute, and then look how new resources generated clicks and annotations. Following, we present the model of the process that produced this data and then focus on our two hypotheses.

3.1 Descriptive results

Search. We found three main groups of search behaviour among the registered users; the ones who only used explicit (47 per cent) or community search features (6 per cent) and about half of the users who used mixed methods (47 per cent). Of all searches



Note: The portal was not in use during the summer months

Figure 3.
Tag and user growth in MELT

executed on the portal, 82 per cent were explicit methods (53 per cent advanced searches; 29 per cent browsing by discipline) and 18 per cent community browsing.

Click-through. All users played 1,547 distinct resources a total of 2,828 times. Users generated click-through (i.e. play) differently: 52 per cent only played resources on the search result list, 10 per cent only in community browsing areas, and the rest (38 per cent) in different parts of the portal.

Table III shows that users played resources without explicit interest indicators in the Search result (69 per cent), whereas 31 per cent of the click-through was generated on resources that had explicit Interest indicators. We consider the latter to be an outcome of the SIR methods, the point we come back to in *H1*.

Annotations. A total of 77 per cent of registered users who played resources also annotated them: 44 per cent both rated and tagged resources, whereas 33 per cent only rated or tagged resources. Table IV shows that users rated and bookmarked very similarly. As the median suggests (3 for both), there were many variations in individual users habits. For example, two users out-performed others with 120 and 108 annotations. Most ratings (84 per cent) are positive (≥ 3).

A total of 40 per cent of users only annotated resources in the search result list and 24 per cent only in community browsing parts of the portal, 36 per cent of users annotated in both places, which resulted in most of annotations (70 per cent).

Table III.
Click/through areas of the portal

Click-through	Registered users	Other	All	%
Search result list	728	1,235	1,963	69.4
Search result list with explicit interest indicators	40	85	125	4.4
Tagcloud	103	124	227	8.0
"Travel well" list	68	300	368	13.0
Favourites	20	34	54	1.9
"Most bookmarked" list	15	76	91	3.2
Grand total	974	1,854	2,828	–

Table IV.
Distribution of annotations

Annotations	Bookmarks and tags	Ratings	Bookmarks obtained from *n*	Bookmarks obtained from %	Ratings done in *n*	Ratings done in %
Users	48	46				
Number of actions	350	384				
Number of tags	1,507	≥ 3 (84%)				
Minimum of actions	1	1				
Maximum of actions	65	56				
Mean of bookmarks	7.29	8.34				
Median	3	3				
Mode	1	1				
Standard deviation of annot.	12.19	12.53				
Explicit search no SI			236	67	258	67
Explicit search with SI			49	14	26	7
Community search			65	19	85	22
Personal search			n/a		15	4

Explicit interest indicators, click-through and contributions. In some cases, resources with explicit interest indicators generated more actions. For example 14 per cent of all played resources with explicit Interest indicators generated 29 per cent of all plays. We studied the correlation between explicit interest indicators and different actions using Kendall's Tau and found a small correlation coefficient between explicit interest indicators and click-through (0.253 $p < 0.01$), interest indicators and bookmark (0.329 $p < 0.01$) and less with Interest indicators and rate (0.196 $p < 0.01$).

Finally, the correlation coefficient between the actions was small, but significant: bookmarking and rating (0.300 $p < 0.01$); play-bookmark (0.327 $p < 0.01$) and play-rate (0.233 $p < 0.01$). These correlations between actions can be further studied for generating implicit interest indicators that are less intrusive for users.

3.2 Modelling users' actions: ecology of social search

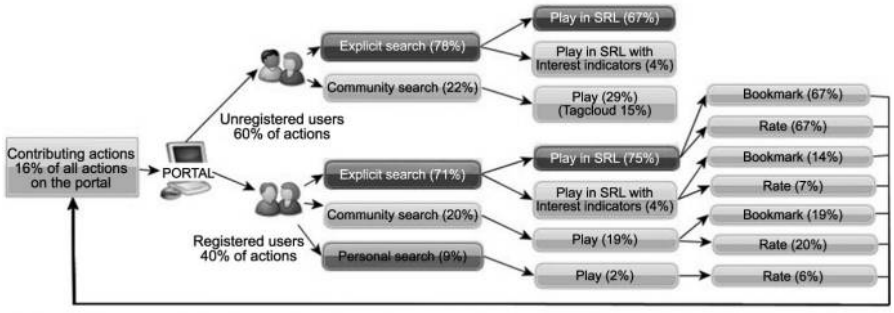
A model was created of the process that produced the above described data to study how processes are interlinked; for example, how newly created annotations become part of the search process and lead to eventual play of the resource.

Figure 4 shows registered and unregistered users and the percentage of their actions by their category. In principal, these two groups search rather similarly: explicit search is preferred by both groups and community search methods account for about 20 per cent of all search actions.

The main difference is that the unregistered users tend to choose exploratory search strategies more (51 per cent): 29 per cent browse by discipline and 22 per cent community browsing, whereas registered users have more explicit search strategy (75 per cent) and additionally use personal search (9 per cent) within their MyFavourites-section.

Users play resources differently, unregistered users play resources in the search result list (71 per cent) and 29 per cent in community browsing areas. Registered users, on the other hand, play three-quarters of resources in the SRL and only one quarter in community browsing areas.

Only registered users contribute in terms of annotations, they amount to 16 per cent of all recorded actions. Most annotations (67 per cent) are on newly discovered resources, whereas the rest (33 per cent) is generated on resources that have already been annotated and thus discovered in the community browsing areas. The



Note: Light grey indicates actions based on social search and contributions, whereas dark grey indicates actions of Explicit search

Figure 4.
Users consume and contribute

annotations follow a rather regular pattern, however, for ratings, a small amount is created in the user's favourites.

The model shows that the contributing actions (i.e. explicit interest indicators) play an integral part in creating more diverse ways to social navigate through resource portal. Although not all users contribute (40 per cent), most still benefit from them (60 per cent): the community browsing was used in 21 per cent of all searches and explicit Interest indicators supported users when playing resources (31 per cent). Our finding points to the same direction as Glahn *et al.* (2008) who found that accessing of tagged resources is independent from the contribution level of a participant. However, we did not find that all participants use tags similarly while searching or accessing tagged resources: we observed different search preferences by users.

*3.3 Measure of efficiency: search-play-contribute ratio (*H1*)*

H1 tests whether the search methods that take advantage of social information retrieval yield more relevant resources with less effort from users. We use the above model to create a measure to test our hypothesis by studying the ratio between search, play and contributing actions. We are inspired by the click-through rate that measures the success of an online advertising campaign. The rate can be obtained by dividing the number of users who clicked on an advertisement by the number of times it was delivered (e.g. Ward and Kalyanam, 2007).

Our application of the efficiency measure shows how many search actions it takes to play and/or annotate a resource. For both search methods we created the following efficiency ratios: search-play, search-rate (3 or higher), search-bookmark, play-rate (3 or higher), and play-bookmark. The lower the figure the better, as it indicates the number of actions that it takes the user to achieve the goal,

For the baseline, explicit search is only comprised of text-based search results excluding the resources that are played and annotated as a result of explicit search but contained explicit interest indicators. We regard them to be part of SIR methods, as explained before. In Table V, by comparing the figures of the two top rows, we find that the search-play, search-bookmark and play-bookmark ratio for registered users is almost identical using both methods, whereas community browsing is more efficient for rating. Additionally, we calculate an efficiency rate for each search method that is the average of all ratios and allows for quick comparison. "Explicit search (comparison)" reports the same ratios from another portal (calibrate) where no explicit interest indicators such as bookmarks or ratings were made available to users (Vuorikari and Ochoa, 2009).

Comparing the explicit search baseline to social information retrieval methods shows an efficiency gain, the efficiency rate drops from 4.4. to 2.8. Search-rate ratio comes down from approximately seven searches to four searches, whereas play-rate from three searches to two searches.

In Table V the search-play ratio for unregistered users is very high. The inefficiency of the search can partly be explained by the optimising efforts and heavy testing of the portal, which has often times taken place without staff logging in. We believe that the ratio calculated from registered users is closer to reality, although still rather inefficient.

We conclude that on the MELT portal, keyword based explicit search and community browsing perform very similarly (average efficiency rate: 4.4 to 3.9).

Table V. Users' efficiency with different search methods on the MELT portal

	Unreg u: Search-play ratio	Reg u: search-play ratio	Search-rate (≥3) ratio	Search-bookmark ratio	Play-rate (≥3) ratio	Play-bookmark ratio	Efficiency rate (reg u)
Explicit search (baseline)	4.0	2.1	7.0	6.4	3.3	3.1	4.4
Community search (baseline)	2.6	2.0	5.3	6.5	2.6	3.2	3.9
SIR methods	2.2	1.7	4.0	3.7	2.3	2.2	2.8
Explicit search (comparison)	n/a	0.5	21.6	11.3	42.6	22.2	19.6

However, when comparing the baseline to SIR methods, we see an efficiency gain (average efficiency rate: 4.4 to 2.8). For both the baseline and SIR data, Pearson Chi-square test was highly significant ($p < 0.001$). Despite the optimisation problems of the search (which occasionally affects all the search features similarly making them slow to response), we can approve *H1*.

*3.4 Discovery of cross-boundary resources (*H2*)*

H2 tests whether the users who use community browsing discover more cross-boundary learning resources. In addition to using the above measures, we add a component indicating the cross-boundary nature of a bookmark. To do this, we compared the country of the resource to that of the user and the language of the resource to that of the user's mother tongue as in Vuorikari and Koper (n.d.). Additionally, we created a "search method" profile and "cross-boundary resource profile" for each user. These profiles are comprised of percentages of different search methods by the user and the percentage of resources across national and linguistic boundaries.

A total of 57 per cent of all bookmarks, total of 198, are cross-boundary discoveries. Of 48 users who bookmarked resources, 40 had cross-boundary resources (i.e. 83 per cent with cross-boundary profile and 17 per cent with only national profile). This split reflects the goal of the portal that promotes the discovery of educational material from different countries. Such cross-boundary profiles are usually also "cross-repository" profiles, which can be used to make links between content in different repositories that otherwise is not cross-referenced via hyperlinks nor metadata (Table VI).

Cross-boundary resources were most often bookmarked in the Search result list (72 per cent), whereas 28 per cent were a result of community browsing. Within community browsing, 23 per cent were discovered in the tagcloud and 5 per cent chosen from the "Travel well" list. Moreover, to test *H2* we calculated the correlation between each user's "search method" profile and "cross-boundary resource" profile using Pearson r (0.17). This prompts us to refute *H2*.

Lastly, we still looked at the relation between social information and cross-boundary discovery. The majority of cross-boundary bookmarks did not have SI (63 per cent). The correlation between cross-boundary discovery and the presence of SI is a very small (0.167, $p < 0.05$). Using the "overlap among collections" measure from Vuorikari and Koper (n.d.), we find that resources with explicit interest indicators have been shared much more often (0.29) than resources that do not contain any explicit Interest indicators (0.10). Even if the correlation between the two was small, however significant, we note that it seems appropriate to further investigate this topic with a dataset not so sparse as ours.

Table VI.
Cross-boundary discovery

	Distinct LOs		Distinct L0s w/SI		"New" discoveries	
	n	%	*n*	%	*n*	%
Cross-boundary discovery	163	55 of all	52	32	111	68
Times	198	57 of all	73	37	125	63

4. Conclusion

In this paper we used empirical data from server-side logging to study and model the ecology of social search of a learning resource portal integrated with a social bookmarking and tagging system. We conclude that explicit Interest indicators have an important role as a part of the social search ecology and studies into inter-relations of these variables will offer interesting further insights. By studying the cross-boundary discoveries, we find that users create underlying connections between resources that come from a number of countries and are in a variety of languages, which is important for bringing them under the umbrella of SIR methods.

H1 was approved showing that the search taking advantage of social information retrieval (SIR) methods yield more relevant resources with less effort from the user. Despite this edge, users have a strong search preference for explicit search methods (two-thirds of all executed searches). These conventional search methods strongly proved their role in discovering new resources. This also led us to refute our second hypothesis (*H2*): most cross-boundary resources are discovered using explicit search. Encouraged by the *H1*, though, we believe that enhancing explicit interest indicators to support cross-boundary discovery (e.g. indicating the cross-boundary nature of resource discoveries, tag clouds filtered by language and by the country of users) and collaborative filtering methods for like-minded users are worth studying further, once the new item problem has been overcome.

A limitation in this research was that we studied a system that was still evolving. This has the positive effect of allowing us to revisit our SIR strategies for both cross-boundary and within-boundary discoveries to better support users. A second limitation is that as the study is based on server-side log-files, we have left out subjective measures such as user satisfaction or cognitive load while searching, which would also add important information in studying such system. Future studies should include testing wider range of SIR methods to leverage the underlying connections that users have created though social tagging and bookmarking between resources that originate from a number of repositories and are in a variety of languages.

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