Tags and self-organisation:
a metadata ecology
for
learning resources in a multilingual context

(Tags en zelforganisatie: metadata ecologie
voor
digitaal leermateriaal in een meertalige context)

Tags and self-organisation: a metadata ecology for learning resources in a multilingual context

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Riina Vuorikari

Synopsis

This thesis studies social tagging of learning resources in a multilingual context. Social tagging and its end products, tags, are regarded as part of the learning resources metadata ecology. The term “metadata ecology” is used to mean the interrelation of conventional metadata and social tags, and their interaction with the environment, which can be understood as the repository in the large sense (resources, metadata, interfaces and underlying technology) and its community of users. The main hypothesis is that the self-organisation aspect of a social tagging system on a learning resource portal helps users discover learning resources more efficiently. Moreover, user-generated tags make the system, which operates in a multilingual context, more robust and flexible.

Social tags offer an interesting aspect to study learning resources, its metadata and how users interact with them in a multilingual context. Tags, as opposed to conventional metadata description such as Learning Object Metadata (LOM), are free, non-hierarchical keywords that end-users associate with a digital artefact, e.g. a learning resource. Tags are formed by a triple of (user,item,tag). Tags and the resulting networks, folksonomies, are commonly modelled as tri-partite hypergraphs. This ternary relational structure gives rise to a number of novel relations to better understand, capture and model contextual information. The (user,item) relationship is a parameter of the interaction between a user and the learning resource. In the (user,tag) relation, on the other hand, tags are regarded as part of the user model that reflects user’s interests and intentions. The full relational structure emphasises the (item,tag) relation that allows tags to be part of describing the item that they are related to (e.g. a learning resource). Additionally, the (item,tag) relation can be extended to the metadata of the item (e.g. LOM), from which an additional relationship (tag,LOM) is inferred.

To this end, this thesis first provides two exploratory studies to better understand how users tag learning resources in a multilingual context and to find evidence on the “cross-boundary use” of learning resources. The term cross-boundary use means that the user and the resource come from different countries and that the language of the resource is different from that of the user’s mother tongue. The second part introduces a trilogy of studies focusing on self-organisation, flexibility and robustness of a social tagging system using empirical, behavioural data captured from log-files and user’s attention metadata trails on a number of learning resource portals and platforms in a multilingual context.

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Chapter 1

Introduction

Abstract

Social tags offer a novel aspect to study learning resources, its metadata and how users interact with them. The key theme in this research is to understand the central role of social tagging for Technology Enhanced Learning (TEL), more specifically, for digital learning resources in a multilingual context. The main hypothesis is that the self-organisation aspect of a social tagging system on a learning resource portal helps users discover learning resources more efficiently and that user-generated tags make the system, which operates in a multilingual context, more robust and flexible. First, the learning resource landscape is introduced, after which a short look on social tagging and self-organisation is offered. Finally, the structure of this thesis is presented with the main hypothesis.

Introduction

Sharing, using and reusing the content is the main driver of the learning object economy (Campbell, 2003). Participants of this economy are educational institutions, digital libraries and learning object repositories (LOR) and their diverse stake-holders such as policy makers, managers, content providers, educators and learners, each with their own needs, requirements and agendas. Since the late 1990's, digital repositories for learning purposes have gained ground. Such repositories with metadata and/or educational content have been set up on regional, national and international levels to offer digital learning resources for teachers and learners from K-12 to tertiary and vocational education (Tzikopoulos, Manouselis & Vuorikari, 2007; McGreal, 2008). This variety of repositories creates a learning resource landscape where a diversity of models exists (Hylén, 2006). Figure 1.1 depicts the typology of learning resource landscape focusing on two axes: the way in which the content authoring takes place and the context in which the content is made available.

On the one end of the vertical axis the content comes from teachers who create it, i.e. the teacher-created content. On the other end of this axis, there are any third party producers of educational resources such as textbook publishers, museums, broadcasting companies, etc. The horizontal axis introduces the context: "institutional context" referrers to content repositories that are managed by educational institutions and authorities (e.g. Ministry of Education), whereas the other end represents "community driven context" where the content creation typically takes advantage of Web 2.0 style publishing and tools.

This thesis is comprised of a series of studies that has been conducted mainly on the Learning Resource Exchange for schools portal (LRE Portal, 2009), but also on a number of other portals and repositories. Using the illustration of the learning resource landscape, they are found both in the upper left corner of the diagram and in the lower right hand corner. The LRE portal (hereafter referred to as portal) represents an example of institutionalised content in multiple languages. The portal was developed by European Schoolnet (2009) and its partners in the Calibrate (2008) and MELT (2009) projects. Different versions of

the portal with learning resources from providers in Europe and elsewhere were made available to a restricted number of schools. “Practical implementations” in Chapter 8 offer more details. LeMill (2009), on the other hand, represents a community-driven context where teachers from different countries create the content in a variety of languages (lower right corner of the diagram). Additionally, OERCommons (2009) has been studied as part of this research. It federates content from both ends of the spectrums. Lastly, one case study focused on teachers’ use of delicious.com (upper right corner of the diagram), thus acknowledging the fact that users access plethora of resources that not all are made available through content repositories.

Figure 1.1. The learning resource landscape representing the diversity of available resources. EdReNe (2008) members run learning repositories by European educational authorities.

Previous research in this field mainly works with an assumption that the system and its users share one common language. This research emphasises the coexistence of multiple languages and origins of both users and content within the system. The term cross-boundary use of learning resources is used to mean that the user and the content come from different countries, and/or that the content is in a language other than the user’s mother tongue. Previous literature on the learning resources has pointed a number of obstacles to such a cross-boundary use of content, e.g. differences in languages, disciplines, teaching models and tasks for which the resources are used - to mention but a few. Moreover, users’ attitudes play a role in how users perceive the content. Berendt & Kralish (2009) studied the attitudes towards the use of the Web in general and found that due to the under-representation of non-English language content on the Web, especially the people who are not proficient in English perceive the scarcity of information in their native language. This group of people is highly appreciative of content in their mother tongue. In contrary, people who are proficient in English often prefer to navigate in English, even if offered content in their own language. Chapter 3 explores behavioural evidence from two learning resource platforms on the use and reuse of cross-boundary content. The research question asks *Is there evidence of the use and reuse of learning resources across the country and language borders?*

SOCIAL TAGGING AND SELF-ORGANISATION

Learning Object Repositories (LOR) and digital libraries can be regarded as socio-technological systems with complex combinations of people, content artefacts and technologies. A social tagging and bookmarking tool as a feature on a conventional LOR potentially adds a number of dynamical mechanisms in such a system. Tags, as opposed to conventional metadata description such as Learning Object Metadata (LOM) (LOM, 2002), are free, non-hierarchical keywords that end-users associate with a digital artefact, for example a learning resource. Tags are formed by a triple of (user,item,tag). Tags and the resulting networks, folksonomies, are commonly modelled as tri-partite hypergraphs (Marlow, Naaman, boyd & Davis, 2006; Cattuto et al., 2007). This ternary relational structure gives rise to a number of novel relations to better understand, capture and model contextual information. The main interest in this study is to understand these relationships and their ramifications in Technology Enhanced Learning (TEL) and more specifically, for digital learning resources.

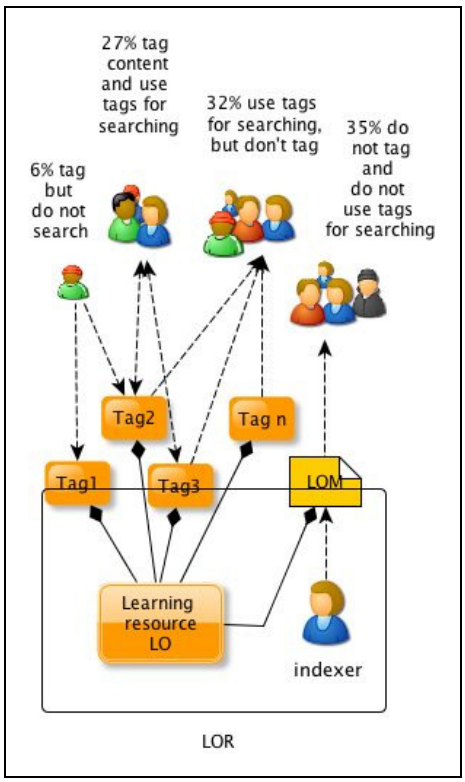

Fig. 1.2. Relational structures that emerge when a social tagging tool is introduced as a feature to a conventional Learning Object Repository (LOR).

Figure 1.2 represents relationships between a user, a learning resource, its metadata (LOM) and tags. In the (user,tag) relation, tags can be regarded as part of the user model that reflects user's interests and intentions either through

the act of adding a tag or using tags for retrieval purposes. On the other hand, the (item,tag) relations allow tags to be part of describing the learning resource that they are related to. Moreover, this relation can be extended to the whole metadata (e.g. LOM) creating an additional relationship (tag,LOM). Lastly, the (user,item) relationship can be regarded as a parameter of the interaction between a user and the learning resource in question.

The act of a user adding a tag to a resource can be regarded as a lower-level interaction on the portal that is executed on the basis of purely local information, e.g. the user has discovered a resource that is relevant to her or his information seeking task. This individual behaviour, however, also modifies the environment of the repository through above-mentioned relationships. The tag(s) added by the user, for example, now appear in the resource-related tagclouds and on the global tagcloud creating patterns on the system level. This, in turn, has a potential to modify the behaviour of other individuals, as they might be inclined to use the tag as a navigational aid or prompt for their own resource discovery process. Such phenomenon is explained as stigmergy, it provides a general mechanism that relates individual and colony-level behaviours in the literature of social insects (first introduced by Grassé, 1959).

Similar ideas have been further used in designing adaptive, decentralised and robust artificial systems, e.g. “swarm intelligence” (Bonabeau, Dorigo & Theraulaz, 1999) and self-organising applications in general (e.g. Mostefaoui et al., 2003). Implementations of these ideas in technology enhanced learning exist, e.g. a collaborative filtering (Dron, Mitchell, Siviter & Boyne, 2000; Dron, 2004), designing lifelong learning networks (Koper, Rusman & Sloep, 2005), self-organising wayfinding support for lifelong learners (Tattersall et al., 2005), sequencing recommendations (Van den Berg et al., 2005), and self-organising navigational support (Janssen et al., 2007). The grounding of these works relies in complexity theory (Kauffman, 1995; Waldrop, 1992).

By studying the behaviour of social insects such as ants, termites or certain wasps, scientists have elicited three characteristics behind their success in carrying out complex tasks such as building a nest or finding a shortest route to a food source (Bonabeau & Meyer, 2001). These are:

- Self-organisation (activities are neither centrally controlled nor locally supervised);
- Flexibility (the colony can adapt to a changing environment);
- Robustness (even when one or more individuals fail, the group can still perform its tasks).

Self-organisation represents the idea that even if individuals follow simple rules, the resulting group behaviour can be surprisingly complex and effective. Self-organisation is explained as “a set of dynamical mechanisms whereby structures appear at the global level of a system from interactions among its lower-level components. The rules specifying these interactions are executed on the basis of purely local information, without reference to the global pattern, which is an emergent property of the system rather than a property imposed upon the system by an external ordering influence.” (Bonabeau, Dorigo &

Theraulaz, 1999, p. 9). According to the authors, the four basic ingredients of self-organisation are the following:

1. **Positive feedback**: simple behavioural "rules of thumb" that promote the creation of structures. An example of this is "recruitment" by ants, i.e. other ants start following a trail to a food source thanks to indirect interactions among insects.
2. **Negative feedback** is a technique of control and it counterbalances positive feedback. In the example of wayfinding among ants, this can be food source exhaustion, or competition between food sources.
3. Self-organisation (SO) relies on **the amplification of fluctuations** (e.g. random walks, errors). Randomness is often crucial since it enables the discovery of new solutions. An example of this is an ant that gets lost and finds a new, unexploited food source.
4. **Multiple interactions**. SO generally requires a minimal density of mutually tolerant individuals who are able to make use of the results of their own activities as well as of others' activities. E.g. trail networks can self-organise and be used collectively if individuals use others' pheromone (a chemical substance that can be sensed by other ants).

STUDYING SELF-ORGANISATION OF A TAGGING SYSTEM IN A MULTILINGUAL CONTEXT

Figure 1.3 presents the front page of the portal which is offered in multiple languages. It shows the two main strategies for search: (1) Conventional search (e.g. text box search with filters) that takes advantage of multilingual metadata as is prescribed in the LRE Application Profile (LRE, 2007) and (2) "Community browsing" that takes advantage of the other users' behaviour based on annotations, such as social tags and ratings. Social tags allow users to find back their interesting resources at a later point and to share them with other users.

Attention metadata, e.g. how do users search, what do users click on, what do they bookmark (e.g. Najjar, Wolpers & Duval, 2006) was collected from users on the portal. When studying a social tagging system, stigmergy and self-organising can be observed in the following ways:

- Users follow a simple rule: "Search resources either through Conventional search or Community browsing. When a resource is relevant, rate and /or bookmark it with tag(s)". These lower-level interactions are executed on the basis of purely local information.
- The resulting tags are aggregated into tagclouds and lists of most bookmarked resources creating global patterns on the system level.
- Tagclouds are an example of the spatiotemporal structures that emerge as a result of self-organisation. A tagcloud influences the behaviour of individuals in discovering new resources and further tagging them.
- When other users start using tags as a social navigation aid, it can be understood as positive feedback to the system.

- This prompts convergence in the behaviour: it increases the frequency of use of the same resources and tags, and creates the emergence of patterns (e.g. “most bookmarked resources” and “top-used tags”).
- Negative feedback is given to the system when a user, for example, does not find a relevant resource using a tag and thus chooses to use some other retrieval method. This is a control mechanism that counterbalances positive feedback in the system.
- Amplification of fluctuations is a counter-measure against too much positive feedback, which can lead to 'suboptimal convergence' and kill innovation, result of which could be no new emerging behaviours. Discovery of new resources through Conventional, text-based search methods introduces new items to the tagclouds that act as seeds from which new structures can nucleate and grow.
- Further exploratory behaviour to discover previously unexploited resources is encouraged through recommendations by expert teachers.
- Multiple interactions from users, both authenticated and non-authenticated, are recorded on the back-end of the LOR using attention metadata schema designed for social discovery processes. Individuals are able to make use of the results of their own activities (e.g. My Favourites and personal tagclouds), and the spatiotemporal structures that emerge are also made available collectively to all the users.

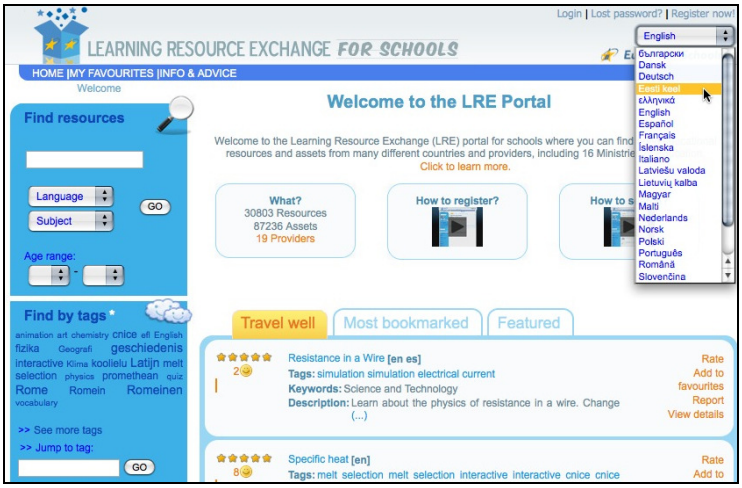

Fig. 1.3. The Learning Resource Exchange (LRE) for schools portal is available in different languages.

Following the idea of self-organisation and stigmergy, learning resources and their metadata on the one hand, and social tagging and its products, tags on the other hand, do not only create new ways to discover learning resources, but also create a learning resource metadata ecology. The term “metadata ecology” is used to mean the interrelation of conventional metadata and social tags, and their interaction with the environment, which can be understood as the

repository in the large sense (resources, their metadata, interfaces and underlying technology) and its community of users.

Chapter 2 offers an introduction to the current studies in the intersection of the areas of digital learning resource repositories, digital libraries and social tagging systems. Users and the usage of different systems in the field of learning resource repositories and digital libraries have been studied by different means, such as using Web metrics (Farooq et al., 2007; Khoo et al., 2008; Ochoa, 2008), attention metadata (Wolpers, Najjar, Verbert & Duval, 2007), data mining techniques (Romero & Ventura, 2007), and mixed and qualitative methods (Harley, Henke & Nasatir, 2006; Petrides, Nguyen, Jimes & Karaglani, 2008). It can be argued that the methods applied in these areas are comparable and complementary. Chapter 3 and 4 set the base for this thesis: a baseline on the use and reuse of cross-boundary resources is introduced, then a study on characteristics of tags and tagging in multilingual contexts is offered.

The second part of this thesis is comprised of a trilogy of studies testing the main hypothesis using empirical, behavioural data captured from log-files and users' attention metadata on the portal and the other repositories.

This hypothesis states that

- *the self-organisation aspect of a social tagging system on a learning resource portal helps users discover learning resources more **efficiently**, and that*
- *user-generated tags make the system, which operates in a multilingual context, more **robust** and **flexible**.*

Chapter 5 introduces the first of the studies where the main focus is on the self-organisation and how users behave on a learning resource portal where bookmarks, ratings and social tags have been used to create Community browsing features. Community browsing means accessing resources through the emergence of the patterns such as ratings, tagclouds and specific lists of most bookmarked resources aggregated from the users of the system, but also "pivot browsing" which means using tags or usernames as a means to reorient browsing. Additionally, Community browsing also includes a recommended list of "travel well" resources created by the expert teachers to further encourage exploratory behaviour of individuals. These are called Social Information Retrieval (SIR) methods.

Based on the captured attention metadata from a period of two and a half months, a behavioural model and a measure of user's efficiency in discovering resources were created. These were used to answer two research questions: *can search strategies based on Social Information Retrieval (SIR) make the discovery of learning resources more efficient for users,* and *can Community search help users discover a wider variety of cross-boundary resources.*

In Chapter 6 the main focus is on robustness of the system. In the context of a multilingual learning resource portal, robustness is interpreted that even when one or more elements fail, users can still perform the task, i.e. discover and

reuse learning resources across contexts (e.g. repository, language, country, curriculum). Thus, robustness can be considered as the robustness of the reuse chain, of which metadata is an important element. To study this, the focus was on the interrelation of conventional metadata and social tags on the one hand, and their interaction with the environment, which can be understood as the repository, its resources and all stakeholders (e.g. managers, metadata indexers and the whole community of users). Chapter 6 also focuses on the aspects of flexibility that the self-organisation brings along. Flexibility is defined as the ability of the *users and the metadata to adapt to a changing environment*. In this study, over a period of six months, empirical data from more than 200 users on the portal was gathered.

Where Chapter 6 shows how users adapt to their changing environment, Chapter 7 focuses on flexibility of *the metadata to adapt to a changing environment*. The research challenge is to demonstrate whether the end-user generated tags can create cross-references between separate pieces of content that reside in heterogeneous content platforms in a multilingual context, and thus create a more flexible interplay between different content platforms. It has been argued that a "repository-centric perspective" of learning resource repositories creates a barrier for the use and reuse of learning resources, as repositories are often introduced as a stand-alone tool to users. Chapter 7 first describes three educational platforms with their social tagging tools (Calibrate, 2008, LeMill, 2009, OERCommons, 2009). The similarities and differences are compared to establish that despite different design decisions, there are many commonalities in tags. Encouraged by these similarities in tags, more than 20,000 tag applications are studied.

The last Chapter, number 8, finally reviews the results and discusses them from the point of view of the main hypothesis. The part "Lessons learned" explores how modelling the contextual information using the triple (user,item,tag), and its extension (tag,LOM) relationship, can be used to better explore and understand users' behaviour, interests and interactions within a multilingual environment of learning resources. Moreover, the part reviews how this information can further be used to enhance context-aware data processing in a multilingual environment to create more intelligent ways to foster and enhance collaborative behaviour among users, content and repositories across languages, countries and other boundaries, such as curricula and repositories. These methods are based on cross-context link-structures that are created through social tagging, thus giving emphasis for humans' subjective judgement of the resources' importance for a given information seeking tasks, the grounding idea of Social Information Retrieval methods. Moreover, "Practical implications" of this thesis and its limitations are discussed, as well as "Future research and development" work is elaborated. Lastly, this thesis includes the list of research references, summaries both in English and Dutch, acknowledgements by the author, her Curriculum Vitae and the list of SIKS thesis from 1998 – 2009.

Chapter 2

State-of-the-art review: tracking usage and attention metadata in multilingual TEL

Chapter is based on Vuorikari, R., & Berendt, B. (2009). Study on contexts in tracking usage and attention metadata in multilingual Technology Enhanced Learning. In S. Fischer, E. Maehle, & R. Reischuk (Eds.), *Im Focus das Leben* (pp. 181, 1654-1663): Lecture Notes in Informatics P-154; Bonn, Germany: Köllen Druck+Verlag GmbH.

Introduction

This opening Chapter serves as background for readers unfamiliar with the area of tracking users' attention metadata in digital learning resource repositories, digital libraries and social tagging systems, and allows them to position this thesis as part of the on-going research in the field. Users and the usage of different systems in these fields have been studied by different means, such as using Data mining techniques (e.g. Romero & Ventura, 2007), Web metrics (e.g. Khoo et al., 2008; Ochoa, 2008), attention metadata (e.g. Wolpers et al., 2007) or more mixed and qualitative methods (e.g. Harley, Henke & Nasatir, 2006; Petrides et al., 2008). It can be argued that that their methods for studying users and usage are in many cases comparable and complementary, and that studying these different but converging contributions can benefit all of these areas.

This Chapter gives an overview of dimensions of context that are relevant in technology enhanced learning (TEL). Usage and attention metadata are considered as an example of the wider notion of context. Specifically, it is argued that context comprises the usage situation and environment as well as persistent and transient properties of the user. Therefore, distinguishing between the macro-context and the micro-context of TEL is important.

Context

In order to gather data about users' information and communication needs and to serve these needs better, determining the context is important. "Context" itself is a contested term and defined differently in fields such as AI, software agents, HCI, ubiquitous computing, and others (an overview in Schmidt, 2002). For this research, the following term is adopted: context as "any information that can be used to characterise the situation of entities" (Dey, 2001) and use the common differentiation between (a) environment (e.g. location, time, weather, other properties of the physical environment or computational infrastructure), (e.g. Lieberman & Selker, 2000), and (b) persistent or transient properties of the user (trait and state variables) such as the social environment, preferences, or task (e.g. Wahlster & Kobsa, 1998; Lieberman & Selker, 2000).

Dey's (2001) definition in particular illustrates that a wide range of things may count as context, a point that has been confirmed by other authors (e.g. Schmidt, 2002). What effectively counts as context will always depend on the domain and the analysis question. For example, while fine-grained geographical coordinates are relevant for location-based services such as restaurant finders (and retrievable with current ubiquitous-computing technology), however, such information is irrelevant for most uses of learning resource repositories in contrast to the more coarse-grained information on the country/region, which

may give important clues regarding the regional or national curriculum alignment that a user (e.g. teacher) is likely to be interested in. Thus, separating the (a) environment and (b) persistent or transient properties allows studying the use of cross-boundary content which means that the user and the content come from different countries (i.e. environment), and/or that the content is in a language other than the user's mother tongue (i.e. persistent or transient properties).

Macro-context in Technology Enhanced Learning

TEL and the analysis of the data it generates take place in different types of educational settings which are called macro-context. It generally has significant influence on what user actions are possible and how they can be interpreted. An overview of main dimensions of macro-context such as educational level, formal and informal learning, delivery setting and different user roles is given to exemplify these dimension, the list is not exhaustive.

Examples of the educational level are K-12 education, Higher Education (HE), Vocational Education and Training (VET) and workplace training. A formal setting for learning includes learning offers from educational institutions (e.g. universities, schools) within a curriculum or syllabus framework, and is characterised as highly structured, leading to a specific accreditation and involving domain experts to guarantee quality. This traditionally occurs in teacher-directed environments with person-to-person interactions, in a live and synchronous manner.

An informal setting, on the other hand, is described in the literature as a learning phase of so-called lifelong learners who are not participating in any formal learning and are responsible for their own learning pace and path (Colley, Hodkinson & Malcom, 2002; Longworth, 2003). The learning process depends to a large extent on individual preferences or choices and is often self-directed (Brockett & Hiemstra, 1991). The resources for informal learning might come from sources such as expert communities, work context, training or even friends might offer an opportunity for an informal competence development.

The TEL involvement can be characterised by the provision of blended learning opportunities to purely distant educational ones (Moore, 2003). Blended learning combines traditional face-to-face learning with computer-supported learning (Graham, 2005). Distance education, on the other hand, can be delivered using TEL environments in either synchronous or asynchronous ways. Traditionally, distance learning was more related to self-paced learning and learning-materials interactions that typically occurred in an asynchronous way (Graham, 2005). However, live streaming and virtual, personal learning environments (e.g. Web 2.0) have facilitated the development of synchronous distance learning services in formal educational settings.

Lastly, different actors and needs can be identified in TEL. A distinction can be made between the teacher-directed interaction and learner-directed learning processes. This has ramifications concerning the intended users of TEL environments. This thesis, for example, considers teachers as main users of the system.

While macro-context has large implications for interpretation and design, its aspects are fairly agreed-upon, and it is comparatively easy to measure. Micro-context is a more contested notion and more difficult to measure. However, while macro-context is domain-specific, concepts for micro-context range over more diverse fields.

Micro-context: usage and user attention at the intersection of digital repositories and social tagging

The term micro-context is used to denote the context that is relevant for interpreting a specific user input (e.g. a search term) and for designing adequate system responses and other system output. Micro-context may be provided by the activities themselves, the user (model), or further background knowledge, often referring to the material. In each case, the question arises how to measure these variables. Answers through exemplary studies are illustrated. This extends a previous comparison of converging context representations in knowledge discovery/web mining, user modelling and TEL (Berendt, 2007).

For many types of (meta)data available in electronic environments, it is rather straightforward to determine whether they relate to activity, user, or material. Tags are an interesting exception: At first sight, a tag may be thought of as just another feature of the material. However, this view ignores the essential role of the user in tagging. Tags and the resulting networks (folksonomies) are commonly modelled as tri-partite hypergraphs, e.g. (e.g. Marlow et al., 2006; Cattuto et al., 2007). This means that they are formed by a triple of (user,item,tag). For analyses, this ternary relational structure is often projected to a lower-dimensional space. This gives rise to a (item,tag) relation that allows tags to be part of the material as context. By looking at the (user,tag) relation, one obtains tags as part of user models – which may for example be leveraged to infer preferred language(s) of the user. Additionally, an investigation of the (user,item) relation can give important clues to the user's content preferences. The full relational structure emphasises that tags may also be regarded as a parameter of the interaction between a user and an item.

INTERACTION AS CONTEXT – PARAMETERS OF INTERACTION FOR MEASURING CONTEXT

This view of context regards a user action that is an interaction with a material as an atomic unit of analysis (such as clicking a hyperlink, giving an answer in a multiple-choice question, or downloading a document). This action is associated

with certain parameters/metadata: date and time including access time and dwell time; action type such as download, insertion, viewing; query terms; IP address; operating system, browser and further technical characteristics of hardware and software; the application or tool used including its name, URI, type such as LOR or LMS (e.g. Najjar, Wolpers & Duval, 2006; Brooks & McCalla, 2006). These are called “implicit interest indicators” because they are collected non-reactively (Claypool, Le, Wased & Brown, 2001).

In contrast, “explicit interest indicators” are derived from users (more) consciously expressing their interest in resources. Explicit interest indicators include tags, ratings, and bookmarks. They can give rise to metadata describing the user’s/learner’s perspective on the LO including feedback on the content or knowledge of the content. Both implicit and explicit interest indicators can be regarded as atomic, or in the context of a complex activity such as a session or search episode (which may be a sequence of atomic interest indicators with different values). First, the atomic versions are described and subsequently their use in activity structures.

Atomic implicit interest indicators

Attention metadata in the TEL context for enriching the metadata regarding learning resources in LOR and LMS are studied in Najjar, Wolpers & Duval, (2006). The idea is to capture the attention metadata about the user's actions across system boundaries to enable better targeted personalisation of learning services (e.g. Recommender systems). The authors propose a Contextual Attention Metadata framework that is based on the exchange of information using an extended version of AttentionXML.

Wolpers et al. (2007) complement the concept of tracking user’s attention (e.g. when, how long, in what sequence has this taken place) across applications that are used regularly in TEL (e.g. Office Suite, Web Browsers, Mail Clients). The authors suggest that contextualised attention metadata schema enables the correlation of the observations, thus reflecting the relationships that exist between the user, her context and the content she works with better. This type of concept seems important especially for informal learning, where learning rarely takes place using institutionalised learning platforms or learning management systems. Khoo et al. (2008) investigated the use of session length (derived from the times of the session’s clicks) as a metric for digital-library site performance. They report that this metric can be very misleading in the context of digital libraries (as opposed to e-commerce), as the relationship between session length and web site quality is a contextual relationship; for some sites, short sessions might be indicators of quality; while for other sites long sessions might be indicators of quality.

Atomic explicit interest indicators, in particular tags

Cattuto et al. (2007) found that folksonomies are highly connected and that the relative path lengths are small, which facilitates the “serendipitous discovery” of new content and other users. Tags have therefore become popular as clear-cut indicators of interest and a basis for recommendation. For example, Santos-

Neto, Ripeanu & Iamnitchi (2007) track user attention in collaborative tagging communities for academic papers in order to harness usage patterns to improve navigability in a growing knowledge space. They find a clear segmentation of interests into a significant number of small sub-communities of interests that are totally separated from each other and further suggest methods for building efficient, online recommendation systems for tagging communities.

Activity structure

Actions generally do not take place in isolation, but in sequences or parallel threads. When previous or parallel other actions provide information for interpreting an action A, we say that the activity structure provides context (for A). Implicit relevance feedback provided by click data on a university document search system was studied in Jung, Herlocker & Webster (2007). They found that considering all the click data in a search session as relevance feedback can increase both precision and recall, however, for high precision, focusing on last visited documents could be more useful.

Santos-Neto, Condon, Nazareno & Ripeanu (2009) focused on individual and social behaviour in tagging systems. They show that individual need for organising content is a stronger motivation for tagging than collaboration with others to categorise the content. They also found low reuse of previously tagged items that leads to sparse datasets. However, they conjecture that the lower segmentation of tag-based interest sharing allows for content discovery, thus leveraging pair-wise tag-item comparison rather than user-item. Similar findings will be reported in Chapter 6 and Chapter 7.

THE USER AS CONTEXT – USER MODELS FOR RECORDING CONTEXT

As argued in the previous Section, tags and other explicit interest indicators can give much information about a current action, and their reuse can be part of models of activity structure. Aggregations over tags created by one user in different activities may also give more “persistent” information about that user. Au Yeung, Gibbins & Shadbolt (2008) and Michlmayr & Cayzer (2007) studied how user modelling can take advantage of personal tags and tagging data in general. Au Yeung, Gibbins & Shadbolt (2008) conclude that the majority of users of tagging systems posses multiple interests and propose a way to reflect that in user profiles. Michlmayr & Cayzer (2007) base their user model on tagging behaviour for the reason that it can adapt over time.

Country and language

Country and language may be operationalised in different ways depending on the domain and the analysis questions. Country of birth and mother tongue are essentially persistent user traits, whereas the country a user works in as well as preferred languages may be persistent or transient traits. Moreover, the country in which the user (e.g. teacher) works can be used to infer certain features of the resource (e.g. how well it could be used in a new context, alignment with national curriculum). This is also illustrated in Chapters 3 and 4.

Knowing whether the user accesses information in a first or in a second language – irrespective of the language itself – leads to an operationalisation of language as a variable depending on the relation between user and material. As shown in Chapter 3, this can be given by self-profiling information or these variables may also be inferred from the automatically measured log file variable IP address as shown in Berendt & Kralisch (2009). In that study, the variable was used for an investigation of the effects of language on usage behaviour and attitudes towards a content portal. Further possible clues are the browser settings (self-profiling); the language of the currently used interface where the service is available in different languages; and the language of search terms and tags (user input). For the latter, however, recognising the language is a challenge, as usually only one or a few terms are used. A language classifier taking advantage of dictionaries can be used to predict the likely language of a user's input. Additionally, information given by using the other above mentioned methods have been investigated in Chapter 4.

BACKGROUND KNOWLEDGE, ESPECIALLY RELATED TO THE MATERIAL, AS CONTEXT

Background knowledge is pre-existing knowledge about materials, users, etc. An example in TEL is the use of Semantic Web techniques for interpreting an action by Brooks & McCalla (2006). They formulate cognitive-behavioural models in RDF, combine a domain ontology (of the topic domain to be learned) and an educational objectives ontology. The Semantic Web architecture allows a flexible association of data on usage with such background models of a learner's behaviour and competencies. Standard, expert-provided background knowledge may also be enriched by tagging. In Chapter 6 tags are studied for the purpose of enriching existing metadata of educational resources in a multilingual context.

Summary

This Chapter positioned the thesis work in the converging area of TEL and digital learning resource repositories, digital libraries and social tagging systems. It introduced the micro and macro contexts, and outlined their importance for further research in the field.

Chapter 3

Evidence of cross-boundary use and reuse of learning resources

Chapter is based on Vuorikari, R. & Koper, R. (2009b). Evidence of cross-boundary use and reuse of digital educational resources. *International Journal of Emerging Technologies in Learning*, *4*(4).

Abstract

In this study an investigation using log-files of teachers' Collections of educational resources in two different platforms was conducted. The goal was to find empirical evidence from the field that teachers use and reuse learning resources that are in a language other than their mother tongue and originate from different countries than they do, for this, the term cross-boundary use of learning resources is used. In both contexts behavioural evidence was found that cross-boundary use and reuse takes place, and it was shown that it correlates with the general use and reuse trends. Moreover, it was found that cross-boundary reuse, when compared to 20% of general reuse, was notably less (37% to 55% of it). The motivation to study cross-boundary use and reuse is to set a baseline for future studies, and to understand how it can be supported and enhanced in the future.

Introduction

Since the late 1990's, digital repositories for learning purposes have gained ground. Such repositories store "any digital resources that can be reused to support learning" (Wiley, 2002) and/or their respective metadata. Repositories have been set up on regional, national and international levels to offer content for teachers and learners from K-12 to tertiary and vocational education (Tzikopoulos, Manouselis & Vuorikari, 2007; McGreal, 2008). Sharing, using and reusing digital educational resources are the main drivers of the learning object economy (Campbell, 2003). Participants of the economy are educational institutions, digital libraries and learning object repositories (LOR) and their policy makers, managers, content providers, educators and learners, each with their own needs, requirements and agendas.

This paper focuses on the use and reuse of educational resources when it happens across language and country borders, e.g., between users and communities that do not share the same mother tongue and/or the same country. This is called cross-boundary use of educational resources and it means that the user and the content come from different countries, and/or that the content is in a language other than the user's mother tongue.

The evidence finding focuses on teachers in K-12 education in a European multilingual context where 497 million people live with diverse linguistic backgrounds. Multilinguality can be defined as a situation where several languages are spoken within a certain geographical area, as well as the ability of a person to master multiple languages. Multilinguality has an important role in the European Union (EU); there are 23 official EU languages, three alphabets, and some 60 other languages are used commonly (COM, 2008). 56% of EU citizens say that they are able to hold a conversation in one language apart from their mother tongue, and 28% in at least two languages. English remains the most widely spoken foreign language throughout Europe (38%), second and third place are French (14%) and German (14%), whereas 6% have foreign language expertise in Spanish and Russian, respectively. Over two-thirds say that they learned foreign languages at school (COM, 2006).

This paper starts by identifying how much cross-boundary use and reuse currently take place in order to have a proper baseline for future studies. Moreover, the interest is to better understand what variables affect on the eventual probability of discovery, and the use and reuse of cross-boundary resources. First, the related work is introduced. Then, the research method, data collection and analyses procedures are described, after which the results are outlined. Following that, the outcomes and their implications for future studies are discussed from the perspective to enhance the discovery and eventual use and reuse of cross-boundary educational content.

Related work

A number of studies has focused on the use and reuse of digital educational resources in different settings from blended learning in a classroom to fully functional distance education at the university level and even in military (e.g., McCormick, Scrimshaw, Li & Carmel 2004; Strijker, 2004; Harley, Henke & Nasatir, 2006; Petrides et al., 2008). In some cases learning resources are used to complement social interaction in learning contexts, whereas in other settings they can be used to imitate or replace social interactions, as can be observed in Technology Enhanced Learning in general (Dillenbourg, 2008). The adoption and use of digital resources vary between different educational settings in a way such that each have their specific requirements; unlike the university sector, standardised local or national curricula are common in schools and colleges which can affect how educators view the reuse (Littlejohn & Broumley, 2003). Additionally, informal learning communities have their specific requirements, too (Brockett & Hiemstra, 1991).

The use and reuse of learning resources can be interpreted as the result of the success of a chain of consecutive events where each event needs to succeed for the use or reuse to take place (Weitl, Kammerl & Göstl, 2004; Ochoa, 2008). In learning object repositories (LOR), these are related to the lifecycle of Learning Objects, the main steps of which are obtaining, labelling, offering, selecting, using and retaining (Collis & Strijker, 2004). Depending on the context the steps differ, however, the important ones are the discovery of the resource, evaluating its usefulness for the given context, accessing it, and adapting and integrating it into a new context.

Koper (2003) defines three levels of reuse of learning resources: the creator of the resource reuses it (first level), the user reuses a resource created by someone else within the same community (second level) and the third level of reuse when the resource reused is created by someone else from outside of the user's community. Ochoa (2008) conducted a quantitative analysis of learning object reuse and observes that the reuse is around 20% across resources of different granularity of content. The following criteria of reuse is applied: "considered reuse if a component is present in more than one slide, if a module is used in more than one collection, or if a course is mandatory in more than

one curriculum" [Ochoa, 2008, p.66]. Duncan (2009) also studied reuse of learning resources in a repository, where a similar finding was reported.

Berendt & Kralish (2009) studied the availability of content on the Internet and how this content is accessed in users' first and second languages. The results indicate that non-English languages are under-represented on the Web and that this is partly due to content-creation, link-setting and users' link-following behaviour. Thus, making educational content available in the users' mother tongue has been the goal of institutionalised learning resource repositories that have been set up by national or regional educational authorities in Europe (EdReNe, 2008). Main efforts also include the labelling of educational resources for indexing and search purposes by using standardised metadata (e.g., LOM, 2002) and Application Profiles with multilingual vocabularies and thesauri (LRE, 2002). Despite these efforts, in a context of crossing national, cultural and language boundaries, locating suitable content has proven challenging (Colin & Massart, 2006), as the gap between the end-user and expert vocabularies remains wide (McCormick et al., 2004, p. 53).

Turning the emphasis away from technical issues, Petrides et al. (2008) studied the reuse behaviours of open educational resources and found that language translations represent only 1% of cases (p.110). Seen from this light, Littlejohn's question (2003, p.5) "Is global sharing of resources a possibility?" seems relevant. The challenges' list is long: problems not only within disciplines that "differ in their languages, in their methods of enquiry and in their social and cultural organisation (Becher & Trowler, 1989)", but also at a transnational level, where "cultural and language differences add a further complexity to the idea of resource sharing", e.g. the concern of the fit to the local curriculum (McCormick et al., 2004, p. 93); diverse models of teaching and related cultural expectations, as well as types of tasks for which learning resources are used (Margaryan, Currier, Littlejohn & Nicol, 2007).

It has been suggested that studying sharing and the reuse cannot only include the dimensions of the repository and individuals, but other dimensions influence on users' decisions. These can depend on issues such as the subject discipline, who contributes to the repository, its reward and incentive schemes as well as pedagogical approaches (Littlejohn & Margaryan, 2006). Towards this direction, Community key dimensions framework has been introduced which include dimensions such as "community purpose", "dialogue", and "composition" (Margaryan, Currier, Littlejohn & Nicol, 2007). Emphasising the importance of the community around the reuse of learning resources, Duncan (2009), in a study on reuse of learning resources, reported that when there was at least one person in common with both the module (i.e. learning resource) and the collection, the modules were included in collections 3.67 times more often. Similar preferential behaviour is found in other areas, for example Cohen, Frazzini & Malloy (2008) report on American fund managers investing more money in firms run by people who were known via shared education networks.

Method

For this study, two learning resource platforms were selected. Table 3.1 presents the datasets for Calibrate (2008) and LeMill (2009). The Calibrate portal (currently known as Learning Resource Exchange for Schools) represents institutional context, it federates content from a number of European Schoolnet (2009) partners, whereas in LeMill, teachers create resources in a community-driven context. The systems and their tagging tools have been described in Vuorikari, Põldoja & Koper (2010), found in Chapter 7.

In this study, bookmarks and users' Collections of learning resources are considered as a proxy for the use and reuse of resources. Claypool et al. (2001) have identified implicit and explicit Interest indicators in the context of resource discovery on the Internet, they can be described as a way to create a digital handle to a resource so that it can be later retrieved again (e.g. bookmark, tag, addition to a Collection). Such digital handle was used to gather data for this study. Namely, log-files on teachers' bookmarks and Collections of educational resources were gathered from both platforms. They consisted of the following data: the user (user id, country of origin, languages spoken); the resource (resource id, title, URL and some other LOM metadata); and the Interest indicator (e.g. an id that indicated the content is part of a Collection or an id of the bookmark with tags).

Table 3.1. Data description of different sets.

	Calibrate lreforschools.eun.org	**LeMill lemil.net**
Users in the system	478	2000
Users in this study	142	188
Percentage of all users	30% of users in the system	10% of users in the system
Users in the study	Austria, Estonia, Hungary, Lithuania, Poland and Slovenia	Estonia, Lithuania, Hungary, Georgia, Finland, other
Resources in system	~11 000	~2000
Resources saved in Collections (general use)	1555	1645
Resources saved in more than one Collection (general, 2nd level reuse)	7% (19%)	22%
Distinct resources used out of all resources (coverage)	9%	70%
Average size of a Collection	9.9 resources	8.75 resources
Date of dataset	Dec-07	May-08

When a learning resource has an Interest indicator at least once, “General use” is considered, even if no further evidence is gathered about its use in teaching or learning. Similar measures were taken to study cross-boundary use. A classical example is represented in Figure 3.2, the resource with an Interest indicator originates from a different country than the user and is in different language than that of the user’s mother tongue.

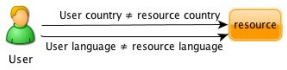

Figure 3.2. Cross-boundary resource.

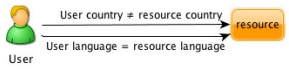

Figure 3.3. Cross-country, but not a cross-language resource, e.g. a German resource and an Austrian user.

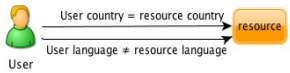

Figure 3.4. Cross-language, but not a cross-country resource, e.g. resource in English as a second language.

While processing the data other cross-boundary cases were found, namely that the resource with an Interest indicator is in a user’s mother tongue, but the user and resource come from different countries, e.g., Austria and Germany (Figure 3.3). Lastly, the user and the resource come from the same country, but the content is in a different language, for example in English (Figure 3.4), which was often the case for the content in LeMill. The prominence of English language in the reuse setting is discussed at a later point.

The reuse is considered taking place on different levels using the vocabulary from Koper (2003). The first level reuse by the creator of the resource is not considered in this study. The second level of reuse takes place within the repository, users of which are considered as a meta-community. When the resource is integrated in a new context with other components of the repository, and when this occurred more than once, this is considered “General reuse” or second level of reuse.

As the focus is on languages and national boundaries, they are also used to define communities. When the resource reused is created by someone else from outside of the user’s language or country-related community, it is considered the third level of reuse. For example, the following two cases can be identified for language related cross-boundary reuse:

a. A Finnish teacher with competences in English and French is not only part of the meta-community of the repository, but also part of the language-based sub-communities like Finnish, English and French. The reuse takes place on this level when she reuses resources in English or French.

b. A Finnish teacher who reuses a resource that is in a language outside of her language competencies (e.g., Hungarian), but still within the same disciplinary or pedagogical culture, is also considered the third level of reuse.

For each data set, a number of measures, which are presented in Table 3.2, are established and manually verified. The general use is counted by how many times the resource appears in Collections and then compared with the total number of resources in that given set. The reuse is counted using the number of times that the resource appeared in more than one Collection, and then compared with the total number of resources in that given set. This gives us a comparable figure to the reuse of about 20% as in Ochoa (2008). The same measures are used for cross-boundary usage.

Table 3.2. Metrics for the cross-boundary use and reuse of learning resources.

Name	Metric	Formula
General use	Number of resource integrated in a new context at least once	Number of resources in Collections at least once/ Number of all resources in the set
General cross-boundary use	Same as above, but using cross-boundary measures	Same as above, but using cross-boundary measures
General reuse (2nd level)	Number of resource integrated in a new context more than once	Number of resource in more than one Collection/ Number of all resources in the set
Cross-boundary reuse (3rd level)	Number of cross-boundary use integrated in a new context more than once	Same as "General reuse", but only for cross-boundary usage
Coverage	Degree to which the used/reused resources cover the entire set of items within a system	Distinct number resources used/reused - Total of distinct resources in the system

In addition to cross-boundary use, another metric was used. In the recommender system literature, Coverage measures the degree to which the recommendations cover the entire set of items (Mobasher, Dai, Luo & Nakagawa, 2001). In this context, Coverage measures the degree to which the used or reused resources cover the entire set of items within a system. It is calculated using the distinct number of resources used/reused (i.e. individual resources) and subtracting it from the total of distinct resources in the system.

Results on use and reuse across boundaries

RESULTS IN LEMILL

In LeMill, about 10% of all the users have used the Collection-feature which in this study is used as a proxy for defining the use and reuse of resources. Considering the metrics defined in Table 3.2, the general use in LeMill is 82% and the general reuse is 21% (Table 3.3). As for the cross-boundary usage: 29% of resources in the entire LeMill are used across boundaries, whereas the figure for the cross-boundary reuse is 12%. The latter amounts to about 5% of distinct resources in LeMill.

When the cross-boundary usage is studied, it is found that most of it (64%) takes place across language borders, i.e., resources have been produced in the

same country as the user, but are in another language (Figure 3.4). For example, 51% of cross-language content was used in English, but produced by non-native English speaker in the same country. The other major languages for cross-language use are Russian (21%) and Estonian (12%). The cross-boundary use both across languages and countries was 35% (Figure 3.2).

Table 3.3. Use and reuse in LeMill.

LeMill ~2000 resources	General		Cross-boundary	
Users with Collections	188	9%	129	6%
General use	1645	82%	582	29%
General reuse	440	22%	247	12%
Coverage (used resources)		69%		21%

Use and reuse: different granularity and different languages

In LeMill, it was possible to look how users used and reused resources of different types in English and in other available languages. Table 3.4 presents the different types of resources in LeMill, the percentages of general and cross-boundary reuse. MultimediaMaterial was the most reused, especially across-boundaries (48%), where 56% was reused in English. 25% of cross-boundary reuse was reported in “LeMillReferences”, 47% of them in English. Interestingly, “ExerciseMaterial” was reused more evenly across languages. When it comes to reuse in LeMill, it can be observed that it is not distributed evenly across different content types, but that MultimediaMaterial is by far more reused than other types.

Table 3.4. Cross-boundary reuse of resources in LeMill. ISO 639-1 language codes are used for languages.

N=582 resources	Gene-ral reuse	Cross-boun-dary reuse	en	et	ru	se	hu	de	sp
Multimedia Material	41%	48%	155	40	37	35	4	4	1
LeMill Reference	17%	25%	63	-	49	-	-	13	7
Exercise Material	12.5%	13%	35	19	18	-	1	1	-
Presentation Material	9%	7%	41	2	16	-	-	-	-
Piece - other	20%	3%	19	-	-	-	3	-	-

When it comes to cross-boundary use and reuse, it is shown that 35% of the time when a resource was used in a Collection, it takes place across boundaries. Again, MultimediaMaterial was by far more used (17%) and reused

(8%) than other types of resources, and in this case the material was mostly in English.

RESULTS IN CALIBRATE

In Calibrate, 30% of all users have used the Collections-feature that is used as a proxy for use and reuse (Table 3.5). 14% of general use is found across all 4,000 learning resources (*) and 7,000 assets (i.e. resources with lower level granularity such as individual photos). The general reuse figure is 7%. The cross-boundary use and reuse follows very closely the general use and reuse. It can thus be observed that use and/or reuse in Calibrate, takes place mostly across language and country borders.

Table 3.5. Resources use and reuse in Calibrate.

Calibrate 11000 (4000 resources*)	**General**		**Cross-boundary**	
Users with Collections	142	30%	138	29%
General use	1555	14% (34*) %	1503	14%
General reuse	784	7% (19*) %	738	7%
Coverage (used resources)		9%		9%

A manual verification of URLs to infer the file format was performed to better understand the type and granularity of the resource. This selection method gave returns of 60% of the total resources. 13% of the URLs indicated file formats such as images, videos and flash files, which usually cannot be disaggregated to smaller granularity. 87% were file format like .htm, .php, zip-files, .pdf, .exe from which it can be inferred that these are more likely aggregated learning resources (Table 3.6). As for the reused resources, it was found that 95% of analysed URLs represented the latter category. Based on this data, an assumption was made that most reused resources exclude small granularity resources, as Table 3.6 suggests. Thus, the general reuse for Calibrate can be calculated to be 18.6%(*). This result, again, very clearly indicates that resources of different granularity were reused differently.

Table 3.6. Granularity of resources used in Calibrate

	Used resources (n=980)	**General use from n=980**	**Reused resources (n=172)**	**General reuse from n=172**
Small granularity	126	13%	9	5%
Learning resource	854	87%	163	95%

Use of content originating from a country other than that of a user

Table 3.7 displays the used and reused resources: users who originate from different pilot countries are enumerated in the left column, whereas the top row indicates the country of origin of the resource.

The table shows that for example Estonians have used 13% resources originating from Estonia, 25% originating from top domains in .eu, 3% resources from Finland, 7% from Poland, etc. In general, users from all pilot countries used resources from almost all other countries. Moreover, it can be observed that resources from some countries were more popular (in **bold**) amongst pilot countries. For example, Hungarians, Polish and Slovenians used Estonian resources more often than average. Notably, there was very little use of resources originating from the same country as the user.

Table 3.7. Resources used and reused across country borders in Calibrate (n=1496). Top row indicates the country or region of resources, whereas the left row the origin of the pilot participants.

⇓Pilot country	De	Et	.eu	Fi	Hu	No	Pl	Si	UK	US	Other
Austria	4%	10%	**19%**	10%	7%	-	**8%**	7%	**9%**	10%	14%
Estonia	-	13%	**25%**	3%	-	-	7%	**18%**	6%	10%	**18%**
Hungary	7%	**16%**	14%	**7%**	4%	**5%**	7%	**12%**	5%	8%	15%
Lithuania	-	10%	**19%**	4%	3%	**6%**	**8%**	9%	**9%**	**11%**	14%
Poland	6%	**16%**	11%	3%	**17%**	4%	5%	10%	6%	5%	16%
Slovenia	**10%**	**16%**	18%	4%	7%	2%	6%	7%	2%	8%	**17%**
Mean by country (9%)	*7%*	*14%*	*18%*	*5%*	*9%*	*4%*	*7%*	*11%*	*6%*	*9%*	*16%*

This demonstrates that teachers from the pilot countries have shown interest in resources that originate from a different curriculum context than their own. The resources originating from ".eu" were the most used across the pilot countries; these resources usually originate from the EU-institutions (usually using the domain name ".eu") and are made available in multiple European languages. The content originating from the UK, USA and in the category of "other" was mostly in English.

GENERAL USE AND REUSE VS. CROSS-BORDER USE AND REUSE

The use and reuse have now been studied among the general level (2nd level), and to what extent does it take place across language and country boundaries (3rd level). As LeMill and Calibrate datasets and user-base are similar, the correlation between the second level and third level of use and reuse of resources was calculated by using the measures in Table 3.2. The Pearson R correlation between the use and reuse on the second level and the use and reuse on the 3rd level was performed. A strong and significant positive correlation $r = .928$ was observed ($p<0.01$).

Discussion and future work

Two different sources of educational content coming from different contexts and authoring backgrounds were studied; Calibrate with institutional content and LeMill with teacher-generated content. Despite the social, cultural and technical barriers that were reviewed in the Related work-Section, evidence was found that the use and reuse of educational resources take place across language and country boundaries (i.e. 3rd level of reuse).

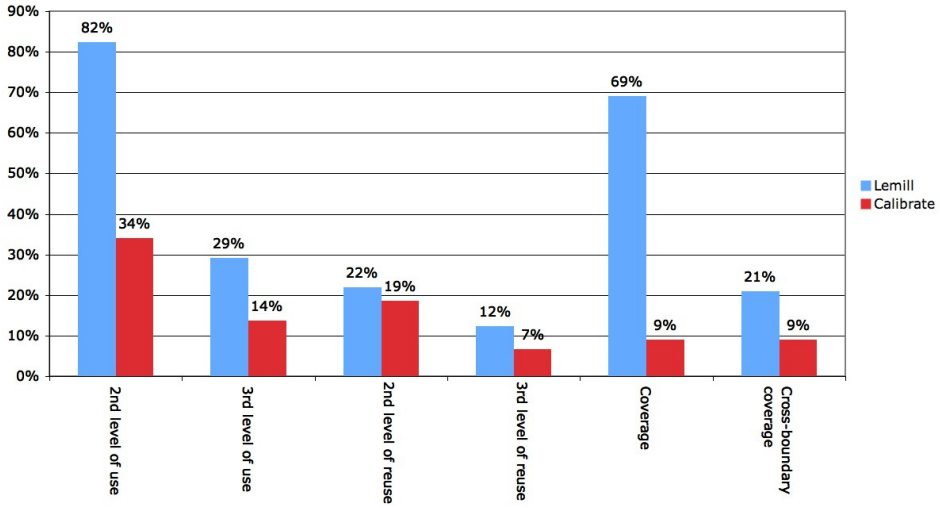

Figure 3.5. Use and reuse of resources (2nd level) vs. Cross-boundary use and reuse (3rd level)

In LeMill, where the content is created by teachers, it was found that the users create and share material both within the language communities and across them, indicating that the purpose of the platform fits and supports the typical activities that the meta-community carries out in order to achieve its goals. When the cross-boundary use is studied, it was found that most of it takes place across languages, e.g. content is produced in English by a non-native speaker in the same country where the use takes place (Figure 3.4). A similar situation is becoming more common especially in Europe, where educational institutions and individuals who aim at attracting a wider cross-boundary audience for their content, make resources available in widely spoken foreign languages. The Calibrate portal, on the other hand, operates in an institutional context where the focus is not on the creation of material, but on the discovery and eventual use and reuse. The observed use of resources was generally less than in LeMill (Figure 3.5, the bars depicting the 2nd level of use), however, in Calibrate, the use of resources within boundaries (2nd level) and across them (3rd level) was rather similar (Table 3.5).

The statement that in common settings, the amount of learning resources reuse is around 20% across collections of different granularity (Ochoa, 2008) was

tested. The second level of reuse in LeMill (22%) follows the general trend, however, the reuse is not evenly distributed across the different types. In Calibrate, the second level of reuse when looked across all the items was well below the baseline (7%). Excluding the small granularity content in Calibrate (the data from Table 3.4), the reuse at 19% was observed. This finding also hints that not all the content with different granularities is equally reused. The figures for the cross-boundary (i.e. 3rd level) reuse are 12% in LeMill and 7% in Calibrate. The cross-boundary reuse is 55% to 37% of the general reuse (respectively).

Additionally, to better understand the extent to which the resources are used, the metric of Coverage was used. The Coverage in LeMill is 69%, whereas in Calibrate this is low, 9% of all items. Regarding the cross-boundary coverage, the figures are 21% and 9% respectively. The “inconvenient truth” reveals that the coverage is rather low and better ways to support both 2nd and 3rd level reuse should be created.

Literatures in the Related work-Section suggests that the use and reuse of resources cannot be solely studied by looking at the figures from behavioural data, as those are not an indicator of attitudes and preferences. Berendt & Kralish (2009) caution against drawing too simplistic conclusions based on behaviour alone: in the absence of links and/or content in their native languages, users will acquiesce to English-language content, however, their preference will persist. In user-group sessions (documented in Zens, 2009) many of the barriers discussed in the Related work-section have re-emerged, however, many positive usages of cross-boundary resources have been observed. Supporting such behaviour, the sessions highlighted that sharing cross-boundary resources alone is not sufficient, but sharing usage scenarios and stories along with the resource is important for teachers.

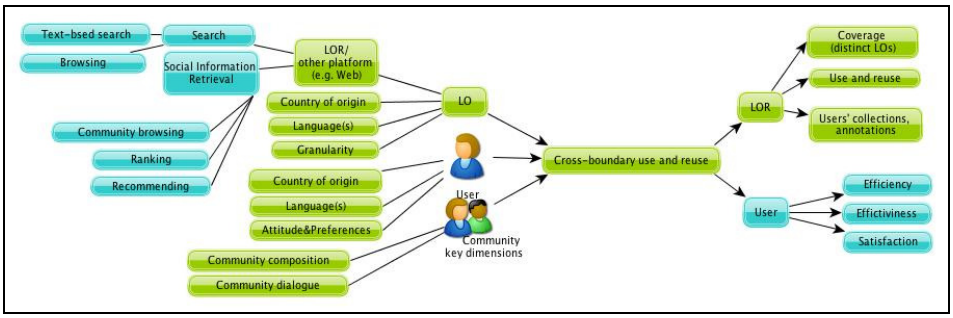

Figure 3.6. A number of variables in cross-boundary use and reuse setting. The ones in green have been the focus of this study.

Using Community key dimensions framework (Margaryan et al., 2007) and supporting elements such as ”dialogue”, i.e. different modes of participation and communication, for example through tagging, evaluations of resources and usage scenarios can thus offer ways to engage in more use and reuse on both levels, a field that offers interesting future studies. Additionally, future

implementations and studies focusing on how different types of sub-communities ("composition") can support the use and reuse on different levels should offer interesting insights also for the cross-boundary discovery of resources and their eventual use. Such sub-communities could be based on disciplines, spoken languages, user-behaviour (downloads, bookmarks, tags and ratings), to mention but a few (Figure 3.6). Such features emphasise the social aspect of resource sharing, which to a certain point, has been confirmed in Duncan's (2009) study where people who knew one another were more likely to share and reuse resources from one another. These dimensions could also help establishing not only more non-English content on the Web, but also enhance creating new ways for users' link-following behaviour.

Establishing better metrics for cross-boundary use and reuse of learning resources is needed to allow a better quantitative and periodical measuring of the cross-boundary actions. This is a logical extension of already existing Learnometrics (Ochoa, 2008), Web metrics for digital libraries (Khoo et al., 2008) and metrics evaluating tagging behaviour in social bookmarking systems (Farooq et al., 2007). Having established a baseline for cross-boundary use and reuse in this study can be considered as a contribution towards such metrics, as well as the work in Vuorikari & Ochoa, 2009 where metrics were proposed for tagging in a multilingual context (i.e. Chapter 4).

Lastly, as a limitation of this study it can be pointed out that using Interest indicators as a proxy for the use and reuse of learning resources can be misleading, as there is no further evidence on their use in teaching related activities. The real figure of cross-boundary reuse can be bigger (or smaller).

Conclusion

An investigation using log-files and social bookmarks on teachers' Collections of educational resources as a proxy for use and reuse of resources was conducted. The goal was to find out how much cross-boundary use and reuse currently take place by comparing the origin and languages of the user to the origin and languages of the learning resources. The motivation for setting a baseline for such use and reuse is to better understand how it could be supported and enhanced in the future.

In both sources behavioural evidence was found that cross-boundary use and reuse takes place and that it correlates with the general use and reuse trends. The cross-boundary reuse within a platform (third level of reuse), when compared to 20% of general reuse, was notably less (37% to 55% of it). Following the idea that improving even one of the steps in the reuse chain would improve the probability of reuse and therefore, the amount of reuse within the platform, it can be suggested that better ways to support and enhance cross-boundary use should be the focus of future studies.

Chapter 4

Exploratory analysis of the main characteristics of tags and tagging of educational resources in a multilingual context

Chapter is based on Vuorikari, R. & Ochoa, X. (2009). Exploratory Analysis of the Main Characteristics of Tags and Tagging of Educational Resources in a Multi-lingual Context. In *Journal of Digital Information, 10*(2).

Abstract

Although social, collaborative classification through tagging has been the focus of recent research, the effect of multilinguality is often overlooked. This work presents an exploratory study of the production and use of tags in multiple languages in a context of European Learning Resources Exchange. First, a tagging tool used by teachers from 6 countries is described, and the main characteristics of tags and how users tag when multiple languages are presented are studied. Early indication is found that tags and bookmarks could be used to facilitate the discovery of educational resources across country and language borders. “Hiding all but the right tags” becomes crucial for the success of a multilingual collaborative tagging system.

Introduction

The use of social, collaborative classification systems has grown dramatically in recent years. An example of this is a multitude of sites that provide some type of social annotation of digital artefacts and social navigation system (Flickr, del.icio.us, CiteULike, Last.fm, among others). Social tagging, i.e. allowing individuals to apply free text keywords to digital objects, potentially offers advantages in terms of personal knowledge management, serendipitous access to objects through tags, and enhanced possibilities to share content with emerging social networks among other users. In the core of the tagging system, there are the implicit and/or explicit relationships between resources through the users that tag them; similarly, users are connected by the resources they bookmark and tag (Marlow et al., 2006).

Several studies have been undertaken to better understand the behaviour and evolution of social tagging systems. Early research conducted by Mathes (2004) coined the term “folksonomy” to be used for the emerging socially generated vocabulary that he compared with more formal ontologies. Golder & Huberman (2006) first looked at user patterns of collaborative tagging systems. Recent studies also focus on understanding the network properties (Catutto et al., 2007).

A prevailing aspect among current studies concerning tagging is that it is assumed that tags are represented in a common language (Hammond, Hannay, Lund & Scott, 2005) which is understandable by all the members of the user community. Guy & Tonkin (2006) suggest that this is not always the case; they found that the bulk of tags in their study was valid English. However, tags from other languages were present in small numbers. They acknowledge that gauging the source language of tags is challenging due to technical issues as well as linguistics (e.g. many words exist in multiple languages with a differing meaning or a different grammatical structure). The most difficult aspect outlined in that study was "malformed" tags, which put the tags beyond the grasp of a multilingual spell-checker. Lately, multilingual tags have started to emerge on popular social tagging systems as their user base grows at the international level. Roughly, two different ways to process multiple languages can be observed: by users and by “system”.

Examples of how users deal with multiple languages include Flickr or del.icio.us where users share the same system and use multiple languages to tag. Tags are added in different languages (e.g. “achat”, “shopping”), and, even on some occasions, a tag identifying the source language has been added (e.g. lang:fi). This is very marginal, though, less than 18,000 such tags were applied in del.icio.us (accessed in July 2008) that has more than 10,000000 tags. There is no system level support that allows users to see tags, say, only in French or Finnish. In LibraryThing (2009), which has launched different language versions of the service, experienced users can also combine tags under one tag. On some occasions, tags in different languages have been grouped together. As for the community of Flickr, its tag base has become a source for cross-language retrieval studies by iCLEF (2008). On the other hand, approaches like Yahoo!'s MyWeb (2009) offer tags and tagclouds in different languages in localised parts of the portal (e.g. .fr, .es, ...), which indicates that there is some system level support for multiple languages. An outcome of this method of localisation is that users from different countries and language groups are kept separated from one another.

This work, still at its early stage, attempts to shed light on a community of users who use a common tagging system across country and language borders, but do not share a common language. One of the main questions is to study whether a tagging system, where users tag in multiple languages, still functions as one system, or is it split into separate communities of users based on their languages? This exploration takes place in the context of two European Community funded projects, Calibrate (2008) and MELT (2009), both focusing on sharing and reusing digital learning resources in primary and secondary education.

First, the phenomenon of tagging in multiple languages is studied from the system point of view, and then the users and their tagging behaviour in the multilingual context is studied. Second, a user study on how users perceive multilingual tags is presented. Following, the research questions are considered and the design requirements of a multilingual tagging system that helps bridge across languages and country barriers are elicited. Lastly, the future work and conclusions are outlined.

Research rationale

Marlow et al. (2006) present a conceptual model for social tagging system; tags are represented as typed edges connecting users and resources. Such a tagging system is studied where users from different pilot countries (Austria, Estonia, Hungary, Lithuania, Poland and Slovenia) assign tags to resources that they discover from a federation of learning repositories. The implicit relationships between resources through the users that tag them are of interest, similarly to the connection that users form through the resources they bookmark and tag. The basic unit of study in this paper thus consists of a (user,item, tag)

triple, which Farooq et al. (2007) call a “tag application” and Catutto et al. (2007) as a “post”. In this research, the both terms are used for the unit of study.

Definition of a Post / Tag application:
- *User*: A teacher bookmarks an educational resources on the portal
- *Resource*: An educational resource that exists in the federation and is described with metadata
- *Tag*: User-generated keyword, either a new one (distinct tag) or an already existing one (reuse)

The primary goal of the analysis is to explore the dataset to better understand the phenomenon of tagging in the context of multiple languages. There are two main research questions:
1) *What happens when users tag in multiple languages instead of one common language?*

Decomposing the question gives arise to sub-questions such as; Does the presence of multiple languages have any implication on the global growth of tags in a tagging system?; How do users behave in a tagging system where multiple languages are present, i.e. in what languages do users tag and how do they reuse tags?; How do users perceive multilingual tags?

2) *Can we find evidence that tagging and bookmarking through implicit connection between users, resources and tags, could be used to facilitate the cross-boundary use of learning resources?*

Regarding the second research question, early indicators are needed to understand whether the triple (item,user,tag) could be used to facilitate cross-boundary discovery and use of educational resources in a federation of educational repositories. The term cross-boundary discovery means that the user and the learning resource come from different countries, and/or that the learning resource is in a language other than the user’s mother tongue. Understanding the type of information multilingual tags can yield about the resources and their possible use in different contexts is important, on the other hand, the value of tags for resource discovery and as a navigational tool to enhance the discovery becomes crucial.

This analysis, which is based on log-file analyses of tags and tagging, is used as a requirements’ survey to better understand the user needs. For this purpose, a number of metrics from previous studies are used, notably those from Farooq et al. (2007). The same terminology is also applied: global tags (previously used by all users of the system), personal tags (previously used by the user) and paper-specific tags (previously used by all users of the system for the target paper), which hereafter is referred to as *resource-specific tags*. Additionally, the tag categorisation factual, subjective and personal tags from Sen et al. (2006) are used.

Finally, the methodology also includes a user study with 13 participants. Details of this study are discussed elsewhere in Vuorikari, Ochoa & Duval (2007). The aim is to gain a better understanding of how users react when they are confronted with tags in multiple languages, especially in those languages that they do not speak or have knowledge of. The results of this user study are useful to guide design decisions in the development of retrieval tools for learning resources in a multilingual environment.

SYSTEM SET-UP AND DATASET

Since November 2006, a group of pilot teachers in Austria, Estonia, Hungary, Lithuania, Poland and Slovenia had access to a learning resource portal which was made available within the Calibrate project. One of the main goals of the project was to facilitate the reuse of learning resources among primary and secondary schools in Europe and beyond. The Calibrate portal (hereafter referred to as portal) is connected to a federation of learning resource repositories (Colin & Massart, 2006). Approximately 4000 learning resources and nearly 7000 learning assets (e.g. images, sound) were provided by the Ministries of Education in Austria, Estonia, Hungary, Lithuania, Poland and Slovenia for pilot school teachers to use.

Figure 4.1. Viewable-tagging interface of the Calibrate portal. The user has found a resource "Comparison in action" and adds tags. She is shown all her personal tags, and additionally one resource-related tag from other users who tagged in English.

The pilot teachers were asked to use the portal from November 2006 to October 2007 to search for useful educational resources among those made available by the participating Ministries of Education. The pilot group was asked to use the available search modes such as browsing resources by topic category, as well as simple and advanced search options. They were asked to produce lesson plans in which they describe the learning resources and how they used them in their teaching. One of the tools to facilitate this work is called the

Favourites. It allows teachers to create personal collections of resources and assign tags to them in any desired language(s). The Favourites-tool creates a unique handle to a resource that is available through the portal, so that the user can easily retrieve it again.

The portal was made available in all the languages of the pilot (language choices seen on top right corner of Figure 4.1) and the tagging interface was always in the language that the user had selected. Figure 4.1 shows the Favourites-tool and its tagging interface in English. The user is about to add tags to a resource named “Comparison in action”. The personal tags of the user are displayed below the text field for tags with a number in parenthesis that indicates how many times it has already been applied. The user can choose a tag by clicking on it or by typing in a new one into the empty text box. When the user now adds a new tag while using the English interface, the tag will automatically be assigned “English” as metadata regarding its language. Tags are to be separated with the use of a comma, otherwise they appear as compound terms.

The tagging interface additionally supports viewable tagging whenever resource-specific tags are available in the language of the interface. In this case (Figure 4.1) the user is shown the tag “adjectives (1)” in English because the interface language is in English. No tags in any other languages are exposed, even if they exist. Additionally, users could add comments to the resource that they tag. These comments can be made public or kept private, but they are out of the scope of this study. At the beginning of the pilot the system had no tags attached to resources, thus users were left to invent their own tags. No incentives were given to users to add tags, other than the fact that the tags would help the user to retrieve these resources later.

Table 4.2. Data regarding the unit of study.

	Languages	Unique ID	Other metadata
User	x	x	Country, school, interested topics
Resource	x	x	LOM metadata such as LRE (2007).
Tag	x	x	Timestamp, ID of the related LO, ID of the user

Table 4.2 presents data that was used for this study. To conclude on the system set-up, it is worth noting that the Favourites bookmarking and tagging tool used in this pilot differs from some other well-known services on the Internet in terms of offering very little social features or support. The bookmarks were not shared among users (this was planned for future development), and users were not able to take advantage of navigational cues such as how many other users have bookmarked resources, tagclouds, etc.

Dataset and validity

A total of 478 users were registered to the portal during the time of the pilot. Only 142 of them, however, had made at least one post (there was no obligation to use the tagging tool). The dataset is comprised of the users who

made at least one post, which represents 30% of the pilot participants. It is out of the scope of this study to find out why the remaining 70% were not interested in the tagging tool. This study does not include any data on the use of tags for resources discovery.

Table 4.3. Description of the dataset.

Data from November 2006 to October 2007	Number
Active users/total number of users	142/478
Resources added to Favourites	682
Posts	1022
Distinct tags	832
Tags applied (reuse)	1282

The data for this analysis is from a period of twelve months, November 1 2006 to October 31 2007 (Table 4.3). However, a number of posts (16) before the initial start were recorded, and were kept as part of the dataset. The dataset is comprised of 1022 posts, covering 682 individual learning resources. There were 1031 individual, distinct tags, however, users had deleted some, resulting in 832 individual multilingual tags in the system. The deleted tags were also analysed to gain more insight into the tagging behaviour.

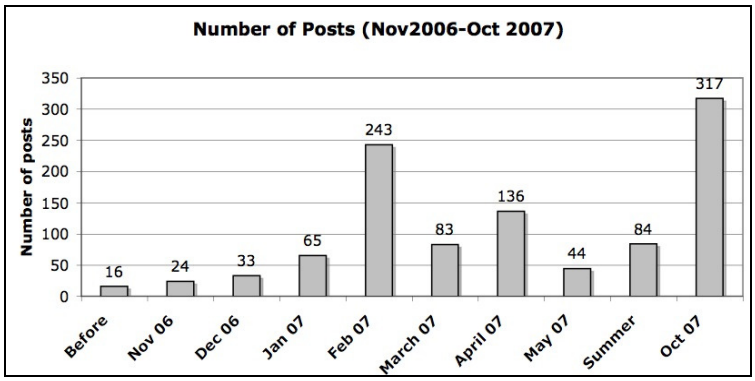

Figure 4.2. Number of posts per month in Calibrate.

The tags and the tagging behaviour of a pilot group of teachers are analysed. The implication of the data being gathered from a closed pilot, with a rather small sample size, is that the outcomes of this analysis cannot be generalised in a straightforward way to any web-based tagging system. The results will be valuable, however, to define better system design criteria for a tagging tool that should support the use of multiple languages.

Outcomes of the analysis

OBSERVATIONS ON THE TAGGING SYSTEM

To analyse the tags in the tagging system and to better understand the phenomenon, the general tagging activity is first analysed and then the tag growth and the tag reuse are studied both on the global and personal level.

General tagging activity and distribution of posts

The general tagging activity over time is presented in Figure 4.2. The low number of posts in the summer months can be explained by the holiday period, and more intense activity in February and October by users performing their pilot activities.

Figure 4.3 represents the distribution of posts per user (grey points). The graph is presented in logarithmic or log-log scale. As in some other systems (e.g. CiteULike), it is found that most posts were generated by a small group of "super users": the top users had 54 and 53 posts, respectively. On the average each user had 7.2 posts (median 3 posts per user). The wide distribution (dotted line) can be better illustrated by an inverse power law (an exponent of -0.78) with an exponential cut-off (with a rate of 0.062). This distribution suggests that highly productive users are very rare; nonetheless, they provide most of the tags in the system.

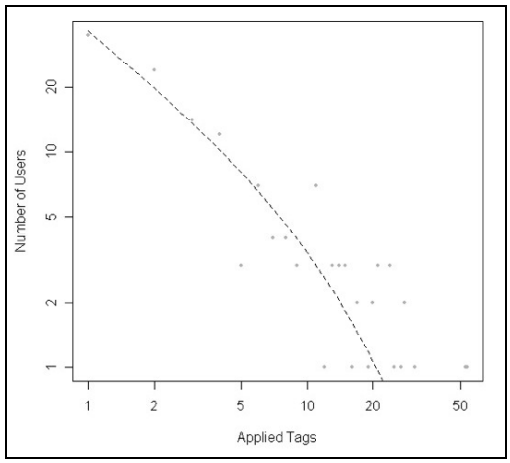

Figure 4.3. Distribution of posts in the Calibrate system.

Finally, the correlation between the number of individual resources and the number of tags that users had applied to them is 0.863, somewhat lower than that in CiteULike (0.944). Farooq et al. (2007) explain that in their case the strong linear relationship between the number of resources bookmarked and the number of tags for each user can explain that the system is still maturing and has not yet reached its relatively stable stage. It can be speculated that this is also the case on the portal. When the coverage of learning resources that

have tags applied to them on the portal is studied, only 6.2% of all the resources available through the federation have tags applied to them.

Tag growth and reuse

The Growth metric by Farooq et al. (2007) measures how the tags are evolving over time, at what rate the new ones are created and whether there are signs of the vocabulary stabilising. Creation of new tags in the system has closely followed the number of posts that the users have entered in the system (Figure 4.4).

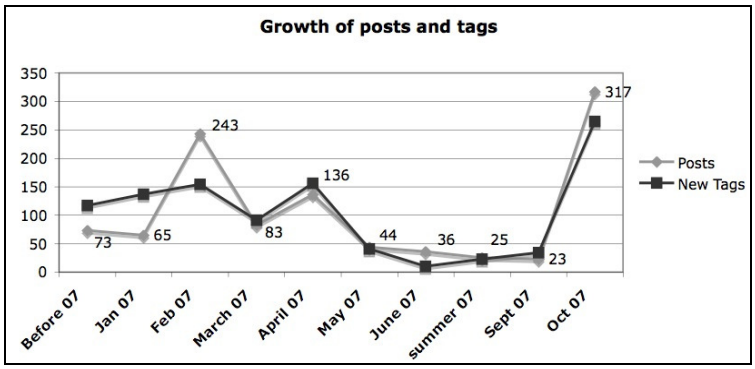

Figure 4.4. Growth in absolute numbers per month and reuse of tags.

Reuse relates to how tags are shared among users; whether tags converge over time or if users only reuse their own personal tags over and over again? The same metric was used both for personal and global tags in the system. The tag reuse was calculated using the following formula by Sen et al. (2006) for which their baseline was 1.10 users per tag.

$$\textit{Tag reuse} = \sum \textit{(\# of distinct users for each tag)} / \textit{\# of tags.}$$

The reuse of tags on the global level was very low, 1.22 users/tag. It was also rather low in CiteULike (1.59users/tag). Furthermore, the number of occurrences of tag reuse for each tag was calculated (number of posts per tag minus 1). The average (3.2) on the portal was even lower than that of CiteULike (3.9).

Table 4.4 lists the twenty most reused tags in the pilot. The tag name, its language, number of times reused and the number of users are given. Additionally, the category of tags is given, which will be explained later. Some of the tag reuse indicates common pilot activities (e.g., Table 4.4, Hungarian tags 1, 2, 3, 5). These were tags used to make a personal collection of good learning resources in foreign languages by a group of about ten teachers. Additionally, there are indications of rather unintentional sharing of a few tags among a few users (e.g. Table 4, tags 7 or 9).

Table 4.4. Most used tags, the language, number of applications, tag class and number of users. ISO 639-1 language codes are used for languages, as in all the tables hereafter.

	Tag	Lang of the tag	No of use	Category	No of distinct users
1.	külföldi jó (good foreign material)	hu	70	Subjective	10
2.	külföldi közepes (average foreign material)	hu	52	Subjective	10
3.	külföldi gyenge (weak for.mat)	hu	37	Subjective	11
4.	Angličtina (English)	cz	20	Factual, topic	3
5.	Értékeltek (evaluation)	hu	16	Subjective	2
6.	Literatura (literature)	cz, “travel well”	14	Factual, topic	2
7.	Matematika	cz, hu, “travel well”	13	Factual, topic	7
8.	Global problems	en	11	Factual	2
9.	Test	“travel well”	10	Factual, type	3
10.	Vesmír (space)	cz	7	Factual, topic	2
11.	fyzika (physics)	cz, “travel well”	7	Factual, topic	2
12.	chemie (chemistry)	cz, “travel well”	6	Factual, topic	1
13.	english in general	en	6	Factual, topic	2
14.	europa	“travel well”	6	Factual, name	2
15.	geometrie (geometry)	hu, “travel well”	6	Factual, topic	1
16.	fénytan (optics)	hu	5	Factual, topic	1
17.	animáció (animation)	hu	5	Factual, type	4
18.	evropa	“travel well”	5	Factual, name	3
19.	planety (planets)	pl	5	Factual, topic	2
20.	safety	en	5	Factual, topic	2

Reuse on a personal level (i.e. applying previously created tags to posts) followed the same trend as the global reuse. 58% of the users did not reuse their personal tags; their posts only contained distinct tags. This was oftentimes related to the low number of personal tags. In some cases, the users had created many distinct tags and never reused them. Differences in personal tagging behaviour remain an area of interest for future studies.

Interpretation of the results on growth and reuse: The growth of posts in the system is sporadic, which may be explained by school holidays and teachers’ active periods during the pilot. The fact that the number of new tags follows closely the number of posts (pink and blue lines in Figure 4.4) indicates that users are creating their personal tags as they create new posts, which most likely means that they have not yet developed a steady personal tag base. Others have observed that the growth entirely diminishes over time (Marlow et al., 2006). When it comes to the tag reuse in the system, possible reasons for it to be very low (1.22 users/tag) are of concern. Similar to the interpretation from Farooq et al. (2007), we partly opt for the influence of the tagging interface where global tags were absent, and where resource-specific tags were only shown in the same language as the interface. The so-called “cold start problem” may also contribute to the low reuse of tags; only 6.2% available learning resources have tags applied to them. When no social cues were made available, e.g. “5 users have added this to Favourites”, it is rather random that a

user tags a resource that was previously already tagged. Lastly, the low level of personal reuse of tags was probably partly due to the fact that users were not familiar with tagging and they were not able to see its benefits. In Table 4.4 some examples of tags are seen that were reused personally in order to create a collection of resources related to literature, chemistry and geometry (tags 6, 12, 15). This indicates that some teachers see the value of tagging for creating personal collection. It can be assumed that once other users see this type of example through a tagcloud they would follow. Thus, in the future, observing to what level "social functionalities" such as a tagcloud affects both personal and global reuse of tags are of interest.

USER'S TAGGING BEHAVIOUR IN THE MULTILINGUAL CONTEXT

Tagging in multiple languages

All the unique tags that were recorded in the system were analysed, even the ones that users had deleted (199) from the posts in order to better understand the tagging behaviour. There were a total of 1031 tags in the system. Each tag has a unique ID. Additionally the system adds the language of the tag, timestamp and the ID of the learning resources that the tag is applied to. The language of the tag is inferred from the user interface language used while tagging (called hereafter "inferred language"). The interface was made available in the languages of the pilot and in English. The choice of the tagging interface language chosen was studied, the pilot participants mostly chose to use the interface in their mother tongue (77%), and the rest of the time they mostly used the English interface.

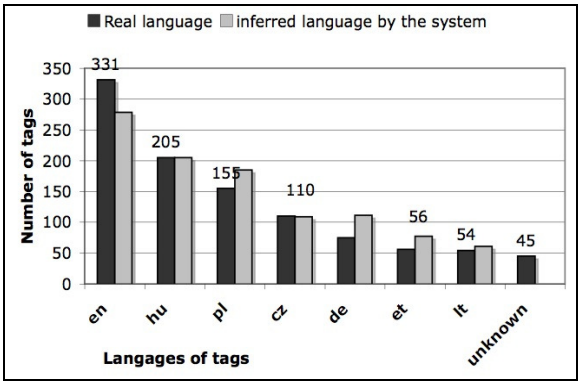

Figure 4.5. Tagging behaviour by language groups. The blue bars illustrate the verified language, whereas the red bars illustrate the inferred language, the error rate of which was about 30%.

Interpretation of the results on tagging in multiple languages: It was found that users explore with the tagging system in different languages. On average, every fourth tag was entered while using the tagging interface in another language than the user's mother tongue. More studies in this area would allow us to better understand personal tagging preferences: does everyone change languages while tagging, or only some of the users? Moreover, it can be

speculated that how users tag and in which languages they tag has ramifications on the viewable-tagging, thus further studies are needed to gauge what languages to display in order to promote multilinguality and cross-boundary use of resources. Most likely this will have implications also on the convergence of tags over time within a language and languages in a multilingual and cultural context.

Inferring the language of the tag from the tagging interface reveals an error rate of about 30%. This is about the same as what Guy & Tonkin (2006) obtained while checking against a multilingual software dictionary. This discrepancy of language identification has ramifications on the usability of the portal, reuse of tags, and how they can be used as navigational support. For example, the tag "Internet" was found four times in the system, twice with different capitalisation, once in Hungarian and once in English. Similar double entries of the same word with different language identification contributed to the fact that almost every 7th tag was redundant in the system.

Tag classification and "Travel well" tags

Apart from statistical properties of tags, the semantics of tags were studied. In two different periods, a manual categorisation of a sample of 819 reused tags was done using the classification from Sen et al. (2006), which is also based on the categories of Golder & Huberman (2006). They are Factual tags (Golder: item topics, kinds of item, category refinements); Subjective tags (Golder: item qualities) and Personal tags (Golder: item ownership, self-reference, tasks organisation). These categories are also identified in Table 4.4 for most used tags. Table 4.6 presents the tag categories of the sample. 74% of the tags applied are of factual type, such as describing the topic of the resource, its file type, the language or country the resources is related to. The second main category, some 25%, is subjective tags. These tags are used to describe the qualities of the resources or how the person felt about them. Apart from common pilot activities, there were very few subjective tags.

Table 4.6. Categories of tags. * indicates that the information is also available in the LRE Application Profile (LRE, 2007) that was used to describe the learning resources.

Category	No	%
Factual	608	74%
-Topic	455	56%
-Type	76	9%
-Language*	9	1%
-Title*	12	1%
-Country*	21	3%
-Name*	12	1%
-Other	9	1%
Subjective	211	26%
Personal	0	-
Total	819	

During the semantic tag analyses it was discovered that a number of tags stood apart hinting of some emerging trends. These tags were hard to group with one language as the spelling was identical in many languages (e.g. “chemie” has the same spelling in German, Dutch and Czech). Additionally, there were tags that presented a general term, a name, a place, or a country/area (e.g. EU, Euroopa, Evropa, Europa, europe) that is easily understood in other languages even if the spelling is slightly different. Other similar groups were people’s names (e.g. Pythagoras, da Vinci) and commonly known acronyms (e.g. AIDS, USA). These tags are called “travel well” tags, as users from different countries could easily understand them even without translation. Some of the “travel well” tags were among the most reused tags in the system, examples of which can be seen in Table 4.4. The term “Matematika” (Table 4.4, no: 7), for example, has the same spelling both in Czech and Hungarian. On the other hand, “test” (Table 4.4, no: 9, it was verified that this tag was not used to “test” the system), is used in many languages to indicate material suitable for exams or evaluation.

Interpretation of the results on semantic analysis: On the one hand, getting tags that “add value” to the system is important, and on the other hand, a better understanding of these tags’ usefulness for the resource discovery across country and language border is crucial. Others have also looked at the value of tags for an information system. Farooq et al. (2007) studied their system and introduced the Tag Non-obviousness metric. This metric is used to detect tags that do not add much intellectual value to the tagging system as a whole. An example is a tag that repeats a term in the resource title. Such a tag, when part of personal tags, can be useful as a personal descriptor and for retrieval, however, for the global use in the tagging system, it adds little new information.

The LRE Application profile metadata already contains information such as the title of the resource, its language, etc. (indicated with * in Table 4.6). Thus, this type of information gathered from tags is redundant from the system point of view and adds little intellectual value to the tagging system as a whole. On the other hand, tags from different categories can also add value in terms of helping users in their tasks. Sen et al. (2006) have looked at how different categories of tags were found useful for different tasks. For example, in MovieLens factual tags were good for finding movies and learning more about them, whereas subjective tags were good for making a decision on which movie to watch. Similarly, future observations on tag categorises are of interest to see whether any similarities emerge.

As to the second goal with tags, i.e. using them as a navigational support to discover resources across borders, “travel well” tags have emerged. Due to the intrinsic properties that make them easily understood by many people, they can act as a bridge between language groups to connect like-minded people across country and linguistic borders. Moreover, “travel well” tags, which seem to be present mostly in the factual category, could become useful especially for less used languages in the system. As displaying tagclouds in separate languages seem reasonable, “travel well” tags could prove useful for less used languages. Also, when a user’s language preferences are not known, or when no other resource-specific tags are available in the user’s language, “travel well” tags

can be used. This analysis helped to tune the system towards “travel well” tags and make sure that the new system requirements take advantage of these tags, either through an automated process or by asking users to identify them. The peril of this approach is that there are also words that look similar but have a different meaning in different languages. There exist, for example, many *faux amis* (false friends) between English and French.

How users perceive tags in multiple languages

So far the portal has allowed the use of tags only for personal management of learning resources, to “keep found things found” and managed. In the future, tags will be made public and displayed as part of the resource metadata and in a tagcloud. Thus, users’ reactions to tags in multiple languages became an important focus to study. Especially, taking into account the issue discussed regarding language verification of tags, understanding how users react and cope with tags in languages that they are not familiar with is important. In Vuorikari, Ochoa & Duval (2007) details of this user study are reported.

In this study users indicated which thesaurus keywords and user-generated tags they found useful. Among the two most useful terms for each resource, thesaurus terms were somewhat more popular (60%) than tags (40%). Another interesting outcome is that users occasionally found tags useful even if they were in languages that they did not have skills in. Most of these tags were what were described above as “travel well” tags. Figure 4.7 shows five bars that display the language of useful keywords to users. The white bars are in a language that the user says he has skills in, and the black bars represent keywords in the languages that users did not have skills in.

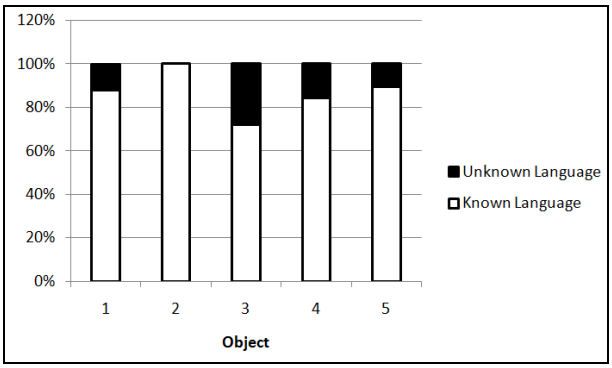

Figure 4.7. Percentage of keywords per LO in known languages (orange) and unknown language (red) that users found descriptive.

Lastly, the user study shows that the issue of multilingual tags evokes sentiments and also splits users. Half of the users found them useful, whereas the other half found them confusing. One user even claimed to hate seeing keywords in languages that he/she does not understand. Participants in the last group also described that seeing tags in multiple language was rather irritating,

especially when they were in languages that they did not recognise. It was also mentioned that multilingual tags make it harder and slower to pick the useful terms out of all the tags.

Interpretation of the results: The user study, which focused on users' attitudes towards multilingual tags, shows that tags in multiple languages divide users: some like them and others do not. Additionally, it gave indications that users may also find tags useful even if they are in languages that they do not claim to have competencies. This hinted to the direction of importance of "travel well" tags.

Contribution to design requirements of a multilingual tagging tool and future work

This early study contributes to the understanding of tags and tagging behaviour in multiple languages. First the two research questions are reviewed, and then design requirements for a multilingual tagging and navigation tool are enumerated.

1) *What happens when users tag in multiple languages?*
Due to the small sample size and the pilot nature of the tagging system, it is impossible to conclude whether tagging in many languages has a real impact on tag growth. It can be observed that the growth was rather similar to another tagging system in a similar context (Farooq et al. 2007) and that the users create new tags, either in their mother tongue, but also in English, in a manner similar to what happens in a mostly monolingual system. When it comes to reuse of tags, indications of similar behaviour was found. However, two main issues that hindered the analyses were identified. First and foremost, the correctness of tag encoding and its related metadata needs to be addressed. Indications were also discovered that the tag reuse most likely suffered from the design of the tagging interface, i.e. how multilingual tags were supported in viewable tagging.

It was shown that users discover resources in different languages and tag them using multiple languages. Some clear patterns emerge in how users tag in a multilingual context: mainly in their mother tongue and in English (Table 4.4). More importantly, despite tagging in different languages, there are tags that seem to be somewhat widely spread despite language borders. These are called "travel well" tags, as they seem to be easily understood without translation.

2) *Can we find any indication towards the use of tags and bookmarks to facilitate the cross-boundary use of learning resources?*
The semantic analyses performed for this study help see that users mostly apply tags that are factual. Even if some of tags were redundant with the information that the metadata already contained (e.g. they repeat the title or the language of resource), it appears that users find tags in multiple languages

somewhat descriptive and useful. This gives an incentive to conduct future studies on their usefulness as a navigational tool.

Moreover, “travel well” tags were discovered. Due to the properties that make them easily understood by many people, they can act as a bridge across language and national borders, thus helping create communities and clusters of like-minded users around tags and resources. During these analyses indications in this direction were found, e.g. shared use of some tags, as presented in Table 4.4, and small groups of users that formed around a number of tags.

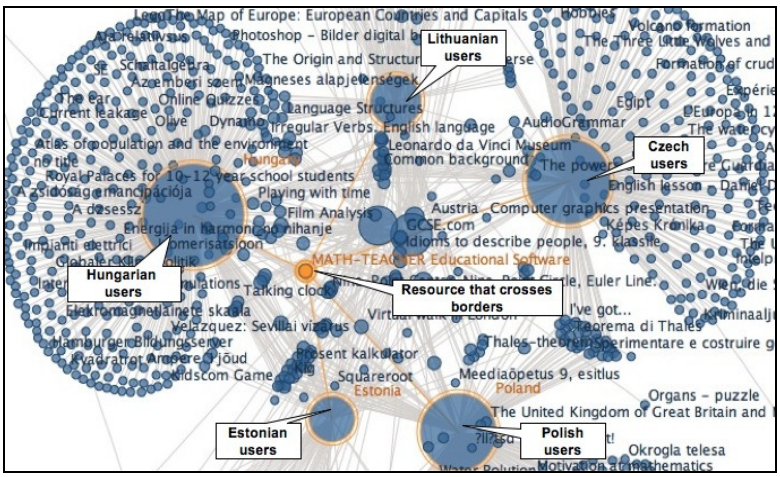

Figure 4.8. Visualisation of bookmarked resources that cross national borders. Each big node represents users from the pilot country (e.g. Estonia, Poland). The resources that are shared with users from different countries are used across borders.

Figure 4.8 demonstrate the across the national boundaries usage of digital resources. Each big node represents users from the pilot country (e.g. Estonia, Poland). The nodes are connected by edges to the resources that users have bookmarked. The resource in the middle, “Match-Teacher Educational Software”, is highlighted in orange with edges connecting to users in five different countries (Poland, Estonia, Hungary, Lithuania and Chez Republic). This illustrates across the borders usage of the resource. Similarly, a number of small clusters are visible between the country nodes. These represent resources that bridge across national boundaries. In Klerkx & Duval (2009) another visualisation tool used for the same purpose is described in details.

DESIGN REQUIREMENTS AND FUTURE WORK IN A MULTILINGUAL CONTEXT

The issue of multilingual resources and tags is intriguing and offers interesting possibilities not only for end-users, but also for learning resources repository managers and administrators. This study showed the importance of the tagging interface in a multilingual context and how it can passively affect on the tag reuse. These descriptive analyses show the importance of a correctly fine-tuned

system that supports tagging in multiple languages; correct identification of the tag language is crucial, which will allow the correct metadata on the language of the tag. Moreover, overwhelming the user with tags in languages that they do not have competencies in can do a disservice for a multilingual system.

For a suitable tag language identification mechanism both existing software solutions and the ones taking advantage of users' tagging behaviour could be envisaged. Although if the approach that this research opted for yields almost as good results as using multilingual dictionary software (e.g. Guy & Tonkin 2006), the one applied to this research is only able to cover the languages in which the user interface exists. This is clearly insufficient in the future. Possible ways forwards could investigate, for example, tags against a properly managed multilingual list, e.g. WordNet (2009) or creating lists of previously entered and validated tags. Testing new tags against characters specific to each language (e.g. language recognition chart in Wikipedia) could offer interesting results. Moreover, similar methods could be used for identifying "travel well" tags. Once the tag language has been correctly identified, its metadata can be added to the system correctly.

Now that new, effective technical architectures are in place to enable better discovery of educational resources across repositories on the international level, sharing tags with other learning resource repositories becomes interesting. A number of educational repositories allow end-user tagging, e.g. LeMill (2009), OERCommons (2009), KlasCement (2009). These repositories already share conventional resources metadata (e.g. through LRE 2009; Globe, 2009). Currently, however, tags are not shared and not used for navigational aid across repositories. A small initial study on tags in Calibrate, LeMill and OERCommons shows that there are many overlapping tags and interests by users in all systems (Vuorikari & Põldoja, 2008). Therefore, offering a way to navigate between systems by using tags could provide interesting avenues for end-users to cross system borders.

The analyses make it clear that using established metrics (e.g. Ochoa & Duval, 2006; Farooq et al., 2007) allows comparing one's system to other existing systems, and thus benchmark against them. Apart from systematic and automated computation of the metrics introduced here, the creation of metrics to better track cross-boundary interactions is needed. For example, enlarging the Contextual Attention Metadata framework to support social information retrieval methods (Najjar, Wolpers & Duval, 2006) becomes interesting. The advantages would be manifold. Such metrics would yield more behavioural evidence on the usefulness of multilingual tags for users by showing how often a tag has been used to discover the resource, as opposed to using more conventional methods such as thesaurus terms or keyword based searches.

Moreover, such metrics could be used to calculate the cross-boundary interactions of a given resource and tag by adding contextual information to the use of tags, bookmarks and resources from users who come from a variety of countries. This would be useful for a more context-aware data management in a multilingual context, which could be used to help identify resources that

previous users from varied lingual backgrounds have found attractive within a large-scale collection of multilingual resources. The same could be applied to flag out learning resources that “travel well”. Similar to the concept of “travel well” tags, these are resources that cross language and country borders easily. To identify potentially interesting “travel well” resources, a cross-boundary metrics to better filter, rank and recommend these resources can be used, validation of which would yield relevant information for future studies. A potential direction for future work will also need to consider recommender systems. A hybrid recommender system could consider a bookmark or tag as a vote for the resource. Additionally, other metadata (e.g. LOM) could be used to support content based filtering.

Conclusions

In this paper, some early and initial analyses of a multilingual tagging system are presented. The general characteristics of a multilingual system are studied, as well as its tag growth, tag reuse and categorisation of tags. The tagging behaviour was investigated in a multilingual context. The findings were discussed in conjunction with design requirements to enhance a tagging system in a multilingual context. It is concluded that tags in a multi-cultural and multilingual context offer potential advantages to the collaborative tagging system and its multilingual user communities (e.g. Europe, on the international level). However, there are challenges and research questions that need further attention. As it becomes clear that some tags are useful for some users, the design challenge becomes “hiding all but the right tags”.

Acknowledgements

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Chapter 5

Ecology of social search for learning resources

Chapter is based on Vuorikari, R. & Koper, R (2009a). Ecology of social search for learning resources. *Campus-Wide Information Systems, 26*(4), 272-286.

Abstract

This paper deals with user-generated Interest indicators (e.g., ratings, bookmarks, tags) which are collected from a learning resource portal with a social tagging tool that allows users to bookmark and tag resources from a federation of multilingual learning resource repositories. Users' attention metadata based on a logging scheme are collected, i.e. how do users search, what do they click on and what do they eventually annotate. This empirical data is used to create a behavioural model that allows studying the self-organisation aspects of such system. Additionally, a measure for user's efficiency in finding relevant resources was defined.

Two research questions are answered: can search strategies based on Social Information Retrieval (SIR) make the discovery of learning resources more efficient for users, and can Community search help users discover a wider variety of cross-boundary resources. The term cross-boundary resource is used to mean 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. Similarly to the success of social insects in carrying out complex tasks like finding a shortest route to a food source, it is shown that individuals can use tags and ratings as signs to indicate the shortest path and thus become more efficient in their resource discovery process. However, Community search alone does not help users discover a wider variety of 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.

Keywords: learning resources, social information retrieval, social tagging, metrics, efficiency, Research paper

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'etre. 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 educational content. Currently, novel exploratory search systems are developed for learning resources to assist users in obtaining content that meets 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 & Foo, 2007).

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, Dourish, Höök, Resnick & Wexelblat, 2000). Such footprints in an online environment are what Claypool et al. (2001) define as Interest indicators which 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 & Tuzhilin, 2005). Evaluation of recommender systems traditionally focuses on the algorithms and their performance (Herlocker, Konstan, Terveen & Riedl, 2004), similar to exploratory search systems (White, Marchionini & Muresan, 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, Dan-Gur & Barak (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. Dron, Mitchell, Siviter & Boyne (2000) and Dron (2004) use collaborative filtering ideas in a self-organising resource database for learners, whereas self-organisation and emergence were used in designing lifelong learning networks (Koper al al., 2005), self-organising way-finding support for lifelong learners (Tattersall et al., 2005), sequencing recommendations (Van den Berg et al., 2005) and self-organising navigational support (Janssen et al., 2007). 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 & 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, Herlocker & Webster (2007) studied implicit click data to increase both precision and recall of the feedback data on a university search portal. Tang & McCalla (2009) studied the pedagogical value while using collaborative filtering to recommend papers for learners, and Manouselis, Vuorikari & Van Assche (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 & Tuzhilin, 2005; Rafaeli, Dan-Gur & Barak, 2005). Social bookmarking and tagging can offer new prospective thanks to tags, in which users describe their interest. This creates a triple (user,item,tag) which indicates user's relationship between the resource and tags (Golder & Huberman, 2006; Marlow et al., 2006; Sen et al., 2006). Such underlying structure allows flexible social navigation (e.g. tag-item, tag-user, user-item), but could also be a source for collaborative recommender systems by linking like-minded users not only through resources, but also through tag-based interest sharing (Santos-Neto, Condon, Nazareno & Ripeanu, 2009). The idea of social tagging and bookmarking has been implemented in the TEL context (Bateman, Brooks, Mccalla & Brusilovsky, 2007; Maier & Thalmann, 2008; Vuorikari & Põldoja, 2008), in digital libraries (Puspitasari et al., 2007) and for scientific papers (Farooq et al., 2007; Catutto , et al., 2008).

Millen, Yang, Whittaker & Feinberg (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 & Mao, 2004). A similar implementation is studied, namely a federation of learning resource repositories in a multilingual context that has a social bookmarking and tagging tool (Vuorikari & Van Assche, 2007). The 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.

The 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 5.1).

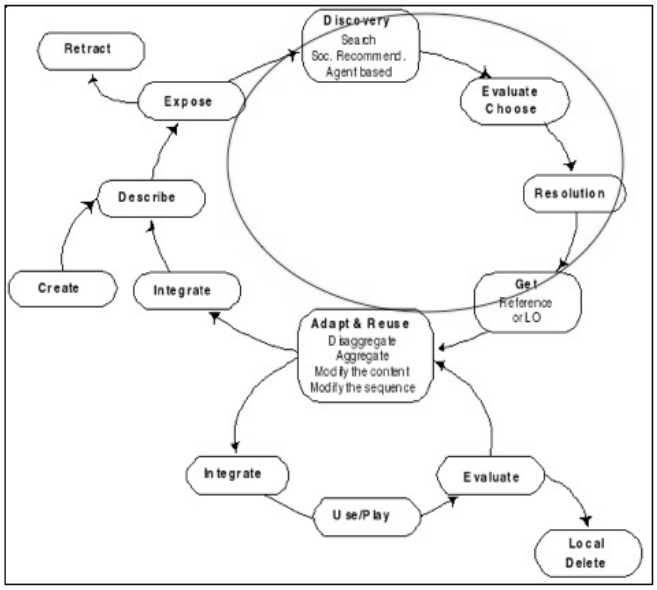

Figure 5.1. Learning resource life-cycle (Van Assche & Vuorikari, 2006).

In this study the specific questions focus on the efficiency of resource discovery process and how users can be supported in discovering cross-boundary resources. The term “cross-boundary discovery” is used when the user bookmarks or rates a resource that comes from a different country than she does and that is in a language other than that of the user’s mother tongue. Evidence from previous studies (e.g. McCormick et al., 2004; Vuorikari & Koper, 2009b) show that users of educational content use cross-boundary resources to a certain extent, but their reuse remains rather low. The following hypotheses were defined:

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-based search.

In the next section the study methodology and the data set are introduced. Then, the results are reviewed which is followed by a short discussion. The paper is concluded with an outlook for future work.

Context of the study and its method

The portal studied 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, shown in Figure 5.2, was developed in the MELT project (2009), offers three different categories of searches (Millen et al., 2007).

Figure 5.2. The MELT portal front page.

Explicit search: comprises the traditional search box with text and filtering options based on multilingual metadata. "Find by subject" offers browsing through pre-defined categories. The results are shown on the Search Result List (SRL) with metadata and annotations, if available.

Community browsing: these are social navigation features such as accessing resources through tagclouds and specific lists of most bookmarked resources, but also “pivot browsing” which means using tags or usernames as a means to reorient browsing. Figure 5.2 shows examples such as the multilingual tagcloud and different tabs (e.g. most bookmarked).

Personal search: looking for bookmarks from one's own personal collection of bookmarks (MyFavourites).

In this study, Social Information Retrieval methods mean all the Community browsing features, and it also is comprised of retrieved resources that contain user-generated Interest indicators. These are Interest indicators like a rating on a scale 1 to 5 (1=”of no use” to 5=”very useful”) or a bookmark with tags (called Favourites). These public annotations are also called contributing actions. By clicking on the link the user plays a resource and generates clickstream which is an implicit Interest indicator. The following metric was used 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. The other types of relevance, such as the query and object match or topical relevance, are not considered (Borlund, 2003). With "less effort from the user" is meant that users will play and annotate relevant resources with fewer executed searches.

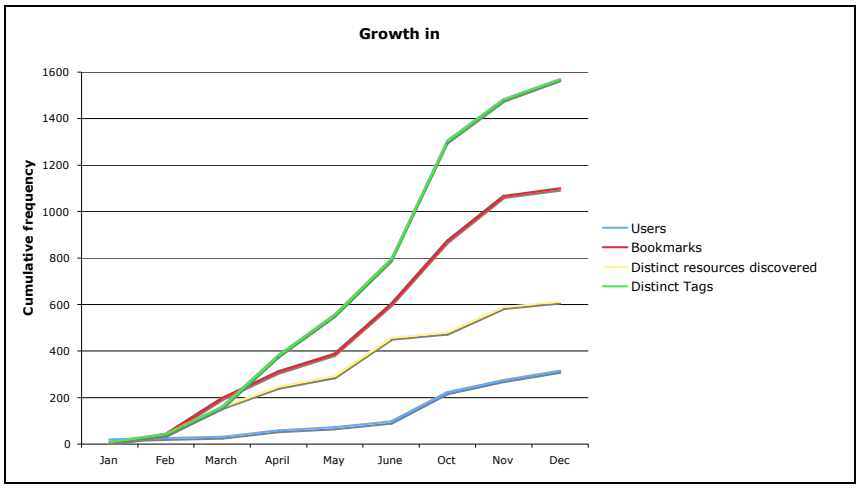

Figure 5.3. Tag and user growth in MELT. The portal was not in use during the summer months.

DESCRIPTION OF THE DATA

The logging scheme for users’ attention metadata was defined which is exportable in a Contextual Attention Metadata compliant format (Najjar, Wolpers & Duval, 2006). It was first used in the Calibrate pilot, however the scheme was redefined to cover a range of contributing actions and social search. Table 5.1 describes the scheme that includes 3 main units: the resources, the user and

the user's actions. The latter includes three main categories: search, click and contributing actions. Each time a user arrives on the portal, a new session is started, regardless if the user logs in. Table 5.1 shows, for example, that metadata variable "languages" is gathered for the resource, the user (mother tongue and spoken languages) and for the tags.

Table 5.1. Logging scheme on the portal to capture users' attention metadata. LO stands for Learning object (resource).

Metadata	Unique ID	Langu-ages	Loca-tion	Time stamp	Other metadata
1. Resources	x	x			LRE Application profile
2. Users	x	x		x	Country, school, topics of interest
3. Actions					
3.1 Session	x			x	ID, if logged in
3.2 Search				x	Type of search: advanced, browse topics, tag search
3.3 Click			x	x	The LO, tag, rating, other user clicked on
3.4 Bookmark	x		x	x	User ID, LO ID
3.5 Tag	x	x	x	x	User ID, LO ID
3.6 Rate	x		x	x	User ID, LO ID, value, comment

The attention metadata logs were collected from the period of October 1 to December 18 2008. The registered users, mostly primary and secondary teachers, had been invited to use the portal after an initial pilot period. They came from 11 different European countries (Austria, Belgium, Estonia, Finland, France, Germany, Greece, Hungary, Slovenia, Sweden and United Kingdom). Table 5.2 presents the data used for this study: in addition to actions from unregistered users, 82 authenticated users were included in the study after excluding the project staff and inactive users.

Table 5.2. Data description of all recorded attention and actions included in the study.

Users	Sessi ons	Executed searches	All plays	Distinct resources played	Distinct resources annotated
Unregistered	2036	7846	1854	1547	Not possible
Registered (82)	310	1863	974	687	394

During the pilot, a selection of more than 30,000 distinct resources was made available. 565 resources (less than 2% of all resources) had been annotated prior to the period of study by the project staff. Figure 5.3 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 (i.e. when the growth plateaus as explained in Marlow et al., 2006), a view that is also adopted for the system studied.

DATA PROCESSING

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

Results

First the descriptive results are given on the three main actions: how do users search, play and contribute, and then we look how new resources generated clicks and annotations. Following, the model of the process that produced this data is presented after which the two hypotheses are tested.

DESCRIPTIVE RESULTS

Search

Three main groups of search behaviour among the registered users was found; the ones who only used Explicit (47%) or only Community search features (6%) and about half of the users who used mixed methods (47%). Of all searches executed on the portal, 82% were Explicit methods (53% advanced searches; 29% browsing by discipline) and 18% were Community browsing.

Table 5.3. Amount and percentages by areas of the portal where clickstream (play) was generated.

Clickstream	Registered users	Other	*All*	*%*
Search Result List	728	1235	*1963*	*69.4%*
Search Result List with 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*	*1854*	*2828*	*99,9%*

Clickstream

Users generate clickstream when they “play” a resource. Counting all clickstream from all users, 1547 distinct resources were played 2828 times. Different user behaviour was observed among registered users: 52% played resources only on the Search result list, 10% only in Community browsing areas, and the rest (38%) in different parts of the portal.

Table 5.3 shows that 69% of the clickstream was generated on the Search result list on resources with no Interest indicators, whereas 31% of the clickstream came from resources that had Interest indicators. As Explicit search does not take advantage of any Interest indicators (the results are not even ranked according the rating), the latter is considered to be an outcome of Social Information Retrieval.

Annotations

77% of registered users who played resources also annotated them: 44% both rated and tagged resources, whereas 33% only rated or tagged resources. Table 5.4 shows that users rated and bookmarked very similarly. Two users out-performed others with 120 and 108 annotations. In general, the ratings are positive; 84% voted 3 or greater (≥3) and only 16% of the ratings indicate a resource "of no use" (=1 or 2).

Table 5.4. Distribution of bookmarks and tags, and areas of the portal where they were obtained.

Annotations	Bookmarks and tags	Ratings
Users	48	46
Number of actions	350	384
Number of tags	1507	Rating ≥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 annotations	12.19	12.53

Table 5.5. Place of the portal where annotations took place.

	Bookmarks obtained after..	Ratings done in..
..Explicit search no annotations	236 (67%)	258 (67%)
..Explicit search with annotations	49 (14%)	26 (7%)
..Community Search	65 (19%)	85 (22%)
..Personal Search	n/a	15 (4%)

Annotations by authenticated users took place in different parts of the portal: 40% of the users only annotated resources in the Search result list, 24% only in Community browsing parts of the portal and 36% of the users annotated in both places, which resulted in most of the annotations (70%). Most resources that were annotated (67%) had no previous annotations and were found through Explicit search (Table 5.5).

Interest indicators, clickstream and contributions

A tendency that resources with Interest indicators generated more actions was found: 14% of all played resources that had Interest indicators generated 29% of all plays. Table 5.6 shows that a small correlation coefficient between resources that had existing Interest indicators and bookmarking action (0.329, $p<0.01$) was found, similarly between actions play and bookmark (0.327, $p<0.01$) and some between bookmark-rate (0.300, $p<0.01$). These correlations between actions can be further studied for generating implicit Interest indicators that are less intrusive for users, and that can be used to better cover actions from users who prefer not to authenticate with the system.

Table 5.6. Correlation coefficient between different actions.

Correlation coefficient between	Kendall Tau
Resource w/Interest indicators – bookmark action	(0.329, $p<0.01$)
Clickstream -bookmark action	(0.327, $p<0.01$)
Bookmark action –rate action	(0.300, $p<0.01$)
Resource w/Interest indicators and clickstream	(0.253, $p<0.01$)
Clickstream –rate action	(0.233, $p<0.01$)
Resource w/Interest indicators and rate action	(0.196, $p<0.01$)

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 (i.e. ecology); for example, how newly created annotations become part of the search process where users interact and eventually annotate them.

Figure 5.4 shows authenticated and unauthenticated users on the portal and the percentage of their actions by each category (search-play-contribute). In principle, these two groups search rather similarly: Explicit search is preferred by both groups and Community browsing methods account for 21% of all search actions.

When looking into details, the main difference is that the unauthenticated users tend to explore resources through browsing (51%): 30% browse by discipline and 22% by Community browsing, whereas the authenticated users browse less (38%), but additionally use Personal search (9%). The Pearson Chi-Square test was significant ($p<0.001$) for these differences.

Users play resources differently, unauthenticated users play 71% of resources in the Search Result list (SRL) after an Explicit search and 29% in Community browsing areas. Authenticated users, on the other hand, play 79% of resources in the SRL and only 21% in Community browsing areas. The Pearson Chi-Square test was significant ($p<0.001$) for these differences.

Only users who are authenticated to the system can contribute. Out of all the actions recorded in the system, contributing actions amount to 16%. Most contributing actions are annotations (67%) on newly discovered resources,

whereas 33% is generated in the Community browsing areas on resources that have previous annotations. The annotations are generated following a rather regular pattern (grey boxes in Figure 5.4), however, for ratings, a small amount is created in the user's Favourites.

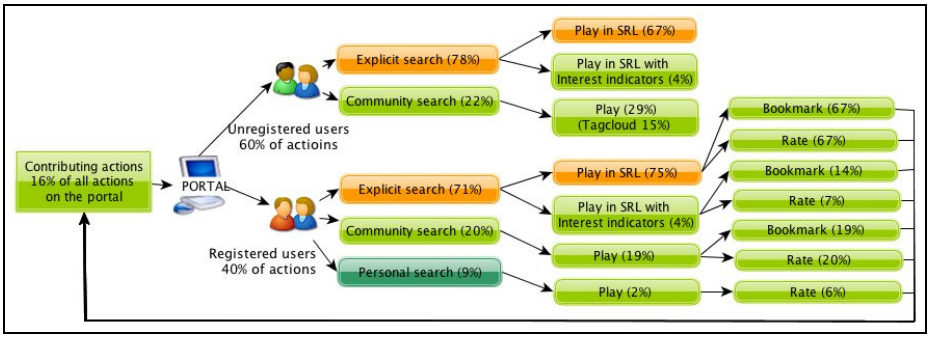

Figure 5.4. Users consuming and contributing, light green indicates actions based on social search and orange on Explicit search.

The model shows that the annotations (i.e. Interest indicators) play an integral part in creating a social search ecology and offer more flexible ways to discover resources, as is explained in Chapter 1 related to self-organisation. 16% of all the annotation actions are aggregated to create structures on the global level that can be used by other users to discover resources. 21% of all search actions took advantage of these structures, and they supported 31% of plays. This finding points to the same direction as Glahn, Specht & Koper (2007) who found that accessing of tagged resources is independent from the contribution level of a participant. However, it was not found that all participants use tags similarly while searching or accessing tagged resources: different search preferences by users were observed.

MEASURE OF EFFICIENCY: SEARCH-PLAY-CONTRIBUTE RATIO (H1)

Hypothesis 1 (H1) states that the search methods based on Social Information Retrieval yield more relevant resources with less effort from users. The above model was used to create a measure to test the hypothesis by studying the ratio between search, play and contributing actions from users who were authenticated on the portal. This was 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. Hanson & Kalyanam, 2007).

The application of the efficiency measure shows how many search actions it takes to play and/or annotate a resource. For both search methods the following efficiency ratios were created: 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 search actions that it takes the user to achieve the goal.

Table 5.7 presents the two baselines against which the measure are compared. *Explicit search* indicates the results from a text-based search excluding the plays on resources that contained Interest indicators (i.e. ratings, tags). *Community browsing* indicates the results from tagcloud, lists and pivot browsing. SIR methods, against which the efficiency is measured, include results from *Explicit search with Interest indicators* (i.e. ratings, tags) and from *Community browsing*. On the top row, different ratios for actions are indicated, e.g. how many searches does it take to play a resource (2.1 Explicit searches to one play). An *Efficiency rate* for each search method is displayed, which is an average of all ratios. This allows for quick comparison. Lastly, *Explicit search (comparison)* reports the same ratios from another portal where no Interest indicators were made public (see Vuorikari & Ochoa, 2009). Comparing the two top rows, the efficiency of *Explicit search* with *Community browsing* is compared. The search-play, search-bookmark and play-bookmark ratio is almost identical using both methods, whereas Community browsing is more efficient for rating.

Table 5.7. Users' efficiency with different search methods on the MELT portal.

Actions for authenticated users in MELT	Search: play ratio	Search: rate (≥3) ratio	Search: bookmark ratio	Play: rate (≥3) ratio	Play: bookmark ratio	*Efficiency rate*
Explicit search (baseline)	2.1:1	7.0:1	6.4:1	3.3:1	3.1:1	*4.4*
Community browsing (baseline)	2.0:1	5.3:1	6.5:1	2.6:1	3.2:1	*3.9*
SIR methods	1.7:1	4.0:1	3.7:1	2.3:1	2.2:1	*2.8*
Explicit search (comparison)	0.5:1	21.6:1	11.3:1	42.6:1	22.2:1	*19.6*

Comparing the *Explicit search baseline* to *SIR methods* shows an efficiency gain, the Efficiency rate drops from 4.4. to 2.8. Search-rate ratio comes down from approximately 7 searches to 4 searches, whereas play-rate from 3 searches to 2 searches.

On the portal, *Explicit search* and *Community browsing* perform very similarly. However, *Explicit search* compared with *SIR methods* shows an efficiency gain of 1.6 units. For both the Explicit search data and SIR data, Pearson Chi-Square test was highly significant ($p<0.001$). We thus conclude that the findings support *H1* and *H1* can be accepted.

DISCOVERY OF CROSS-BOUNDARY RESOURCES (H2)

Hypothesis 2 (H2) states that the users who use Community browsing discover more cross-boundary learning resources. In addition to using the above

measures, a component indicating the cross-boundary nature of a bookmark is added. To do this, the country of the resource is compared to that of the user and the language of the resource to that of the user's mother tongue as in Vuorikari & Koper (2009b). Additionally, a "search method" profile and "cross-boundary resource" profile were created based on bookmarked resources recorded by each user. These profiles are comprised of percentages of different search methods by the user, and the percentage of resources that cross national and linguistic boundaries.

The cross-boundary nature of resources that users had bookmarked was studies. 83% of the users had a "cross-boundary profile" meaning that they had resources originating from different countries and in different languages. 17% of the users had only national profile, indicating that all their resources originated from the same country as they did. This split reflects the goal of the portal which promotes the discovery of educational material from different countries. 57% of all bookmarked resources, a total of 198, are cross-boundary discoveries (Table 5.8). Such cross-boundary profiles are usually also "cross-repository" profiles, information of which can be used to make link-structures between content in different repositories that otherwise is not cross-referenced via hyperlinks nor metadata.

Table 5.8. Cross-boundary discoveries by users.

	Distinct LOs		**Distinct L0s w/SI**		**"New" discoveries**	
Cross-boundary discovery	198	(57% of all)	73	(37%)	125	(63%)

72% of these bookmarked cross-boundary resources were discovered in the Search result list as a result of Explicit search, whereas 28% were a result of Community browsing. Within Community browsing, 23% were discovered in the tagcloud and 5% chosen from the "Travel well" list. These findings show that most often users discover cross-boundary learning resources as a result of Explicit search, and when the resource is deemed relevant, they bookmark it in the Search result list. This finding from the current data points to the direction that *H2* cannot be supported, and prompts us to reject *H2*.

Discussion and conclusion

In this paper empirical data in the form of attention metadata to track users' actions was used. This data was used to model the ecology of social search of a learning resource portal integrated with a social bookmarking and tagging tool. It can be concluded that Interest indicators have an important role as a part of the social search ecology which, with users following a simple rule of searching and annotating, results in a complex but effective group behaviour similar to that found in self-organising systems. Future studies into inter-relations of these variables will offer interesting insights on the self-organisation aspects supporting users in their learning resource discovery. By studying the cross-boundary discoveries, it was found 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.

Hypothesis 1 was accepted 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 (2/3 of all executed searches). These conventional search methods strongly proved their role in discovering new resources and thus also alleviating the "cold start problem". The newly annotated resources through these methods add new seeds from which new Community browsing features can grow. This finding led us to reject the second *hypothesis (H2)*: most cross-boundary resources are discovered using Explicit search. Encouraged by the *H1*, though, we believe that leveraging both implicit and explicit Interest indicators to support cross-boundary discovery (e.g. indicating the cross-boundary nature of resource discoveries, tagclouds filtered by language and by the country of users), and collaborative filtering methods for like-minded users based both on item and tag-based interests, are worth studying further.

A limitation in this research was that a system that was studied was still evolving. This has the positive effect of allowing us to revisit the 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 leaves out subjective measures such as user satisfaction or cognitive load while searching for cross-language content, 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 through social tagging and bookmarking between resources that originate from a number of repositories and are in a variety of languages.

Chapter 6

Are tags from Mars and descriptors from Venus? A study on the ecology of educational resource metadata

Chapter is based on Vuorikari, R., Sillaots, M., Panzavolta, S. & Koper, R. (2009). Are tags from Mars and descriptors from Venus? A study on the ecology of educational resource metadata. In M. Spaniol, Q. Li, R. Klamma & R.W.H. Lau (Eds.), *Advances in Web-Based Learning - ICWL 2009* (pp. 400–409): Lecture Notes in Computer Science 5686; Berlin, Heidelberg: Springer-Verlag.

Abstract

In this study, over a period of six months, empirical data from more than 200 users on a learning resource portal with a social bookmarking and tagging tool was gathered. The aim was to study the interrelation of conventional metadata and social tags on the one hand, and their interaction with the environment, which can be understood as the repository, its resources and all stakeholders that included the managers, metadata indexers and the whole community of users, on the other hand. An interplay between end-user tags and conventional metadata descriptors was found, and we show how tags can enrich and add value to multilingual controlled vocabularies in various ways. This can help build a more robust system, especially in a multilingual context, as even if one of the elements of conventional LOM fails to describe the resource, the system can still accommodate its users in discovering learning resources. We also show that tags can offer adaptability to a changing environment of users' demands, thus offering more flexibility, which was studied through a measure of "attractive tags".

Introduction

A conceptual model and taxonomy for a social tagging system was presented in Marlow et al. (2006) where the authors argue that tagging is motivated both by personal needs and sociable interests, e.g. attract attention, self presentation, future retrieval, contribution and sharing. Vander Wal (2005) observed that tagging could be used to compensate for missing terms in a taxonomy, whereas Lin, Beaudoin, Bul & Desal (2006) and Al-Khalifa & Davis (2006) explored the overlap of tags with controlled vocabularies and automatic indexing. Sen, Harper, LaPitz & Riedl (2007) have studied the quality of tags and tagclouds, Farooq et al. (2007) focus on folksonomies adding intellectual value to a tagging system, whereas Heymann, Koutrika & Garcia-Molina (2008) observe that tags are present in the page text of 50% of annotated pages and in 16% of the titles.

The quality of tags, like metadata, can be evaluated from two different perspectives: the validity of the metadata in describing the resources, and their usefulness in terms of searchability and the extent to which the metadata supports the retrieval of resources (Barritt & Alderman, 2004). In this study, the value of user-generated tags for the learning resource "metadata ecology" is studied. The term metadata ecology is used to describe the interrelation of conventional metadata (e.g. LRE Application profile, LRE, 2007) and social tags on the one hand, and their interaction with the environment, which can be understood as the repository, its resources and stakeholders, such as the managers, metadata indexers and the whole community of users, on the other hand. Moreover, the focus is to find evidence to support the hypothesis as explained in Chapter 1 on the flexibility and robustness.

In the remaining part of this Chapter, the context of the study and the data set are described. Then, the results of a number of studies with different stakeholders in the learning resource economy, including end-users, librarians/expert indexers and repository owners, are presented. Finally, a discussion is provided on the findings with conclusion and possible future work.

CONTEXT AND METHOD

The portal under consideration is the Learning Resource Exchange (LRE, 2009) developed by European Schoolnet (2009) and its partners in the MELT project (2009). At the time of the data gathering (January 31 2009), a version of the LRE federation of repositories was made available to a restricted number of schools with more than 30,000 open educational resources and nearly 90,000 assets from 19 content providers in Europe and elsewhere (Massart, 2009). These resources exist in different languages and conform to different national and local curricula. Content providers use a common Learning Resource Exchange Application Profile (LRE, 2007) that makes the use of classification keywords from the LRE Thesaurus mandatory (LRE, 2002). This Thesaurus currently exists in 17 languages.

Figure 5.2 shows the front page of the LRE portal (2009), hereafter referred to as portal. The portal offers different categories of searches: “Explicit search” and “Browse by category” that take advantage of multilingual metadata. “Community browsing”, on the other hand, takes advantage of the other user’s behaviour. This includes: the use of tagclouds and tags; social navigation features such as “most bookmarked resources”; and “Personal search” where users can search the resources they have previously saved in their Favourites by using tags.

The data set was gathered using a logging scheme for users’ attention metadata, details of which can be found in Vuorikari & Koper (2009a), also in Chapter 5. The current data is a snapshot from a six-month period. From July 2008 to January 2009, primary and secondary school teachers from Austria, Belgium, Hungary, Finland, Estonia, United Kingdom, Slovenia, Sweden, France, Germany and Greece became involved in the pilot test. In total this meant 234 users out of which 77 used the bookmarking and tagging tool. Table 6.1 shows the number of bookmarks and tags produced by the users, and the amount of attention metadata that tags generated.

Table 6.1. Resources bookmarked and tagged on the portal.

July 1 2008 to Jan 31 2009	**Distinct**	**All**
Bookmarks	1857	2490
Tags	3832	9219
Tags clicked	419	3631

Results

A review on how teachers tag and interact with tags on the portal is first given. Then, two different evaluations on tags are provided; one by expert indexers and another one by a focus group of learning resource repository owners.

HOW DO USERS TAG?

The basic dataset on users' tags is presented in Table 6.2. Out of all users, 33% added bookmarks and tags. In total, 1857 distinct resources were bookmarked 2490 times out of more than 30,000 learning resources made available. On average, each resource had 1.3 bookmarks; however, in reality, 80% of resources had only one bookmark. The remaining 20% accumulated 53% of all bookmarks. Each bookmark had an average of 3.7 tags (Table 5.2). When the tags per resource were studied, it was found that each resource had an average of 5 tags. However, the top 39% of resources had 70% of tags and the remaining 61% of resources had less than five tags (18% had only one tag).

Table 6.2. Average tags per bookmark, average tags per resource, and how users tag on average.

Average bookmark	Average resource	Average tag	Average user
3.7 tags	5 tags	2.4 applications	28 bookmarks, 118 tags

There were 3832 distinct tags applied 9219 times. On average, each tag was applied 2.4 times. 15% of tags were used more than average; these tags comprised 59% of all applied tags. There were three tags that were applied more than a hundred times, namely "english" (257), "interactive" (161) and "Vocabulary" (126). Each user who bookmarked (77) added an average of 28 bookmarks. The top 28% of users were responsible for 85% of all bookmarks, whereas 72% users were below the average. An average user applied 118 tags to bookmarks. However, it is found that 29% of users added over 92% of all tags, whereas 71% of users were below average.

As the LRE portal (2009) is made available to teachers from European countries and its interface is made available in multiple languages, it is normal that users tag in multiple languages. With the help of the LRE Multilingual Thesaurus, the language of the applied tags in a sample (n=3738) was verified. Table 6.3 shows the languages that were used for tagging. 29% of the tags were in English, although a very few users had English as mother tongue. A medium correlation (r=0.57) between the language of the content and language of tags was found. The tagging behaviour in a multilingual context is further studied in Vuorikari & Ochoa, 2009 (Chapter 4).

Table 6.3. Language in which users add tags, the language in which the tagged content exists and the percentage of users coming from different countries. 12% of content was either multilingual or language independent.

N=3738 tags	UK(en)	Hu	At (de)	Fr	Be (nl)	Sl	Fi	Se
Language of Tags	29%	24%	7%	6%	6%	5%	3%	4%
Language of content	18%	35%	32%	<1%	n/a	<1%	n/a	<1%
% of users who tag	2%	78%	5%	0.1%	5%	0.5%	1%	0.2%

A database query was run against all the tags and the multilingual Thesaurus terms. 11.3% of distinct user-generated tags exist in the LRE multilingual Thesaurus. These are called "Thesaurus tags", as they are end-user generated,

but they also exist in the Thesaurus. The number of times "Thesaurus tags" were applied rises to 30.6% of all tags (i.e. the same tag added to many resources). On average, these tags were reused 11.8 times compared to other tags which were reused on average 2.4 times. In the following evaluations the popularity of these terms is repeated (e.g. Table 5.5). It is interesting that, especially in a multilingual context, such a high percentage of overlap exists between natural language and controlled vocabularies. Al-Khalifa & Davis (2006) report that the folksonomy set overlapped with the indexer set on average 19.5%.

WHAT DO USERS ACTUALLY CLICK?

Table 6.4 shows that 58% of all users had clicked on tags while searching for resources, whereas 42% never used tags. This means that more people use tags for retrieval than actually add tags (33%).

Table 6.4. Users of the study: 33% of users tag and 58% of users take advantage of tags for searching purposes.

Users=234	Uses tags for searching	Does not use tags for searching	Total
Users don't tag	74	83	157 (67%)
Users tag	64	14	78 (33%)
Total	137 (58%)	97 (42%)	

For the resource discovery, the interest is to see whether all the tags were used in a similar way. Out of more than 3800 distinct tags, the logging analyses show that 419 tags generated 2631 clicks of attention metadata, i.e. clickstream. On average, each tag received 6.9 clicks; however, in reality, 20% of the top clicked tags generated 80% of the clickstream. In Table 6.5, in the middle column, the tags that generated the most clickstream are found. There were three end-user added tags that rose above others (english, interactive, animation), which also probably constitute the "wish list" of the users of an international learning resource portal.

Table 6.5. Most added and clicked on tags on the LRE portal. "Add to LOM" shows the most voted tags by expert indexers to be added to LOM. * indicates the potential "Thesaurus tags" and ** indicates tags that were not added by the end-users, but project staff.

Tag	Added	Tag	Clic-ked	Tag	Add to LOM
english*	294	melt selection**	498	english*	90
interactive*	173	promethean**	371	vocabulary*	80
vocabulary*	136	english*	185	NewYork	75
angol*	94	interactive*	119	french*	73
efl	91	animation	109	young_learners	70
SDT	91	Deutschland*	77	képleírás	70
grammar*	69	cultural_background	76	Europe*	67
informatika	58	may10**	76	esl	66
animals*	57	history*	71	interactive*	60
quiz	53	koolielu	66	photo*	60

As for Community browsing, it is found that not only tags attract clickstream, but bookmarks are also used for social navigation. By registered users, tagcloud receives 22% of all search actions, whereas personal bookmarks receive 5% and another additional 2% come from clicking on other users' bookmarks. This shows that to a small extent, tags are used to discover resources by other users, but also for Personal searches.

Lastly, it was asked whether the tags that were added a lot by users, also received users' attention. In the other words, does the offer of tags by teachers match the demand by teachers? A measure for "attractive tags" was created which compared the amount of clickstream (i.e. demand) on a tag to how many times it had been added by teachers (i.e. supply). If the number is above one (1), it means that the tag has generated more clickstream than tag applications. This means that the tag is "attractive". If the number equals one, it means that there is an equal amount of both, and below one indicates that there are tag applications, but no demand. 21% of tags were found "attractive" (Figure 5.2) and 24% had an equal demand and offer. 55% of tags received less clicks than there were tags applied to resources. Language-wise, within the "attractive" and "equal" tags, 28% were in another language than English.

WHAT DO EXPERT INDEXERS THINK OF TAGS?

Out of the original dataset, a sample of ten learning resources with user-generated tags was selected that a) had a high number of tags and/or b) offered some variety in terms of discipline and type of resources. This data was used in order to obtain feedback from 15 expert indexers who work with metadata and classification of resources in a learning resource repository or portal. The details of these evaluations are reported in Vuorikari & Ayre (2009). There were ten resources that included 23 Thesaurus terms as descriptors and 88 tags. The indexers were asked to evaluate the usefulness of end-user created tags as descriptors of learning resources.

In general, it was detected that expert indexers were positive towards tags; they were evaluated as being suitable (i.e. clear and unambiguous) as indexing keywords (average 30%) and were actually added to the original LOM description (average 26%). The "Thesaurus tags" featured prominently (43%) among tags that expert indexers voted above average on the question "Would you want to revise the original LOM description of the resource and, if so, which of the following terms might you adopt" (Table 6.5, right column). Especially in the case where the original indexing was poor or limited, for example, due to too broad indexing, participants in the study indicated that they would be prepared to adopt these "Thesaurus tags". Examples of these tags in our analyses are: chemistry, culture, Európa, Europe, grammar, information, kemia, kultúra, reading, szobor, thermodynamics, vocabulary.

There were also potential Thesaurus tags – some tags that have an almost identical spelling to Thesaurus terms; however, these cannot be identified automatically, but require human intervention. Examples are tags such as

"english" which could be mapped to Thesaurus term "English language", or "french" to "French language".

WHAT DO REPOSITORY MANAGERS THINK OF TAGS?

A focus group with five learning resource repository or portal managers was run to better understand how they perceived the value of tags. These are reported in detail in Vuorikari & Ayre (2009). One of the activities was a small case study where a repository manager analysed the added value of tags to existing Learning Object Metadata (LOM). The case in question is the repository of the Tiger Leap Foundation (2009) which is part of the LRE federation. The study comprised 84 bookmarks on 63 distinct resources where users from different European countries had added tags to them. The tags were compared with the existing LOM, its keywords, LRE Thesaurus terms and other classification information such as curriculum topics.

In 25% of the cases the tags provided additional value for the repository. Tags, for example, described the content of the resource more clearly (tags 'Australia' and 'USA' added for the resource "English-speaking countries", or 'culture', 'nature' added for a resource titled "Scotland"). Even if the sample size is very small, the results point in the same direction as previous studies, e.g. Hayemann et al., 2008 compared tags with the page text and back and forward link page text, and found that in 20% of the cases tags provided search data not provided by other sources.

It was found that in 49% of the cases, the information that the tags provided was already reflected in existing keywords, LRE Thesaurus terms or in other classification information, and in 26% of the cases tags included somewhat redundant information, which already existed in other elements of the LOM description. The following redundancy was observed with elements of the LOM description:

- LOM 5.2: resource type (e.g. photo, picture; exercises, games; simulations; quiz, web quest)
- LOM 5.7: the age group being addressed (e.g. young learners)
- LOM 1.3: the language of the resource (e.g. English).

Discussion

This study has focused on the interplay of tags and Learning Object Metadata descriptions that takes place on the learning resource portal. The issue has been studied from multiple points of view, namely that of end-users, expert indexers and repository managers. A number of levels where possibilities for interplay exist were shown that arise interesting issues. It was found that a third of tag applications by the end-users are actually descriptors that exist in the LRE Multilingual Thesaurus. These "Thesaurus tags" by users can be used to improve the semantic interoperability of tags. First, they have a potential to be

used as a “bridge” between existing descriptors and tags, and thus enhance the semantic interoperability within and across languages.

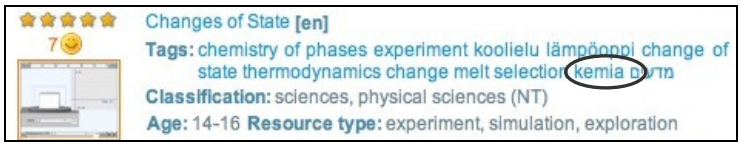

Figure 6.2. Learning resource “Change of State” with tags (e.g. “kemia”) and indexing terms “sciences” and “physical sciences” from the multilingual Thesaurus.

One example is the resource “Change of State” in Figure 6.2, which has tags by end-users as well as the classification terms by the expert indexer. Table 6.6, on the other hand, shows the Thesaurus “descriptor 195” representing the concept of “chemistry” with its language equivalences. As can now be observed, the tag “kemia” is actually a “Thesaurus tag”. Thanks to the multilingual Thesaurus, the similarity between a “Thesaurus tag” and the descriptor was recognised. Properties to these tags can be assigned from the Thesaurus, e.g. the tag “kemia” is related to the concept of “descriptor 195” and its language is Finnish. A similar idea of connecting tags to existing ontologies has been presented by Bateman, Brooks & McCalla (2006), although the difference is that in this case, the resource and its existing descriptors are used as a proxy for the semantic link between the descriptor and tag, and that this process can be automated to take place at the back-end without being intrusive to the user.

The information gained from the link between the “Thesaurus tag” and the descriptor can be used in various ways. It can be used, for example, in the tagcloud to show different translations of the tag “kemia”. As for the retrieval purposes, the system could infer that other resources indexed with the “descriptor 195” are also relevant. Here, the user will get a chance to retrieve learning resources in multiple languages, thanks to the inter-language connection that the multilingual Thesaurus offers. Moreover, “Thesaurus tags” open new options to navigate across multilingual resources as, for example, displaying all the tags that are related to the “descriptor 195” could be envisaged to create a multilingual chemistry tagcloud.

Table 6.6. Language equivalences for the Thesaurus “descriptor 195”, including also one user-generated "Thesaurus tag" kemia.

Descriptor ID	Lg equivalences	
195	Chemie	fr
	chemistry	en
	kemi	sv
	kemia (tag)	fi
	kémia	hu

Secondly, the “Thesaurus tags” can be suitable descriptors to be added to the original LOM description of the learning resource, particularly in cases where

the original indexing has been poor or limited. In the example of “Change of State”, it is known from the Thesaurus hierarchies that the “descriptor 195” is a narrower term of the existing indexing term “physical sciences”. As the “Thesaurus tag” narrows down the current classification of the learning resource in question, its addition as a new classification term for the resource can be automated.

Thirdly, the area of intra-language equivalence within the multilingual Thesaurus could be improved with tags, as in the evaluations they have been identified as a good source for non-descriptors. A non-descriptor provides the intra-language equivalence that facilitates access to resources that are indexed by using the thesaurus terms that do not translate well to the language that the end-user uses. For example, the tag “efl” (= “English as foreign language”) could be expressed in thesauri terms as “English language” + “foreign language”. When the user types a text search “efl”, not only tagged resources would be retrieved, but also the ones with the above descriptors. In this way the gap between natural language and controlled language could be reduced. The same could apply also for gathering better scope-notes, which deal with the meaning of terms and help the user to understand the term better. Especially in a multilingual context, where some differences occur from one language/culture to another, this feature is useful to understand cultural differences.

Lastly, in the area of interplay between the tags and Thesaurus, the Thesaurus enrichment should be noted. Tags can help to define, verify and enrich, and then redefine a number of relationships in thesauri. The evaluations have shown that tags can help identify areas in the Thesaurus where descriptors are not sufficient and thus need enrichment.

It has also been shown that tags can yield important information for the repository owners. In the case study it was shown that a small number of tags added value to the existing LOM by better clarifying the content and thus enriching it. The fact that many tags were redundant with the existing LOM description, on the other hand, can make an interesting case for generating a more complete LOM description automatically from the tags. Moreover, the clickstream generated from the users’ attention could be used to indicate areas in which the users have current interest and thus help the repository manager to display a larger number of potentially relevant resources. Seeing the popularity of some tags in the tagcloud (e.g. English, interactivity), the repository managers could also take advantage of the other elements of LOM (e.g. type, language, classification keyword) to create new navigation paths à la tagcloud, which seem to be very attractive for users. In similar lines goes the ideas that tags interplay with end-users by allowing them to create their own “eco-scape” of resources by using tags in a way that Marlow et al. (2006) call “self presentation”. This enhances the personal retrieval of resources and thus allows users to claim more ownership of resources. This type of “ego-scape” can further be used by other users to discover resources.

Finally, more flexibility was created due to the added value of a social tagging tool, a demonstration of which is the users’ and metadata’s adaptability to a

changing environment. A demonstration of robustness, on the other hand, was that even when one or more elements of original LOM failed in its purpose for describing or retrieval purposes, thanks to social tags, the users were still able to perform the tasks, i.e. discover and reuse learning resources across contexts (e.g. language, country, curriculum, repository).

Conclusion and future work

This study has helped better understand the "metadata ecology", a term that can be used to describe the interrelation of conventional metadata (e.g. LRE Application profile) and social tags on the one hand, and their interaction with the environment, which can be understood as the repository, its resources and stakeholders. Interplay between tags and descriptors was found, and on the other hand, it was shown that tags can enrich and add value to multilingual controlled vocabularies as the multilingual LRE Thesaurus (LRE, 2002). In addition, how tags can become a useful source of metadata for repository owners was shown, as well as how "attractive tags" can be used to gauge users' needs and demands.

Having established in this study that not all the tags are as far from the Thesaurus descriptors as Mars is from Venus, future work should particularly focus on improving the link between tags and terminological knowledge base such as the LRE thesaurus. Tags have been created in a specific cultural context where educational language is used, and thus are valuable as a way to reduce the gap between natural and controlled languages. Moreover, further work should focus on the inherent connections between tags and resources to support and enhance the discovery of learning resources across contexts.

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Chapter 7

Comparison of educational tagging systems – any chances of interplay?

Chapter is based on Vuorikari, R., Põldoja, H. & Koper, R. (2010). Comparison of educational tagging systems – any chances of interplay? *International Journal of Technology Enhanced Learning,2*.

Abstract

Web-based tagging systems for educational resources allow users to associate free keywords with learning resources. First, the similarities and differences of tagging systems that are an integrated part of learning resource platforms are studied, and then a case study on teachers use of social tagging tools is introduced. Finally, more than 20,000 teacher-created tags originating from five different platforms were analysed. It was found that even if the tagging system design decisions differ, more than 30% of the posts were shared through tags between two or more platforms. We show that tags can be used to create interplay not only between the users and their tools, but also between diverse learning resource platforms, adding more flexibility for users. In this paper, the goal is to discuss the use of tags across different contexts (e.g. system, language, nation/region) to create a better interplay between learning resource platforms and their users.

Introduction

End-user generated tags for learning resources in a Learning Object Repository (LOR) can be seen as part of the dialogue for the co-construction of knowledge and individual's participation in social interactions (Vygotsky, 1978; Engeström, 1987). Margaryan & Littlejohn (2008) suggest that Activity Theory offers a theoretical framework that allows studying LORs and communities as a single system, rather than as a loose set of instruments, subjects, objects and outcomes. Similarly, Activity Theory can be adapted to study LORs and tags as part of social interactions.

Using such a framework, the barriers and enablers of learning resource repositories' usage were studied (Margaryan & Littlejohn, 2008). One barrier was the mismatch between how repository curators and users perceived the services. The authors argue that curators' repository-centric perspective frequently leads to introduction of repositories as stand alone tools to users. However, they note that repositories are not used in isolation. They are part of the repertoire of tools that individuals and communities use to achieve learning goals. Therefore, they claim, the interplay between repositories and existing tools has to be considered.

Such an interplay with existing educational offers (e.g. learning resources, learning platforms, tools) is central to this research. In this contribution, the focus is on tagging tools that are offered as a feature of an educational LOR or platform, and how users (e.g. teachers) use these tools in an educational context. Seen from the user's point of view, a LOR is only one component within an entire repertoire of tools that she or he uses for a given information seeking task. Therefore, more flexibility for users is desirable. This paper focuses on the interplay between a number of educational resource platforms (Maier & Thalmann, 2008; Vuorikari & Põldoja, 2008).

First, a brief overview of the application domain, the learning resources repositories, is provided with an introduction to the fundamentals of social

tagging. The following section introduces the educational resource platforms in this study, and using the taxonomy from Marlow et al. (2006), describes how tagging has been applied in these platforms and what are their differences and similarities. Then, a case study on users' learning resource collections is presented. Finally, a proof of concept for the interplay between five tagging systems in educational context is presented proposing that an aggregated cross-application tagcloud can potentially enhance the interplay between existing tools by offering novel ways of social navigation not only across applications, but also across language and national contexts. Finally, a discussion and conclusions are offered.

Learning resources, repositories and social bookmarking

Digital learning resources, and/or their associated metadata, are typically organised, classified and stored in online databases, often called learning object repositories (LORs) or digital libraries. A rich variety of LORs currently operate online facilitating learners', teachers' and tutors' access to learning resources in different contexts (e.g. disciplines, languages, curricula alignment) (Tzikopoulos, Manouselis & Vuorikari, 2007). Previous studies have focused on the use of LORs in different educational contexts (McCormick et al., 2004; Strijker, 2004; Harley, Henke & Nasatir, 2006; Margaryan & Littlejohn, 2008; Petrides et al., 2008).

Conventionally, expert indexers or librarians catalogue learning resources using metadata standards such as the IEEE Learning Object Metadata (LOM, 2002) or the Dublin Core metadata (DC, 2003). The quality of metadata can be evaluated from two different perspectives: its validity in terms of its ability to describe the resource and its usefulness for 'searchability' and how well it supports retrieval of the resource (Barritt & Alderman, 2004).

Searching learning resources both within a repository and across repositories using metadata is crucial (e.g. Ternier et al., 2008; Massart, 2009), as content oftentimes is not cross-referenced via hyperlinks. The situation is similar to "Enterprise search" (Mukherjee & Mao, 2004), where content from heterogeneous repositories is made available on the intranet lacking the typical link-structure of the Internet, and thus unsuitable for PageRank-type of algorithms (Brin & Page, 1998). LORs traditionally share a similar search problem: repositories from different institutions and countries offer content in similar curriculum areas, however, the content is seldom cross-referenced via hyperlinks. Especially in the European context, where learning resources are offered in a variety of national and regional settings (for an overview of learning resource repositories in Europe and beyond, see EdReNe, 2008), cross-referencing across national borders is rare. Halavais (2000) found that Web sites in most cases are more likely to link to another site hosted in the same country than to cross national borders. Language-wise, Berendt & Kralisch (2009) show that the smaller the language is, the smaller the relative percentage of in-links is. This indicates that non-English languages are under-

represented on the Web in terms of the links that content creators set in those languages, creating yet another barrier to cross-language searches.

In the last years, the proliferation of social media has changed how the production and use of metadata is perceived, but also the way users discover content through social networks. Social bookmarking services are a sub-group of social network sites. boyd (2006) offers her definition: "social network site" is a category of websites with profiles, semi-persistent public commentary on the profile, and a traversable publicly articulated social network displayed in relation to the profile. In bookmarking and tagging systems, each user has a profile, annotations are supported in terms of tags on the content artefacts, and the creation and support of implicit and explicit social networks emerge from different types of interactions. Tagging describes the act of end-users adding non-hierarchical, free keywords to any type of digital resource, regardless of its physical existence on a given service, repository, or database.

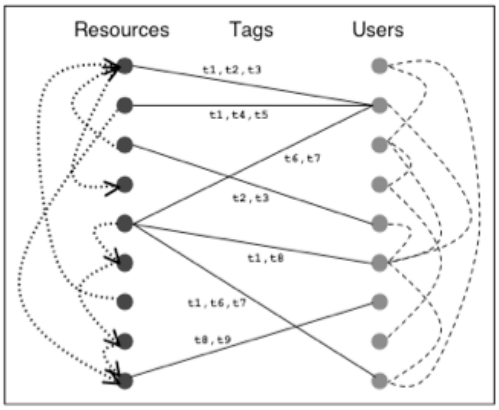

Figure 7.1. Model of a tagging system (Marlow et al., 2006).

Marlow et al. (2006) propose a model for the underlying structure of the social tagging system with three main components; resources, tags and users. Figure 7.1 depicts this conceptual model where users assign tags to a specific resource; tags are represented as typed edges (i.e. links) connecting users and resources. Resources may also be connected to each other (e.g., as links between web pages) and users may be associated by a social network, or sets of affiliations (e.g., users that work for the same company). Moreover, Marlow et al. (2006) show that the socio-technical design of the system affects the information it generates. For the purpose of designing such systems they propose two taxonomies: “System design and attributes” which may affect the nature and distribution of tags, and therefore the attributes of the information collected by the system; and “User incentives” that largely affect how users behave, the forms of contribution allowed and the personal and social motivations for adding input to the system.

Tags and folksonomies thus offer complementary ways to explore the content by searching, filtering, navigating, and exploring other users' tags and tagged items. Tagclouds, for example, consist of tags that users of a given tagging service have associated with the resources, and can be aggregated on different levels, such as personal, resource-specific or global tagclouds. According to Golder & Huberman (2006), tagging is like filtering; out of all the possible items that are tagged, a filter (i.e. a tag) returns only those items identified with that tag. From a user perspective, navigating a tag system is similar to conducting keyword-based searches; regardless of the implementation, users are providing salient, descriptive terms in order to retrieve a set of applicable items.

As the end-users add free keywords to photos, links and various other digital artefacts, the distinction between formal types of metadata and informal ways of 'tagging' resources starts to change. Critics suggest that social tagging and folksonomies are characterised by flaws that formal classification systems are designed to eliminate. In addition, social tagging and folksonomies all but invite deliberately idiosyncratic tagging, called 'meta noise', which burdens users and decreases the systems' information retrieval utility. It is argued that top-down taxonomies or ontologies enable more efficient indexing and searching of content (Guy & Tonkin, 2006).

Recent research on tags has focused on their use to enhance Web search. Heymann, Koutrika & Garcia-Molina (2008) conclude that tags are unlikely to be much more useful than a full text search emphasising page titles, as over 50 % of tags occur in the page's title, the body of text, or within backward or forward links. Yanbe, Jatowt, Nakamura & Tanaka (2007), on the other hand, show that social bookmarks can be used to increase the precision and "freshness" of a standard link-based search, and to extend the search capabilities of existing search engines. Santos-Neto, Condon, Nazareno & Ripeanu (2009) show that the item-based interest structure of social tagging is much more segmented than its tag-based counterpart, thus tag-based social browsing interface could be beneficial.

What makes social tagging systems different from conventional indexing approaches is the fact that they support and enhance social interactions. Such systems allow users to connect to other users, but also to their resources and tags. These connections happen through relationships that are formed between users, their resources and tags. These underlying social structures, or networks, become important for creating the missing cross-referencing structure that did not exist before between separate pieces of content. Millen et al. (2007) studied Social bookmarking in IBM and suggest that when integrated with traditional search engines, social tagging has the potential to solve "Enterprise search" problems.

Similarly, the goal is to study whether this could be the case for the domain of learning resources. Learning resource platforms such as LeMill, Learning Resource Exchange (LRE) and OER Commons have end-user tags and/or social bookmarking as part of the tool sets offered to users. In the following section the tags and the specifics of these different tagging systems in an

educational context are studied to better understand their domain specific use. In addition, the similarities and differences between these systems and their outcomes, tags, are studied in order to investigate their further use for crossing different contexts (e.g. repository, language, nation/region) to enhance the discovery learning resources.

Table 7.1. Dataset description of repositories, * refers to the taxonomy of tagging systems proposed by Marlow et al., 2006. The shaded cells indicate similarities between features.

	Calibrate lreforschools.eun.org	**LeMill lemill.net**	**OER Commons www.oercommons.org**
1. Time span	Nov 2006-Nov 2007	May 2006-Dec 2007	Dec 2006-March 2007
2. # of resources tagged	682	3249	200
3. # of tags	920	3543	244
4. # of tags applied	1282	9257	502
5. # of users tagging	142	436	91
6. Average of tags/resources	1.9 tags/resource	2.8 tags/resource	2.5 tags/resource
7. User incentives to tag*	"Keep found things found", personal retrieval	Share with groups; attract attention, future retrieval	Future retrieval, contribution and sharing
8. Objects types*	Textual, metadata of learning resources	User-contributed, self-authored resource (textual, non-textual)	User-contributed metadata of learning resources
9. Source of material*	System, from educational repositories	User	System, from educational repositories, users
10. Tagging rights *	Free-for-all tagging	Self-tagging, free-for-all	Free-for-all tagging
11. Tagging support*	Blind / viewable tagging	Blind tagging	Viewable tagging
12. Resource connectivity*	None	Grouped, linked	Linked
13. Social connectivity*	None	Grouped, linked	Grouped
14. Other annotations	Rating, comment (public/private)	Teaching/learning story	Ratings, my notes
15. Create a collection	Favourites = bookmark+tags	Collections, no tags related	myPortfolio, add tags possible
16. Language of tags	Multiple languages, users from 5 countries	Multiple languages, users from 39 countries	Mostly English, users from different countries

Comparison study of three tagging systems on learning resources

In order to investigate the possibilities of using tags as a way to access learning resources across different applications, three educational platforms are studied (Table 7.1). Early work on tagging systems in a general context has shown that systems have different dynamics; Marlow et al. (2006) find that system-level design choices and user incentives affect the nature and distribution of tags. Similarly, Sen et al. (2006) demonstrate that tag input systems affect the nature and distribution of tags, as well as the uptake of the tagging activity. Is this also the case with different educational tagging systems, and do tags differ from one platform to another?

TAGGING SYSTEMS AND DATASETS

A uniform way to describe each resource platform with a tagging tool is used in this study to allow the comparison of their differences and similarities. First, a general description is given, then the user incentives to tag and the purposes for which the tags are used are explained for each platform. Following, the 20 most used tags in each system are sampled, their languages, frequency and number of users are studied. The tags are classified to factual, subjective and personal tags (Sen et al., 2006; Golder & Huberman, 2006). Then, a short discussion on tags in each system is provided.

The Calibrate portal, LeMill and OER Commons all share the same macro-context. They offer learning resources in the main curriculum area in English and in other languages for the target audience of teachers, learners and educators. During the period when the datasets were acquired (in December 2007), the Calibrate portal and LeMill mostly had users from the New Member countries in the EU, whereas OER Commons mostly served an American audience. The log-files were obtained from each repository for learning resources that contained at least one tag. The following data was provided for each record: user ID, resource ID and tag(s).

CALIBRATE portal (the current version is known as Learning Resource Exchange http://lreforschools.eun.org). The Calibrate portal provides federated search over a number of educational repositories that belong to European Schoolnet (2009) and its associated partners. The portal was only available to pilot schools, but has now been made available publicly. Users can search (free text and advanced) and browse educational resources through the portal and create their own collections of resources called "Favourites". Users can choose the interface language from ten different languages that can also be used for searching. During the time of the data gathering, the portal provided little collaboration through tags. In the current version, the tags are made public and sharable.

User incentives for tagging: Tagging on the Calibrate portal is related to the action of creating a bookmark to an interesting learning resources that the user

wants to "keep found". Users can thus create their own collections of resources to access them later.

Purpose of tags: The purpose of tags on the Calibrate portal is personal and facilitates individual's future retrieval of interesting resources previously found on the portal. In other words, a user is related to his own collection of resources through personal tags. Tags were also used for free-text search.

Table 7.2. Twenty most used tags in Calibrate. Translations provided in (). ISO 639-1 language codes are used for languages, as in all the tables hereafter.

Calibrate	Language	Number of applications	Tag category	Users
külföldi jó (good foreign resource)	hu	70	Subjective	10
külföldi közepes (average foreign resource)	hu	52	Subjective	10
külföldi gyenge (weak foreign resource)	hu	37	Subjective	11
Angličtina (English)	cz	20	Factual, topic	3
Értékeltek (evaluation)	hu	16	Subjective	2
Literatura	cz	14	Factual, topic	2
Matematika	cz, hu	13	Factual, topic	7
Global problems	en	11	Factual	2
Test	“travel well”	10	Factual, type	3
Vesmír (Space)	cz	7	Factual, topic	2
fyzika	cz	7	Factual, topic	2
chemie	cz	6	Factual, topic	1
english in general	en	6	Factual, topic	2
europa	“travel well”	6	Factual, country	2
geometrie	hu	6	Factual, topic	1
Fénytan (optics)	hu	5	Factual, topic	1
animáció	hu	5	Factual, type	4
evropa	“travel well”	5	Factual, country	3
Planety (planets)	pl	5	Factual, topic	2
safety	en	5	Factual, topic	2

Discussion on tags: Table 7.2 lists the most used tags in the Calibrate portal. Sharing through tags mostly happened though the top three tags that were applied relatively often by a group of about ten users. Additionally, some coincidental sharing takes place: the tag "Matematika" is shared by both Hungarian and Czech users because the same word is used in both languages. Apart from these cases, there is little sharing of tags among users. The low number of users who applied tags can be observed, e.g. one or two users have created collections of resources (e.g. chemistry or geometry).

Low sharing of tags among users is most likely due to the design decision of semi-blind tagging and the fact that tags are not displayed to other users. The low sharing of tags amounts to little convergent among tags and little emerging folksonomy can be observed among users. A manual analysis of the global tags in the Calibrate system reveals that 90% of them have been applied only once by one user. Looking at the tags, some tags are found that, even if not translated, can be rather easily understood thanks to their similar spelling in many languages (e.g. literature, fyzika, chemie, europa, evropa). Tags that hardly even need translation (e.g. test) were identified. These tags are loosely grouped under the umbrella of “travel well” tags, as they propose added value for multilingual users (Vuorikari & Ochoa, 2009). From the same study, it was found that tags used in Calibrate are mostly of a factual type; they identify properties of the objects such as the topical area of the resource and some other attributes, seldom any qualitative properties. This trend is also visible in Table 6.2.

LeMill (http://lemill.net). LeMill is a web community for finding, authoring and sharing learning resources. It is divided into four sections: Content, Methods, Tools and Community. The main target audience are primary and secondary school teachers, but anyone can join. Registered users can publish learning content and descriptions of educational methods and tools. It is a wiki-like system where all the learning resources are published under an open licence and can be edited by other members.

User incentives for tagging: Tagging in LeMill is part of the content authoring workflow that includes creating the resource, adding metadata and publishing the resource. Tags are not a mandatory metadata element. The main motivation for the content creator to add tags is sharing the resource with other users. Second, tags help attract attention to a creator's content through the tagcloud, which has a central role in the navigation. Last, content creators can use tags as a personal management tool to keep their own resources organised. Personal tagclouds can be accessed through the user’s profile. Separate from tagging is a tool that allows users to create personal collections of resources. Content (learning resources, media pieces, references), methods and tools can be added to a collection to easily access them later and share them with others. It is not possible to add tags for collections.

Purpose of tags: The main purpose of tags is to be visible in a tagcloud, one of the main navigation tools. Similar cloud-like navigations have been created around other metadata too, like language, subject area and intended audience. Tags are also a way to contribute to the system and share resources among groups.

Discussion on tags: An example of sharing through tags is shown in Table 7.3 (e.g. like calibrate, r , lemill and dlf07tallinn, the latter tag standing for ”Deer Leap foundation, tallin, 07”). These are tags decided by a community that allows sharing the resources and to aggregate a thematic collection around a tag. Even if these tags are powerful for sharing and retrieving resources among a given group, they are less descriptive for the global audience.

Table 7.3 also reveals less-formal groups or ad-hoc communities that have been formed around some resources (e.g. matemaatika and matematika). These tags can also be “travel well” tags, as they are shared by different language communities. Seen from the small number of users for some tags, it can be inferred that tags in LeMill also are used for personal management to create personal collections, e.g. "projektijuhtimine" (2 users), "hambad" (2 users), geomeetria (1 user) and "felvilagosodas" (1 user).

Table 7.3. Twenty most used tags in LeMill. Translations provided in ().

LeMill	Language	Number of applications	Tag category	Users
calibrate	-	136	Personal, shared	36
r	-	116	Personal, shared	4
algebra lineal (Linear algebra)	sp	97	Factual, topic	19
projektijuhtimine (Project management)	et	82	Factual, topic	2
matemaatika	et	69	Factual, topic	16
lemill	-	65	Personal, shared	15
kõneravi (pronunciation problems)	et	64	Factual, topic	6
a first course in linear algebra	en	54	Factual, topic	10
hambad (Teeth)	et	49	Factual, topic	2
algebra	"travel well"	48	Factual, topic	7
matematika	cz, hu, lt	47	Factual, topic	12
geomeetria	et	46	Factual, topic	1
traduccion	sp	44	Factual, topic	8
felvilágosodás (enlightenment)	hu	38	Factual, topic	1
linnud (birds)	et	38	Factual, topic	16
логика (Logics)	ru	38	Factual, topic	21
Algõpetus	et	38	Factual, topic	2
dlf07tallinn	-	37	Personal, shared	1
english	en	37	Factual, topic	21

OER Commons (http://www.oercommons.org). The OER Commons allows users (teachers and professors from pre-K to graduate school) to access and share course materials and learning resources that are harvested from a number of collaborating educational repositories around the world, as well as added by users. Anyone can access resources, a number of search features that have been made available (text, advanced search, browsing topics and tags). Additionally, authenticated users are offered more features such as creating their own collections, add tags and sharing their material with other users.

User incentives for tagging: The OER Commons encourages users to add searchable metadata, such as tags, to create user's personal keyword vocabulary. The motivation for tags is similar to what Marlow et al. (2006) call "Contribution and sharing: to add to conceptual clusters for the value of either known or unknown audiences". Additionally, users can create private collections in "MyPortfolio". In this area the user can see all the saved items as a list with associated tags on the site. The user cannot, however, use the tags to filter these resources.

Table 7.4. Twenty most used tags in OER Commons.

OERCommons	Language	Number of applications	Tag category	Users
biology	en	20	Factual, topic	15
art	en	11	Factual, topic	3
globalization	en	10	Factual, topic	3
psychology	en	10	Factual, topic	3
media	en	9	Factual, topic	4
internet	“travel well”	9	Factual, topic	5
writing	en	8	Factual, topic	4
science	en	8	Factual, topic	6
civil society	en	8	Factual, topic	3
flu	en	7	Factual, topic	1
education	en	7	Factual, topic	6
evolution	en	7	Factual, topic	6
urban	en	7	Factual, topic	1
engineering	en	7	Factual, topic	4
algebra	en	6	Factual, topic	6
eLearning	en	6	Factual, topic	2
environment	en	5	Factual, topic	3
chemistry	en	5	Factual, topic	4
research	en	5	Factual, topic	3
french	en	5	Factual, topic	3

Purpose of tags: The OER Commons focuses on providing tags as additional metadata that users can use to access resources. Tags, when displayed next to conventional metadata of the resource description, can give additional cues to other users on the content and its use by creating a third-party conceptual cluster of tags. Tags also support discovery of resources; there are both a system and resource level tagclouds for navigation.

Discussion on tags: From Table 7.4 it can be seen that some tags are used by many users (e.g. algebra, evolution and education) indicating a small community forming around the topic. There are also tags that are used clearly only for personal collections of resources (e.g. flu, urban). These both provide added value for the other users through the tagcloud and resource-specific tags. Tags in Table 7.4 are all factual, the type of tag which adds high value to other users (Sen et al., 2006). Additionally, tags are all in English, which

indicates that most users either have English as their mother tongue or use English to facilitate sharing.

DIFFERENCES AND SIMILARITIES BETWEEN TAGGING SYSTEMS AND TAGS

Differences

There are a number of differences between the tagging systems. They can be observed in Table 7.1 which uses the taxonomy of characteristics of system design and user incentives. Similarities in each category are highlighted using grey cells. The main difference is in the logic of the tagging system, which is also related to the incentive for tagging: In Calibrate, tags are purely for personal retrieval purposes (Favourites), whereas in LeMill tags have the purpose of attracting other users (tagcloud) and sharing resources. In OER Commons, on the other hand, tags are searchable, additional metadata.

The tagging rights and types of objects to tag also vary; LeMill is a clear example of self-tagging (e.g. Flickr), where the type of object being tagged is typically a resource or a reference created by the user. In Calibrate and OER Commons, users mostly tag resources that are created by someone else. Users actually tag only the metadata reference of the resources, which might reside on some other educational repository.

Users tag differently (Table 7.5); 80% of users in Calibrate have only applied one tag to a resource, whereas in LeMill and OER Commons, users apply more tags. In LeMill, where the creator of the resource mostly adds tags, about 75% of resources have two or more tags and in OER Commons about 60% of resources have more than one tag.

Table 7.5. Percentage of tags per resource in each platform.

Tags / resource	LeMill	OERCommons	Calibrate
1 tag	28%	41%	80%
2 tags	22%	18%	15%
3 tags	20%	22%	3 more 5%
4 or more tags	30%	19%	-

Looking at the nature of tags in each system, it can be seen that in OER Commons tags are very factual. This can be due to visibility of tags (tagclouds and related tags are displayed). Due to common workshops and project related activities more subjective tags can be observed in Calibrate (Table 7.2, no: 1,2,3) and LeMill (Table 7.4, no: 1,2,5). Both OER Commons and LeMill have more convergent folksonomies starting to emerge, whereas in Calibrate, sharing the same vocabulary between users of the system is less. Lastly, differences in the languages in which people tag are observed: the most used tags in OER Commons are in English, whereas in Calibrate and LeMill different languages reflect the user base of each system.

Table 7.6. Tags that appear in more than one service.

n=4707 distinct tags	Number of distinct tags	% of all distinct tags	Tag applications (% of all)
Tags shared in 3	19	0.4%	313 (2.7%)
Tags shared in 2	244	5.2%	1654 (14.2%)

Similarities

Although there are many differences in design decisions on the system level, the purpose of tags in each system, and the incentive schemes for users to tag, in the sample of the most used tags (20). It can be noted that they are very similar in their nature. A majority of them are factual, and represent properties that might be useful for other users of different educational systems.

Table 7.7. Tags that appear in all three platforms for learning resources.

Tag	Number of applications
algebra	58
biology	37
internet	27
europe	23
environment	22
water	21
art	19
music	15
grammar	14
education	13
film	13
science	12
london	9
eu	7
german	6
culture	5
climate	4
games	4
quiz	4

A manual comparison of the most used tags was conducted on a pairwise basis, as in Muller (2007). It was found that common tags appear in each pair of the tagging services; Calibrate-LeMill (8), LeMill-OER (8) and Calibrate-OER (4). These tags contain semantic similarities: they share the same tag (e.g. algebra), cover similar topical areas (e.g. biology, Birds, linnud=birds in Estonian) or the same topic in different languages (e.g. chemistry, chemie). 18 out of 60 tags appeared in more than one service.

Inspired by these similarities, the overlap of tags in all three services was studied by analysing 4707 distinct tags in the datasets. Table 7.6 shows that 19 tags were shared among all three services (0.4% of all distinct tags) resulting in 313 tag applications (2.7% of all posts). These tags are listed in Table 7.7, where it can be seen that similarities were not only found among the most popular tags, but also in the “long tail”, i.e., among tags that had been applied only a few times. It was also found that about 5% of the distinct tags are shared between two services which results to 14.2% of all tag applications on these platforms, thus forming link-structures across learning resource platforms through tags (pair “tag-item”).

A notable similarity between tags in each system is that they cover a number of the topical areas that are shared among many of the educational systems (e.g. mathematics, sciences). Moreover, "travel well" tags were found in each repository. These tags can be found useful thanks to their similarity in spelling in many languages. These are names such as “internet”, place names (e.g. europe), and commonly known acronyms (e.g. eu). They are easily understandable in many languages and do not always need to be translated, thus they are powerful in a multilingual context.

In this Section the differences and similarities of tagging systems for educational resources were studied. It can be concluded that the tagging systems in an educational context can be described using the common taxonomy for social bookmarking systems. When positioned on the dimensions of the tagging design taxonomy by Marlow et al. (2006), the educational tagging tools represent rather different system types, almost similarly to the comparison that the same authors made on delicious.com vs. Flickr. Tags produced by end-users in these different tagging systems appear very similar despite big differences in system-level design choices and user incentives. The similarities most likely stem from the similarities in the context and the user-base (e.g. teachers), who mostly teach similar curriculum areas (i.e. macro-contexts) despite differences in national and regional curriculum and standards alignment, rather than the inherent differences in the tagging systems as explained by Marlow et al. (2006).

Social bookmarks on non-institutionalised collections of learning resources

Teachers use a plethora of ways to discover educational content online. Harley, Henke & Nasatir (2006) report on search strategies of 4500 US faculty members where Google-like searches are by far the most prominent (81%), second most important being personal Collections of resources (72%), and followed by “portals” that provide links to disciplinary topics (55%). In a user group comprised of 45 language and science teachers in K-12 education, such diversity of strategies was also observed: one third use national and regional educational repositories as their primary source of educational content, 28%

use search engines, 21% said they create their own content, 7% use content from schoolbook publishers and 12% reported all of the above.

These different search strategies highlight the argument from Margaryan & Littlejohn (2008) that learning resource repositories are not used in isolation; rather a diversity of tools is deployed. Table 7.8 presents the data of a case study with 16 teachers. These teachers have an account on both the LRE portal and on delicious.com.

Table 7.8. The data sets from *delicious.com* and the MELT portal.

	Users	Posts downloaded	Distinct resources	Distinct tags	Tags applied	All posts from this Group
delicious.com	16	1176	1081	944	1583	3222
LRE portal	16	245	107	301	665	245

METHOD

The users are primary and secondary teachers in science, language learning and ICTs from Finland, Estonia, Hungary and Belgium. Seven are female and nine male. One participant is under 30 years old, eight are between 30-40 years, five between 40-50 years, and two are between 50 and 60 years old. Most of the participants were first introduced to delicious.com during the MELT Summer school in 2007. In March 2008 they were invited to create a profile on the portal, which collects attention metadata regarding the learning resources bookmarked on the portal (posts). This includes information about the resource itself (e.g. LOM) and the tags applied. Their delicious.com usernames were asked when they participated in the MELT Summer school in 2008, acknowledging participation in this study. Additional user observations and interviews were conducted (Zens, 2009).

From delicious.com, using the html-export service, users' 100 last posts including the tags were gathered. The total number of posts was recorded, as well as all the tags applied and usernames within the network. Table 7.8 presents the data sets; the term "distinct" for a tag or a resource that has been recorded in the system is used, as opposed to applied, which means how many times the tag has been associated with a post or how many times the same resource appears in collections.

RESULTS

A manual analysis of the 50 most used distinct tags associated to posts in delicious.com was performed to assess the nature of these resources. Almost all of them were related to educational context, such as teaching in general and often teaching English and grammar. Additionally, the URLs were analysed to check whether they contain certain keywords (e.g. esl, English) and names (e.g. wiki, blog, YouTube, LeMill, Sulinet). Table 7.9 shows a sample of posts that matched with the keywords, they comprise 57% of the downloaded posts. 52% of these posts are somehow related to learning resources, such as learning

resource portals, science and language learning websites, dictionaries and reference material. 40% of the URLs indicate user-generated content such as blogs, wiki pages, Google-pages, photos and YouTube, also often related to educational activities. 7% seem to point towards software for the Web and media.

Table 7.9. Type of content that is found in teachers' *delicious.com* accounts.

Type of content in teachers' delicious.com accounts	Tag applications	%
Learning resources (e.g. portals, science and language learning resources, maps)	353	52%
User generated content (e.g. wikis, blogs, photos, Slideshare, YouTube)	273	40%
Other software tools for media and web	49	7%
Percentage of all downloaded posts	*675*	*57%*

Table 7.8 shows that the amount of posts in delicious.com by the studied group is substantial (3222): the median amount of posts was 105.5 per account compared to 15 per account in LRE. 59% of delicious.com users were above average, which can indicate a dedicated and systematic use of the tool. Interestingly, there seemed to be very little overlap of resources in users' collections in delicious.com. Whereas in LRE, the number of distinct resources is more than twice as high as the posts (245 vs. 107), in delicious.com this number is almost equal (1176 vs. 1081).

DISCUSSION

Although the data sets are not directly comparable (most users have been using delicious.com more or less for a year, whereas the portal only for 3 months), they point in the same direction as the previous research (Harley, Henke & Nasatir, 2006; Margaryan & Littlejohn, 2008): teachers apply multiple strategies and use different sources to gather online teaching material, both from institutional sources like LORs by national educational authorities, but also other sources, as well as user generated content. It also raises the question whether repositories and educational platforms should integrate social tagging tools to their services, which in the best case allows communities to form around their content, but at worst, sets the limits only to the offering from the given platform. Or should the use of existing tools like delicious.com or Diigo (2009) be encouraged? In the following Section, some reflection on this question is offered by introducing a mid-way solution.

Sharing tags across educational tagging systems

It has been demonstrated that the tags in different educational platforms share strong similarities. Instead of sharing only resources and their respective LOM, sharing metadata such as "tag-item" pair becomes interesting. Secondly, in the case study, teachers' use of multiple platforms to search for suitable learning resources was studied. Inspired by an observation that curators' repository-

centric perspective frequently leads to introduction of repositories as stand-alone tools to users, interplay between a number of tools (e.g. repositories, authoring and collaboration platforms, social bookmarking services) that individuals and communities use in educational context seems a desirable solution.

Table 7.10.Tags shared among five different tagging tools in an educational context.

Tags appear	Distinct tags	Tag applications	% of tag applications
in more than 2 platforms	147	3047	16.0%
in 2 platforms	519	3405	14.3%
Total in 2 or more platforms	666	6452	30.3%
All distinct tags 5 services	*9036*	*21269*	

All the tags from different services in the previous dataset were collected and the same process of analysing overlap between tags was followed. This results in 9036 distinct tags from Calibrate, LeMill, OER Commons, LRE Portal and delicious.com. It was found that 666 of the distinct tags (7.4% of all distinct tags) overlap at least in two out of five different tagging systems (Table 7.10). They result in 6452 tag applications, which covers 30% of all the posts in the dataset. Using this "tag-item" relation, an aggregated tagcloud can be created which comprises tags that are shared with two or more tagging systems in educational context (Figure 7.2).

In Figure 7.2 the tag "algebra" is highlighted. The user sees that this tag has been used by other users in different learning resource platforms: LeMill (48), OER Commons (6), Calibrate (4), LRE (3) and once in delicious.com. By clicking on any of the names, the user is taken to the respective platform and its search interface, where a list of these handpicked and tagged resources is found. Almost seamlessly to the user, she has crossed over the system border to another resource platform and finds resources that users in that given community have indicated suitable to be used for "algebra".

This type of aggregated "cross-platform tagcloud" creates novel, community-based social navigation systems that take advantage of users' participation in social interaction and co-construction of knowledge. Such a tagcloud could be offered by each platform in addition to their other search tools.

Discussion

In this paper the similarities and differences among three different tagging systems for educational resources has been studied. Additionally, a case study on educators' use of tagging both on a resource portal and using a generic tagging tool to manage their private collections of learning resources was presented. It was shown that even if the tagging system design decisions differ,

the outcomes, i.e. the tags, are very similar across applications. This is allocated to similar macro-contexts: users (e.g. educators, learners) have interest in similar discipline areas and share a number of similar learning and teaching tasks, even across languages, curriculum and national contexts. Moreover, it has been shown that the interplay between the tools and users could be created through an aggregated cross-application tagcloud. Yet another form of interplay emerges, namely that of content coming from heterogeneous repositories that typically do not cross-reference each other via link-structures.

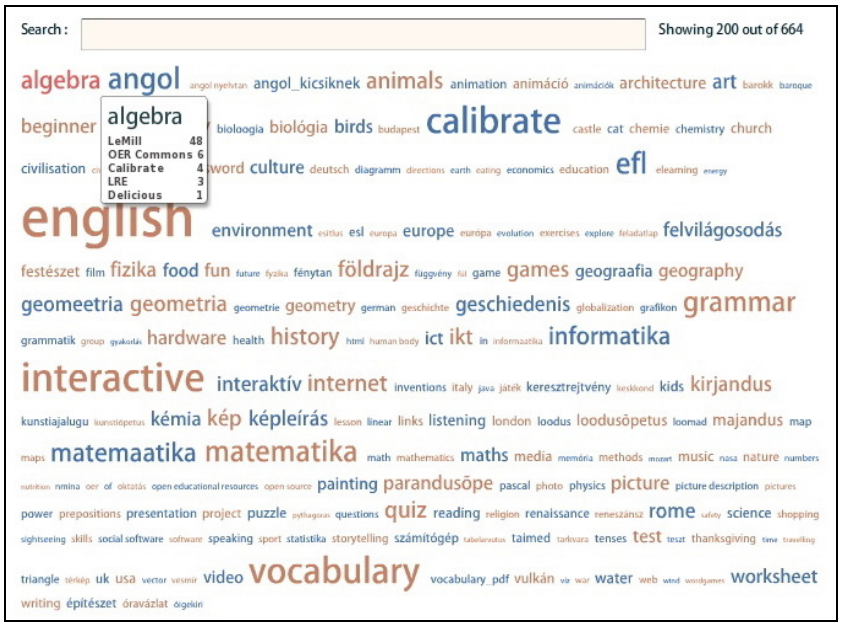

Figure 7.2. An aggregated tagcloud for learning resources from five different tagging applications.

The idea of allowing users to access resources originating from different platforms through tags is complimentary to other forms of sharing learning resources and their metadata between repositories (e.g. Ternier et al., 2008; Massart, 2009). The proposal of a cross-platform tagcloud, though, introduces three new aspects. First, it builds on the social interactions among users in terms of co-construction of knowledge as tags, and secondly, it uses them as a way to offer interplay between learning resource platforms. Lastly, it introduces the idea of accessing both institutional resources (usually subject to some quality control within a closed information retrieval system) and private collections of resources from various sources. Such ideas are novel in the area of learning object repositories, where the de facto way of sharing resources is based on federating and harvesting metadata. Instead of accessing the entire set of “conventional” metadata, which can amount to thousands of resources (e.g. the LRE alone makes more than 35 000 resources available), “human-made” filters, i.e. tags, bridge between platforms and guide the user’s choice of resources.

Positive feedback has been received regarding the use of tagclouds by teachers in a federation of repositories (Zens, 2009). However, “fit for purpose” regarding users’ information seeking tasks is important. Sinclair & Cardew-Hall (2008) show that where the user’s information-seeking task was more general, participants preferred the tagcloud, but, when the information-seeking task required specific information, participants preferred the search interface. Ways to liaise between search tasks, contexts and different ways to search is important. Additionally, future work in this area should concentrate on assessing the intellectual value of tags (e.g. Farooq et al., 2007), as well as multilinguality of tags (Vuorikari & Ochoa, 2009).

Making the user experience more coherent and flexible through the integration across applications, rather than creating one monolithic system that is expected to be used by all, can play an important role. As in the social software scene, where users are offered tools to track their participation on diverse applications (e.g. APML, ULML), similar tools could be offered for learners and teachers to keep track of their attention and participation (e.g. content and communication in a large sense) across educational applications (Vuorikari, 2008). This, however, requires efforts from the educational application providers, for example, to generate metadata regarding users’ attention in Web feeds (e.g. Rss, Atom). Interoperability and data portability, not to mention the privacy, become crucial for the reuse of data.

Lastly, it has been shown that content coming from heterogeneous repositories that typically do not cross-reference each other via link-structures has such cross-references thanks to the triple (user,item,tag). Therefore, the link-structures from the aggregated tagcloud open more sophisticated avenues for resource discovery across contexts (e.g. language, country, curriculum, repository). Future work focusing on using these underlying connections to create measures of resources’ importance will offer plenty of research challenges. Similarly to the Page-Rank algorithm (Brin & Page, 1998), tags, creating underlying connections between seemingly random pieces of content in different languages (and from repositories in different countries), rely on humans’ subjective idea of their importance for a given information-seeking task. Using this new, emerging link-structure, and involving tags as “anchor texts” (Kinsella et al., 2008), could offer totally new ways to “organise the world's learning resources and make them universally accessible and useful”, similar to what Google claims its mission statement is for world’s information. Additionally, resource’s potential for crossing across different contexts could be detected from the same link-structure. Resources-specific tags, for example, that appear in many different languages could indicate that the resource is being used in different language contexts and thus has potential to be used across contexts. Similarly, resources with users from a number of different countries could indicate that these resources are being used in different country and curriculum contexts. Conversely, resources that have tags associated to them only in one language or only by users from the same country as the resource is, could be disregarded and given less importance for the across-context discovery.

Conclusions

In this paper tagging systems and the interplay between users and tools was studied, and on the other hand, the focus was on tags and resources. It has been demonstrated how the end-user generated tags create cross-references between separate pieces of content which reside in heterogeneous content platforms in a multilingual context. The triple (user,item,tag) helps create novel link-structures between cross-language content and offers new ways to take advantage of the methods known in the field of social information retrieval (e.g. social navigation, ranking of resources and social recommendations) in a multilingual context. The analyses in this paper lay the groundwork for social search ecology between a more conventional and formal metadata schemas, and user generated tag-based interest structures to allow novel ways to discover learning resources (both content and other users) across repositories, languages and across national and regional curriculum.

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Chapter 8

Results and further research

Introduction

Continuous investment in both formal and informal learning contexts are important, as people who are willing to invest in their future seek opportunities within educational institutions, but also as lifelong learners in an informal setting. Socio-economic investments in Technology Enhanced Learning and educational content are important in Europe and elsewhere. The Lifelong Learning Programme (LLP) supports learning opportunities with a budget of nearly € 7 billion for 2007 to 2013 (LLP, 2009), whereas the FP7 budget for digital libraries and TEL in 2009-2010 alone outlines € 151 million (FP7, 2009). Philanthropy plays a role too; since 2001 Hewlett Foundation has made grants in excess of $68 million to support institutions and organisations to develop and provide online access to open educational content worldwide (Atkins, Brown, & Hammond, 2007).

Efforts invested in software and content alone, though, have questionable impact: oftentimes their adoption and uptake remains low. Lately, technologies that allow end-users to connect and collaborate have seen a rise (e.g. Web 2.0). Similarly, the collaborative aspects of learning networks through common goals and co-construction of knowledge gain prominence in Europe and elsewhere. An example of this is eTwinning that connects more than 70,000 European primary and secondary school teachers linking about 15% of European schools to an ever-growing network (Fig 8.1).

To this end, this thesis has concentrated in the new emerging opportunities that social tagging and its underlying networks offer for the field of Technology Enhanced Learning, digital libraries and educational resources. What becomes an imminent challenge is to combine the content and users for more powerful collaboration, knowledge construction and sharing. The triple (user,item,tag) was used to study the use and reuse of resources in a multilingual context, paving the road for more important studies using the power of networks to support and enhance learning and teaching.

In the following Section, the results of this research are reviewed through the hypothesises that was presented in Chapter 1, namely that the self-organisation aspect of a social tagging system on a learning resource portal helps users discover learning resources more efficiently, and that user-generated tags make the system, which operates in a multilingual context, more robust and flexible. The part “Lessons learned” explores how modelling the contextual information using the triple (user,item,tag), and its extension (tag,LOM) relationship, can be used to better explore and understand users’ behaviour, interests and interactions within a multilingual environment of learning resources. Moreover, the part reviews how this information can further be used to enhance context-aware data management and processing in a multilingual environment to create more intelligent ways to foster and enhance collaborative behaviour among users, content and repositories across languages, countries and other

boundaries, such as curricula and repositories. These methods are based on cross-context link-structures that are created through social tagging, thus giving emphasis for humans' subjective judgement of the resources' importance for a given information seeking tasks, the grounding idea of Social Information Retrieval methods. Moreover, "Practical implications" of this research are then discussed, the ideas for future research challenges that rise from this research are elaborated and some limitations of this study are reflected upon.

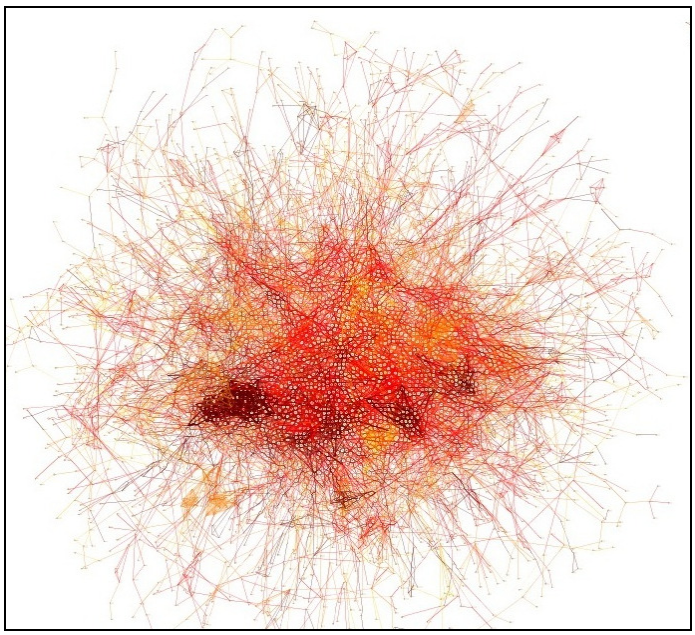

Figure 8.1. A learning network: a social network graph of about 5000 eTwinning teachers connected through common projects. The nodes are teachers and the edges are common projects (Breuer, Klamma, Cao & Vuorikari, 2009).

Self-organisation

Self-organisation represents the idea that activities are neither centrally controlled nor locally supervised. Moreover, even if individuals follow simple rules, the resulting group behaviour can be surprisingly complex and effective. Figure 8.2 represents a model of users' behaviour on a multilingual learning resource portal with a rating and social tagging tool. The main activities modelled are the search/discovery actions, play of resources (i.e. the use) and the annotations (bookmarking, tagging and rating). Self-organisation has four basic characteristics (positive and negative feedback, amplification of fluctuation and multiple actions), which can also be pointed out in this model.

The simple rule that individuals follow is: "search resources either through Conventional search or Community browsing, when a resource is relevant, rate

and/or bookmark it with tag(s)". Users thus discover resources and eventually provide tags and ratings. These annotations are regarded as lower-level interactions on the portal and are executed on the basis of purely local information without central control nor local supervision. They comprise 16.8% of all the actions on the portal (Figure 8.2, the boxes on the right side of the model).

The annotations are aggregated into tagclouds, which are spatiotemporal structures on the system level that have a potential to influence the behaviour of individuals in discovering new resources. The model shows that these Community browsing features have modified the behaviour of other individuals (indicated in green under "searches" in Fig. 8.2): 20% of searches by authenticated users and 22% of searches by unauthenticated users took advantage of these spatiotemporal structures. Moreover, when users play, and eventually rate and tag resources through these structures (i.e. bookmarks and ratings initiated from green boxes in Fig. 8.2), it can be considered as a sign of stigmergy. 33% of all annotations were initiated through these structures.

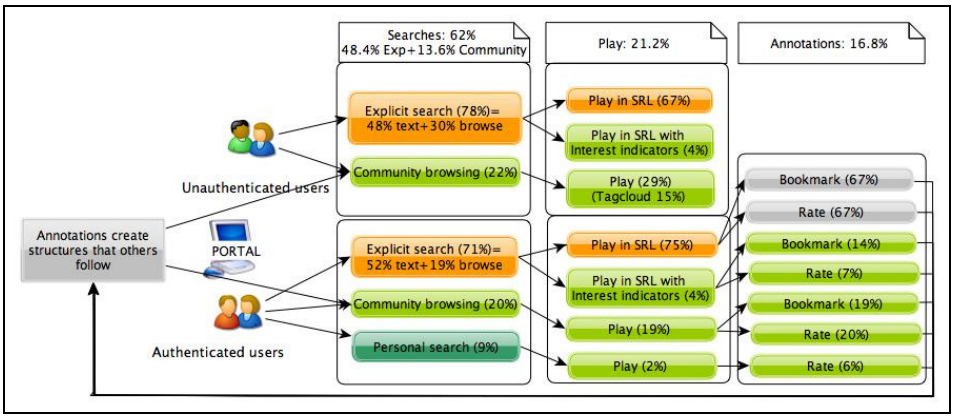

Figure 8.2. Self-organisation on a learning resource portal thanks to social tagging. Stigmergy is illustrated by the arrow from annotations going back to the portal creating new spatiotemporal structures (Chapter 5).

When other users start using tags as a social navigation aid, it is understood as positive feedback to the system which prompts convergence in the behaviour: it increases the frequency of use of the same resources and tags, and creates the emergence of patterns (e.g. "most bookmarked resources" and "most-used tags"). The model shows the plays (indicated as green boxes in the section of Play in Fig. 8.2) which are initiated through Community browsing feature, as well as from Search Result List with previous annotation. With authenticated users, these comprise 23% of all the plays of resources and with unauthenticated users 33%. The second characteristic is negative feedback in the system, this happens for example when a user cannot find a resource through tags. 'Suboptimal convergence' could happen if users only played resources as a result of Community browsing. However, on average only 29%

of the all plays and 33% of annotations are generated through Community browsing.

The third characteristic is the random deviations that are crucial in a self-organising model. These deviations enable the discovery of new solutions. The model shows that the resources that users play, and further bookmark and rate, originate not only from Community browsing, but also through Explicit search, which is based on conventional multilingual metadata by indexers (indicated in orange in under “play” in Fig. 8.2). The majority of the resources that users discover and play have not been previously discovered, and thus do not include any previous annotations (orange box “Play in SRL” = search result list). The model shows that with authenticated users, 75% of played resources result from Explicit search and did not have previous annotations. When these resources are bookmarked and rated (67% of all annotations), they can be regarded as amplification of fluctuations in the self-organising system. When a resource that was never annotated before gets a bookmark, a tag or a rating, it becomes a seed from which new structures can grow.

Lastly, multiple interactions (e.g. search, clickstream, annotate) from users, both authenticated and non-authenticated, are recorded on the back-end to create structures so that individuals can make use of the results of their own activities (e.g. authenticated users play 2% of resources in “My Favourites”). However, these emerging structures are also made available collectively to all the users which increased their use manifold (on average 28% of plays were initiated through these structures).

Furthermore, whether a system with characteristics of self-organisation can make users more efficient in discovering relevant learning resources was studied. According to the ideas of self-organisation, ants, for example, are attracted to the shorter path to a food source because of its higher concentration of “pheromone”, a chemical that ants use to mark the path. Following the same logic, the users who are attracted by the annotations of other users should find the relevant resources with less effort.

The discovery strategies that are based on the Community browsing features, recommendations in the “travel well” list and the retrieved resources that contain previous annotations from other users were grouped together. The previous annotations are called Interest indicators, they are ratings on a scale of 1 to 5 (1=”of no use” to 5=”very useful”) or a bookmark with tags. The above-mentioned strategies are grouped under the umbrella of Social Information Retrieval (SIR) strategies. In Chapter 5 a measure for user’s efficiency in finding relevant resources was defined. It was shown that by taking advantage of the given SIR methods on the portal, the users spent less effort in finding relevant resources. The average efficiency ratio went down from 4.4:1 to 2.8:1, meaning that with SIR methods, 2.8 searches were performed to find one relevant resource. However, it was not possible to show that by using Community browsing methods users were able to discover more relevant cross-boundary resources.

The results on the self-organisation aspects of the social tagging system in a multilingual context have been reviewed. The findings support the hypothesis that the self-organisation aspect of a social tagging system on a learning resource portal helps users discover learning resources more efficiently.

Additionally, the study also focused on robustness and flexibility of the system. These two, combined with self-organisation, are the characteristics behind the success of social insects in carrying out complex tasks such as building a nest or finding the shortest route to a food source (e.g. Bonabeau & Meyer, 2001). These two aspects were considered from the point of view of the user and the metadata ecology.

A more robust system

Robustness is one of the characteristics behind the success of social insects in carrying out complex tasks. Bonabeau & Meyer (2001) describe it in the following way: *even when one or more individuals fail, the group can still perform its tasks*. In the context of a multilingual learning resource portal with a social tagging tool, robustness means that even when one or more elements fail (e.g. LOM), the users can still perform their tasks, which is to discover and reuse learning resources across contexts (e.g. language, country, curriculum, repository). This was operationalised to mean the robustness of the reuse chain and its individual elements or steps. Previous studies have shown that metadata is essential in the lifecycle of resources (Collin & Strijker, 2004) and in the reuse chain (Ochoa, 2008). Chapters 4 and 6 focused on the tags' value in describing the resources in a multilingual context and Chapter 5 in using tags and annotations for retrieval purposes.

It was found that users tag in multiple languages; users use their mother tongue and English. Within two of the studies (Chapter 4 and 6), it was shown that about one third of the tags were in English, although very few users had English as their mother tongue. A medium correlation (r=0.57) between the language of the content and language of tags was found. The tags that teachers added to the resources were classified as factual; they identify properties of the objects such as the topical area of the resource and some other attributes, seldom any qualitative properties. 11.3% of distinct user-generated tags actually exist in the LRE multilingual Thesaurus. These are called "Thesaurus tags", as they are end-user generated, but they also exist in the Thesaurus. The number of times "Thesaurus tags" were applied rises to 30.6% of all tags. On average, these tags were reused 11.8 times compared to other tags which were reused on average 2.4 times, indicating their value to build a more robust system.

Apart from being heavily reused, the "Thesaurus tags" offer new potential ways to take advantage of tags. This is exemplified though the resource "Change of State" in Figure 8.3. It displays the resources and its metadata, both user-generated multilingual tags and the classification terms by the expert indexers. The tag "kemia" is highlighted.

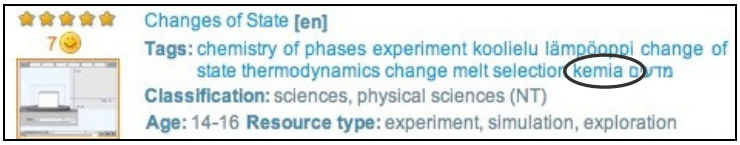

Figure. 8.3. Learning resource “Change of State” with tags (e.g. “kemia”) and indexing terms “sciences” and “physical sciences” from the multilingual Thesaurus.

Table 8.1, on the other hand, shows the Thesaurus “descriptor 195” representing the concept of “chemistry” with its language equivalences. It shows that the tag “kemia” is actually a “Thesaurus tag”. By using a language classifier such as the multilingual Thesaurus, the similarity between a tag and the descriptor can be recognised. A number of properties can be inferred, e.g. the tag “kemia” is related to the concept of “descriptor 195” and its language is Finnish. This process adds semantic structures to tags, which inherently lack them. It can be automated to take place at the back-end without being intrusive to the user.

Table 8.1. Language equivalences for the Thesaurus “descriptor 195”, including also one user-generated "Thesaurus tag" kemia.

Descriptor ID	Lg equivalences	
195	Chemie	fr
	chemistry	en
	Kemi	sv
	kemia (Thesaurus tag)	fi
	Kémia	hu

The information gained from the link between the “Thesaurus tag” and the descriptor can be used in various ways. For the retrieval purposes, the system can infer that other resources indexed with the “descriptor 195” are also relevant, when the user uses the tag “kemia”. Such assumption makes the cross-language searches more robust thanks to the inter-language connection that the multilingual Thesaurus offers (e.g. the user will get a chance to retrieve learning resources in multiple languages).

Especially in the cases where the “Thesaurus tag” narrows down the current classification of the learning resource in question, the “Thesaurus tags” have a potential to make the original LOM description more robust. This is particularly important in cases where the original indexing has been poor or limited (e.g. in the example of “Change of State”, the tag “kemia” is a narrower term of “Physical science”, the classification descriptor currently used for the resource). Automating such additions as new descriptors for the resource become beneficial for robustness of the system.

These “Thesaurus tags” by users have a potential to be used to improve the semantic interoperability of tags. For example, different translations of the tag “kemia” can be shown to allow further pivot browsing of tags in different languages. In this way the “Thesaurus tags” act as a “bridge” between existing descriptors and tags, and thus enhance the semantic interoperability within and across languages. In addition, the potential of tags to build robustness between natural language and controlled language was documented by the potential of tags to become new non-descriptors in the Thesaurus. A non-descriptor provides the intra-language equivalence that facilitates access to resources that are indexed by using the thesaurus terms that do not translate well to the language that the end-user uses. For example, the tag “efl” (= “English as foreign language”) could be expressed in thesaurus terms as “English language” + “foreign language”. When the user types a text search “efl”, not only tagged resources would be retrieved, but also the ones with the above descriptors.

The results regarding robustness of a multilingual learning resource portal with a social tagging tool were reviewed, and it was shown that the findings support the hypothesis that user-generated tags make the system, which operates in a multilingual context, more robust.

A more flexible system

A flexible system in a multilingual context allows users and metadata to *adapt to a chancing environment* which is created by the self-organised system. The flexibility of the learning resource portal with a social tagging tool in a multilingual context was studied both for the users and for the metadata ecology on the portal. Different user behaviour was documented while interacting with the self-organised model. It was found that 33% of the users contributed tags, whereas 32% of users never contributed tags themselves, but used them for retrieval (Fig. 1.2). Moreover, 35% of users did not interact with tags at all. Chi-Square test for these differences is significant ($p < 0.001$). It has thus been shown that 59% of the users adapted to their changing environment and used the new emerging spatiotemporal structures to discover resources.

The flexibility that the self-organisation aspect offers for cross-boundary discoveries was also studied (i.e. how a user discovers a resource that originates from a different country than she does and/or is in a different language than her mother tongue is). It was found that 28% of the cross-boundary discoveries were made through Community browsing. This indicates that due to self-organisation on the portal, more flexible ways to access cross-boundary resources were created.

The interest was also to study whether all the tags were used in a similar way to discover resources. The logging analyses reveal that only 11% of the tags were clicked on. On average, each tag received 6.9 clicks; however, in reality, 20% of the top clicked tags generated 80% of the clickstream. This led to the study of

how the supply of tags in the system matches with the demand, i.e. how flexibly can the portal's offer of resources *adapt to a changing environment.* A measure for "attractive tags" was introduced in Chapter 6. It compares the amount of clickstream on a tag against how many times it had been added to the system by teachers (i.e. supply). If the number is above one (1), it means that the tag has generated more clickstream (i.e. demand) than supply. This means that the tag is "attractive". If the number equals one, it means that there is an equal amount of demand and supply, and below one indicates that there is more supply than demand. 21% of tags were found "attractive" and 24% had an equal demand and supply (Figure 8.4). 55% of tags received fewer clicks than there was supply. Language-wise, within the "attractive" and "equal" tags, 28% are in a language other than English. The flexibility of the tags (i.e. metadata) to *adapt to a changing environment* by accommodating users' demand was demonstrated in showing that 45% of tags attracted more or equal amount of demand than there was supply.

Figure 8.4. Attractive tags, i.e. the tags that proportionally received more clicks from users (i.e. demand) as opposed to tags that were added by users (i.e. supply), creating users' "wish list" on an international learning resource portal.

The interplay between different contexts, in this case separate content platforms, was studied through the relationship of (item,tag). This is regarded as creating flexible environments in a self-organising system. The research challenge in Chapter 7 was to demonstrate whether the end-user generated tags can create cross-references between separate pieces of content that reside in heterogeneous content platforms in a multilingual context. Santos-Neto, Condon, Nazareno & Ripeanu (2009) argue that tag-based interest structures in social tagging systems are less segmented than item-based interest structures, which are typically used for social recommendation purposes. Therefore, tag-based interest structure was used on learning resources that teachers had tagged on a number of different educational platforms or tools.

To study the possibility of a flexible interplay between separate educational platforms, more than 20,000 tag applications from five different educational resource platforms were collected (Calibrate, 2008; LeMill, 2009;

OERCommons, 2009; LRE portal, 2009; delicious.com, 2009). The tags were analysed to find whether users used the same tags in these platforms. It was found that 7.4% of all distinct tags have been used in at least two out of five tagging systems. Using this interest-based structure, a “cross-platform learning resource tagcloud” can be aggregated that filters 30% of all tag applications in the dataset (Table 8.2). This aggregated tagcloud creates human-made link-structures between content that is scattered across five separate platforms. This type of tagcloud allows users to access resources across system boundaries (Fig.8.5).

Table 8.2. Tags shared among five different tagging tools in an educational context.

Tags appear	Distinct tags	Applications	% tag applications
Total of same tags in 2 or more platforms	666	6452	30.3%
All tags 5 services	*9036*	*21269*	*100%*

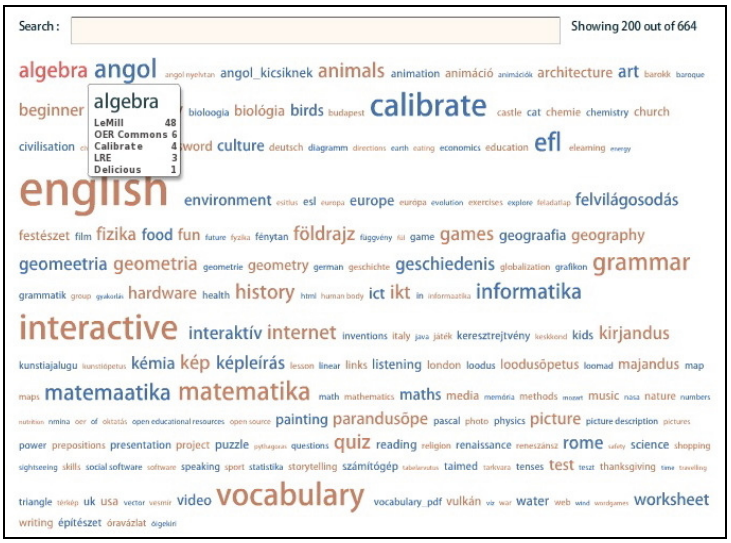

Figure 8.5. Tags, human-made filters, create an aggregated “cross-platform tagcloud”.

The idea of allowing users to access resources originating from different platforms through tags is complimentary to other forms of sharing learning resources and their metadata between repositories (Ternier et al., 2008; Massart, 2009). The proposal of a “cross-platform tagcloud”, though, introduces three new aspects. First, it builds on the social interactions among users in terms of co-construction of knowledge as tags, and secondly, it uses them as a way to offer interplay between separate learning resource platforms. Lastly, it introduces the idea of accessing both institutional resources (usually subject to some quality control within a closed information retrieval system) and private collections of resources from various sources (e.g. delicious.com) thus offering more flexibility for the end-users. Such ideas are novel in the area of learning

object repositories, where the de facto way of sharing resources is based on federating and harvesting metadata.

The results regarding the flexibility of a multilingual learning resource portal with a social tagging tool was reviewed and it was shown how the findings support the hypothesis that user-generated tags make the system, which operates in a multilingual context, more flexible.

Lessons learned and final remarks

Similarly to the success of social insects in carrying out complex tasks such as building a nest or finding the shortest route to a food source, it has been shown that a learning resource portal with a rating and social tagging tool shares characteristics of the success. Such characteristics are *self-organisation*, *flexibility* and *robustness*. Self-organisation represents the idea that even if individuals follow simple rules, the resulting group behaviour can be surprisingly complex and effective. An analogue was drawn between a simple rule of "tag relevant resources" and the outcome, which resulted in new spatiotemporal structures (e.g. tags, tagclouds and list of most bookmarked resources) that allowed users to become more efficient in finding relevant resources. Signs of self-organisation were shown on a learning resource portal with a social tagging tool, namely through *positive and negative feedback,* by relying on *amplification of fluctuation* and through *multiple interactions* that make use of the results of other users' interactions. *Flexibility*, on the other hand, was demonstrated by the users' and metadata's adaptability to a changing environment and a demonstration of *robustness* was that even when one or more elements of original LOM fail, users can still perform the tasks, i.e. discover and reuse learning resources across contexts (e.g. language, country, curriculum, repository).

A key theme of this series of studies is the central role that social tagging plays for learning resource discovery in a multilingual context. Tags, through the ternary relational structure, a signature-feature of tags, can be operationalised to describe the construct and data gathering to provide values for a number of variables that are important for the discovery, use and reuse of digital learning resources across contexts (e.g. repository, language, country, curriculum). In the following, a review is provided.

RELATION (ITEM,TAG) AND (TAG,LOM)

The ternary relational structure gives rise to the (item,tag) relation that allows tags to be part of describing the items that they are related to, in this case the learning resource, and the metadata description of the learning resource. Moreover, this relation was found useful in gauging the collective interest-based structures of the users, which become beneficial for the retrieval purposes. This relation also lends itself not only creating interplay across different platforms, but also languages, country and curriculum.

The relation (item,tag) is important for describing learning resources to enrich and compliment the LOM descriptions. It was found that tags were oftentimes redundant with the elements of LOM, a positive side of which is that user-generated tags open new ways to automatically generate a more comprehensive LOM description in the first place. This view was reinforced in studies with indexers and repository owners, where tags were deemed to add value to the LOM description, especially when the original metadata description was poor or limited.

While studying the value of tags for descriptors, a construct of "Thesaurus tags" was formed. These are user-generated tags that match with descriptors found in a multilingual thesaurus. Through this construct, new values can be gathered for variables that describe the language and concept of the tag. Any multilingual dictionary can be used for this purpose. However, there are advantages in using the same taxonomy/ontology that is used for indexing: any other resources that have been indexed with the same descriptor, or its broader and/or narrower terms, can be retrieved too. When a multilingual taxonomy/ontology is used, the cross-language retrieval is therefore facilitated.

An additional relationship (tag,LOM) was inferred which operationalises the relation between the descriptors used for indexing and tags. This makes it possible to create new structures such as thematic tagclouds that aggregate all the tags related to a given indexing descriptor, e.g. science, thus creating novel ways to access resources.

RELATION (USER,TAG)

The relational structure emphasises the relationship (user,tag). It can be regarded as a parameter for different variables both in metadata ecology and in user profiling. By studying users' tagging behaviour in a multilingual context methods inferring the language of tags were created. The importance of adding such properties to the metadata of the tag helps both the usability (users are easily overwhelmed by multilingual tags) and better retrieval in a multilingual context. The recognition of the language of a tag is a challenge, as usually only one or a few terms are used, instead of a proper sentence or paragraph. Potential methods of recognition were proposed, a combination of which performs best. For example, rules created based on the country of origin of the user and the languages spoken (self-profiling); creating rules based on previous behaviour (e.g. language teachers tag in the language of the content); the use of variables such as the language of the resource or the language of the interface; or by using a language classifier taking advantage of a multilingual taxonomy/ontology.

By studying the (user,tag) relation, tags can be regarded as part of user models that reflect user's persistent and/or transient properties, such as preferences, interests and intentions. In social tagging systems, for example, the known or inferred languages of tags, as well as resources, can give further hints as to the user's preferred language profiles. This can further be used for a better-

organised search result list, for recommending content and tags in a preferred language, but also in indirect ways, for example by recommending the bookmark list of other users with a similar “language preference profile” (including the degree of tolerance for mixed-language resources, results, etc.).

Lastly, the (user,tag) relation has also been used to study how different spatiotemporal structures emerge as a result of self-organisation, such as personal tagclouds, but also aggregates of tagclouds, for example, from users who come from the same country.

RELATION (USER,ITEM)

The ternary relational structure gives rise to (user,item) relationship, which can be regarded as a variable of the interaction between a user and a learning resource in question. A variable and values have been defined to infer the user’s attention regarding the learning resources bookmarked. This was used to measure the use and reuse of learning resources in general and cross-boundary use in particular. The term cross-boundary means that the user and learning resource come from different countries and/or that the language is different from that of the user’s mother tongue.

In a multilingual context, the country and language may be operationalised in different ways depending on the domain and the analysed questions. Country of birth and mother tongue, for example, are essentially persistent user traits, whereas the country a user works in, as well as preferred languages may be persistent or transient traits. Lastly, knowing whether the user accesses information in a first or in a second language – irrespective of the language itself – leads to an operationalisation of language as a variable depending on the relation between user and material. This, similar to the relation (user,tag) can be used to create language profiles and preferences of users, and thus further enhance the personalisation.

CREATING LINKS ON CROSS-LANGUAGE CONTENT

In previous studies it has been shown that non-English languages are under-represented on the Web and that this is partly due to content-creation, link-setting and link-following behaviour (e.g. Berendt & Kralisch, 2009). In this research, a new parameter has been shown that can be used to measure links between cross-language content, namely that of the triple (user,item,tag). The added value of this new parameter is that it can be created *a posteriori* to content creation and link-setting. Second, this link can be used to support and enhance a new type of link-following behaviour by end-users. Lastly, this novel way to create cross-language linkage can be accumulative in its nature, which can be used as a variable to measure the popularity of the connection created by the link.

CROSS-CONTEXT LINK-STRUCTURES (E.G. LANGUAGE, CURRICULUM, COUNTRY, REPOSITORY)

Most importantly, in this series of studies, it has been shown that user-tagged content which comes from heterogeneous repositories in different countries and in different languages that typically do not cross-reference each other via link-structures, has such cross-references thanks to the triple (user,item,tag).

Tags creating underlying connections between seemingly random pieces of content and users in different languages (from repositories in different countries), rely on humans' subjective idea of their importance for a given information-seeking task. Therefore, these link-structures open more sophisticated avenues for resource discovery across contexts (e.g. repository, curriculum), especially as it applies to cross-language and cross-country discoveries.

The (user,item) and (item,tag) relationships can be used to infer certain features of the resource that represents a construct of "travel well" resource. "Travel well" resources are deemed to have potential to be useful for teaching and learning activities even if the language of the resource differs from that of the users' and/or if the country of origin is different from that of the users'. The "travel well" construct, in its simplest form, can be operationalised by using information from other users' behaviour. A resource with users from a number of different countries can indicate to other users (and repository owners) that it is useful in different contexts (e.g. country, alignment with national curriculum). Similarly, resources-specific tags that appear in multiple languages (i.e. users have added tags in many different languages to the same learning resources) can be used to infer values for variables that describe the resources' potential to be easily used across linguistic contexts. Conversely, resources that only have mono-lingual tags associated with them could be disregarded and given less importance for cross-context discovery.

Also tags have been found to have "travel well" values, these are tags that cross language and country contexts. Thanks to their similarity in spelling in many languages (e.g. literature, matematika, chemie), they are easily understandable for users from different countries without any translations. "Travel well" tags also represent names of places (e.g., europa, evropa), countries, people (e.g., Da Vinci) and acronyms (e.g. AIDS). These tags are important in creating community-based interest-structures that can rather easily cross language, country and even repository boundaries.

For the vast field of learning resources and the efforts around it, the tags offer novel opportunities to link users, both educators and learners, with content to foster better collaboration, knowledge construction and learning opportunities. The self-organising aspects of social tagging system, when extended to the wide-array of users across different contexts, offers alternative, yet complimentary ways to make separate pieces of learning content accessible and available to all. The underlying link-structures related to information about the use in different contexts, for different purposes and intentions, can be

contextualised and inferred, and further used for novel algorithms that link users and content together for ever more effective lifelong learning opportunities in learning networks across contexts.

PERSONALISATON VS. SOCIAL

Terms personalisation and adaptive systems are often used to mean tailor-made solutions that fit to individual's preferences, aspirations and previous experience/knowledge. This information is usually stored in a user profile which is based on an agreed-upon user model. Problems arise at different levels; for example, does the user model fit for the purpose and how to complete the variables in the profile (e.g. ask users to do that or try to infer it from previous behaviour). Moreover, not all users are interested in creating a profile, reason range from the privacy issues to lack of time. Differences were also observed in this thesis regarding users' behaviour: only 33% of users were found tagging, whereas the most user actions were recorded from unauthenticated users. Such behaviour would be considered problematic for services that aim at personalising their offers to individuals, as in this case only one third of the users would be served.

The nature of social navigation, especially when created taking advantage of self-organisation and spatiotemporal structures, differs fundamentally from that of personalisation. Central to self-organisation is that instead of personalising the service for one individual at the time, all the users of the system can take advantage of it. This alleviates one of the main problems of personalisation: namely that it is hard to scale up. Thanks to characteristics of self-organisation, individuals are able to make use of the results of their own activities as well as of others' activities. Also, even individuals without a user profile could use tags for resource discovery: it has been shown that twice as many people use tags for resources discovery than actually create them.

Practical implementations

The practical implementation where this research has stemmed from is part of the on-going work of European Schoolnet (2009) in the area of learning resource exchange and interoperability. European Schoolnet (EUN) is a unique not-for-profit organisation comprised of a network of 31 Ministries of Education in Europe and beyond. It was created in 1997 with the aim to bring about innovation in teaching and learning to its key stakeholders: Ministries of Education, schools, teachers and researchers.

From October 2005 to March 2008 EUN coordinated the Celebrate project (Calibrate, 2008), which brought together eight Ministries of Education (MoE) including six from new member states. The aim was to support content exchange and collaboration between MoEs for the benefit of the teachers and learners in their respective countries. The continuation for the Celebrate project was MELT (2009), which stands for a Metadata Ecology for Learning and

Teaching, a Content Enrichment project coordinated by European Schoolnet and supported by the European Commissions eContentplus Programme. Again, the aim was to make learning resources available to educators and learners in multilingual Europe, thanks to better quality metadata.

The backbone of this research work has been the design and use of a logging scheme to study user behaviour on a learning resource portal without being too intrusive and yet retaining the proper level of user privacy. In the Calibrate project, EUN first designed and implemented the learning resource portal with a tagging tool. A logging scheme was created to allow a better monitoring and evaluation of teachers' interactions with the portal without the need ask teachers to perform search tasks in an artificial context of usability laboratory. The data for Chapter 4 was collected using the logging tool, it partially served to evaluate the logging scheme, and at the same time, the outcomes were fed to create a better design and usability of the tagging tool. Chapter 4 evaluations were not part of the project's evaluation measures and not stipulated by the project. Through the project collaboration in Calibrate, a close work with the development team of LeMill was possible (another project outcome) which enabled accessing the data used for Chapter 3 and 7.

From October 2006 to March 2009 the MELT portal and tagging tool was designed and implemented. The author of this research helped conceive, conceptualise, design, implement and evaluate different aspects of social tagging, which was one of the novel ways to achieve better quality metadata. Vuorikari & Van Assche (2007) explain the outlines of the annotation services for learning resources. Vuorikari, Hartinger & Ayre (2007) summarises the requirements gathering and use cases for a multilingual tagging tool to be used as part of the federation of learning resource repositories. The requirements elicitation took place with a focus group of teachers with whom a series of paper prototyping exercises were ran that the author of the study, Ms Vuorikari coordinated in collaboration with Ms Hartinger who was one of the developers of the system. An enhanced logging scheme for users' attention metadata, which also supports different aspects of social interactions on the portal, was developed and implemented. This allowed the evaluation of the MELT project according to its goals (Zens, 2009). Ms Vuorikari's research has been conducted parallel, but not directly stipulated nor funded through the project. However, early results of this research have affected the design and decisions of the portal that is currently known as Learning Resource Exchange for schools. This is the case especially for designing and integrating the social tagging tool and social navigation features in this multilingual environment.

In the MELT project, Ms Vuorikari was also part of the team to run two Summer Schools with the pilot teachers where various trainings took place regarding the use of social software and learning resources in multiple languages for educational purposes. This greatly contributed back to the amelioration of the social tagging tool, its features and on the aspects of evaluations. When the pilot teachers started using the portal, Ms Vuorikari coordinated the evaluation activities of social tags in collaboration with Mr Ayre (Vuorikari & Ayre, 2009). The challenge was that very few evaluation methods existed for social tagging

in a multilingual context, thus basic work of adapting existing metrics and creating new ones was part of her tasks. A number of the evaluation measures and requirements from Chapter 4 and 6 were used.

Figure 8.6. Filtering tags based on the language or country of origin. The latter allows users to see tags by other users who most likely share similar curriculum requirements.

The multilinguality of tags is a little researched area where implementations are few and far between. The current tagcloud on the LRE portal offers novel navigation possibilities: users can, for example, filter tagclouds based on the language of tags or the country of origin of the tag (i.e. based on the country of the user who added the tag) (Figure 8.6). The idea of thematic tagcloud based on Thesaurus descriptor (e.g. tagcloud in science) is considered. The metrics and automated identification of learning resources that cross boundaries are also being considered for implementation and are a potential subject of new projects and studies.

METHOD AND LIMITATIONS OF THE RESEARCH

This thesis was designed to use a multiple method approach. As this research considers the interactions within a socio-technological system in a combination of people, content artefacts and technologies, gathering rich empirical data using quantitative methods was considered as the main option. A logging scheme to track and capture users' interactions and attention metadata was designed, and used for a number of studies. Additionally, server-end log-files on users bookmarks and tags from different platforms were acquired. These quantitative methods were supported by qualitative methods such as user

studies, observation of users in the field, user groups and follow-up interviews (Zens, 2009; Vuorikari & Ayre, 2009). Similar research evaluating the integration of digital "repositories" into teaching/learning environments (Marchionini, 2000, Harley, Henke & Nasatir, 2006) argue for triangulation of the results because the study focuses on complex social settings and rapidly evolving technologies.

A limitation in this research was that systems that were studied were still evolving (e.g. MELT). The side effect is that the data was oftentimes produced by users who were part of the project, as opposed to users who were independent of the development of the project. The positive effect, though, is that during the development, the research results were fed in creating a feedback loop that allowed revisiting the SIR strategies to support users in both cross-boundary and within-boundary discoveries. A second limitation is that although mixed methods were used, subjective measures such as user satisfaction, preferences or cognitive load while searching for cross-language content were less systematically studied, areas that would add important information in studying such system. Lastly, using Collections, bookmarks and tags as a proxy for the use and reuse of learning resources can be misleading, as no further evidence on their use in teaching-related activities is available.

Further research and development

A plethora of new research strands have been identified in the course of this research. A few of them are elaborated here, such as social search in a large sense, the idea of reusable and sharable annotations, cross-boundary rank for learning resources and an application to help users to manage the interplay across and between a number of learning resource offerings that are available on the Internet.

SOCIAL SEARCH

Sharing and reusing is the corner stone of learning resource repositories. One way of sharing resources happens on the institutional level through metadata. However, users' experiences in searching, discovering and using resources are less supported. Current studies on Information seeking behaviour have noted that the concept on "search" has been very limited. A recent research from Kayahara & Wellman (2007) suggests that for many people, the Web tends to satisfy curiosity rather than inspire it, as many interpersonal networks are used as an information source before turning to the Web. Evans & Chi (2008) offers a better understanding of a social model including user activities before, during, and after search concentrating on the context and purpose of search. The authors find that in 59% of the cases, the person who searched for information shared it either with proximate others or publicly to others.

> "… social inputs may help users throughout the search process. Before searching, social interactions may help establish the requirements for

> the actual search task. During search, especially for self-motivated informational searches, users may talk to others for advice, feedback, and brainstorming to improve their search schema and query keyword selections. After search, users may still wish to engage with others to collect additional feedback or to share knowledge gained during the search." Evans & Chi (2008, p.4)

In various sessions with user teachers, it has been observed that teachers share resources among their colleagues, however, these practices seem to take place outside of any workflow that current learning resource repositories or digital libraries support. More of an ethnographic type of research into teachers' current practices is needed to understand how the way teachers currently share resources can be better supported and leveraged. A more systematic study of the workflow would yield a better picture of the process including "what happens before" and "what happens after the search". Better understanding of the context where the teacher's information seeking task takes place can offer better understanding of the underlying mechanisms. Similarly, better understanding of the information seeking purpose, or task at hand, would allow us to better match the search methods with the search task (e.g. McNee, 2006; Strohmaier, 2008).

REPOSITORY/REGISTRY FOR SHARING ANNOTATIONS

Social information retrieval systems oftentimes suffer from sparse data sets (Herlocker et al., 2004; Adomavicius & Tuzhilin, 2005). Although federating and harvesting learning resource metadata across repositories can help the sharing and reuse, it multiplies the problem of sparse datasets. For example, a resource "Change of state" originally resides on a repository A which allows users to add a star rating to resources that they found useful. Now, the same resource is federated to repositories B and C which reside in a different language and cultural context. The repository B and C both have their own rating scales or voting mechanisms thus resulting in annotations on the resource "Change of state". However, these annotations (e.g. evaluations, ratings, reviews) are rarely shared and exchanged between repositories, leaving users with less information about whether other users have liked or used the resource in similar or different contexts.

The potential of sharable and reusable evaluations of online resources can be high, as sharing these evaluations and annotations can help attain the critical mass of data required for social information retrieval systems (e.g. a recommender system) to be effective and efficient. This kind of interoperability requires a common framework that can be used to describe the evaluation approach and its results in a reusable manner. Such a concept has been discussed in Vuorikari, Manouselis & Duval (2007) and Manouselis & Vuorikari (2009), implementation of which offers many research challenges.

CROSS-BOUNDARY RANK FOR LEARNING RESOURCES

Creating human-made link-structures based on humans' subjective idea of their importance between seemingly random pieces of learning resources in different languages (from repositories in different countries) would allow the use of more sophisticated search, ranking and recommendation algorithms for resource discovery than the current methods based on conventional metadata. Such cross-references in a multilingual contexts can be created, even a posteori to the content creation and link-setting, thanks to the triple (user,item,tag).

Therefore, the link-structures from the aggregated tagcloud(Chapter 7), or from an annotation repository, open more sophisticated avenues for resource discovery across contexts (e.g. repository, language, country, curriculum). Future work focusing on using these underlying connections to create measures of resources' importance will offer plenty of research challenges. Similarly to the Page-Rank algorithm (Brin & Page, 1998), tags, create underlying connections between pieces of content in different languages, rely on humans' subjective idea of their importance for a given information-seeking task. Using this new, emerging link-structure, and involving tags as "anchor texts", could offer totally new ways to "organise the world's learning resources and make them universally accessible and useful", similar to what Google claims its mission statement is for world's information.

Resource's potential for crossing different contexts could be detected from the same link-structure. Resources-specific tags, for example, that appear in many different languages could indicate that the resource is being used in different language contexts and thus has potential to be used across contexts. Similarly, resources with users from a number of different countries could indicate that these resources are being used in different national and curriculum contexts. Creating algorithms that take advantage of this information and testing their usefulness for users offer an interesting area of future studies.

RESOURCE'S RELEVANCE TO THE INFORMATION SEEKING TASK

This research used explicit Interest indicator, i.e. a bookmark or rating (3 or greater) on a resource as a proxy for the use and resource of resources. It has build on the assumption that the resource's relevance to users can be inferred from their behaviour. Aggregating these Interest indicators into spatiotemporal structures such as tagclouds and lists of most bookmarked resources was used to create flexible social navigation features, as well as to study self-organisation. When a new resources was annotated, it become a seed for new spatiotemporal structures to grow form. Stigmergy is a form of self-organisation meaning that traces left in the environment by an action stimulates the performance of a subsequent action, either by the same or a different individual. In this study, when a user created an explicit Interest indicator on a resource which already had an Interest indicator it was considered as a sign of stigmergy. Essentially, 33% of all contributing actions on the portal were such signs of stigmergy.

Different user behaviour regarding tagging was observed on the portal. It was found that 33% of users added tags, however, 59% of the users also used tags for navigation support, even if more than half of them never added any tags. Also, most searches and clickstream are produced by users who do not log in. It becomes important to understand how to gauge the learning resource's relevance for this type of user who never tags or rates, and who prefers to use the portal unauthenticated. More diverse ways are needed to understand what can constitute digital traces, so that better spatiotemporal structures can be build on the global level and more advantage could be taken from self-organised aspects of a tagging system on a learning resource portal. In the literature, different ways to gather implicit input have been presented (e.g. clicks, time spent, last document viewed), but there still is room for improvement in the learning and teaching context.

iTUNES FOR LEARNING RESOURCES

One of the most powerful and appealing features of iTunes (2009) software is that it makes the management of personal music collections easy. Users start using it to get a proper digital listing of all the artists and track names that they own, despite whether they are on old CDs or in the MP3 format. The playlists that users can create are popular too. Moreover, the music recommendations based on the user's own iTunes' collection offer serendipity for the selection of new music. A number of music recommender systems build their recommender input based on users' iTunes collections and their playlists, e.g. iTunes (2009), MyStrands (2009).

In this research and elsewhere (e.g. Harley, Henke & Nasatir, 2006; Margaryan, 2006) it has been shown that teachers acquire digital learning resources from different sources: from institutional repositories to user-generated content and everything in-between. The users have vast personal collections of resources too, both locally on a hard drive and remotely (e.g. delicious.com). Similarly to the logic of iTunes, offering a meta-tool for the personal management of all these educational resources seems useful. Similar strengths could be listed: by connecting to a service like the LRE, or a similar learning resource federation with waste metadata records (e.g. GLOBE, 2009), teachers would be able to check the resources that they own against the metadata records in a remote service. This would update their "profile" for the better management of resources (by using means to infer different variables as explained in this thesis) that would allow users to tag their resources and create playlists of learning resources for their use in class, for example. The variables from personal collections with their tags and playlists could be used as a good source for the process of further resources discovery and to create recommendations. Social networking features could be added to allow people to follow their colleagues and join topic-related groups. These personal connections, together with learning resources from both institutionalised and personal collections, their metadata and tags, would further be used to create an affinities table of learning resources which would serve to create recommendation of resources across contexts.

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Summary

Summary

A key theme of this research is the central role of social tagging and tags. As opposed to conventional metadata description such as Learning Object Metadata (LOM), tags are free, non-hierarchical keywords that end-users associate with a digital artefact, in this case a learning resource. Tags are formed by triples of (user,item,tag). On the one hand, tags and the act of tagging describe usage, attention, and a number of other persistent and transient properties of users and learning resources. On the other hand, tags and their underlying connections of the triple (user,item,tag) can help exploit these properties to enhance the discoverability of learning resources across different contexts (e.g. language, country, curriculum, repository). The main hypothesis is that the self-organisation aspect of a social tagging system on a learning resource portal helps users discover learning resources more efficiently and that user-generated tags make the system, which operates in a multilingual context, more robust and flexible.

Since the late 1990's, digital repositories for learning purposes have gained ground. Such repositories with metadata and/or educational content have been set up on regional, national and international levels to offer digital learning resources for teachers and learners from K-12 to tertiary and vocational education. Sharing, using and reusing the content usually take place in learning object repositories (LOR) and digital libraries, however, recent studies show that the promise of reuse has not yet come to fruition (discussed in Chapter 3). Lately, social tagging and bookmarking tools have become a feature of conventional LORs and digital libraries which potentially adds a number of dynamical mechanisms in a such system (e.g. Chapter 4, 6 and 7). Social tagging and its end-products, tags, can be regarded as part of learning resources metadata ecology. The term "metadata ecology" is used to mean the interrelation of conventional metadata (e.g. LOM) and social tags, and their interaction with the environment, which can be understood as the repository in the large sense (e.g. resources, metadata, interfaces and underlying technology) and its community of users (Chapter 4, 6 and 7).

A series of studies has been conducted on a learning resource portal currently known as the Learning Resource Exchange hereafter referred to as "portal". The portal was developed by European Schoolnet and its partners in the Calibrate (2008) and MELT (2009) projects. A version of the portal was made available to a restricted number of schools with more than 30,000 open educational resources and nearly 90,000 assets from nineteen content providers in Europe and elsewhere. The portal offers different categories of searches: "Explicit search" and "Browse by category" that take advantage of multilingual metadata are considered conventional search features. "Community browsing", on the other hand, takes advantage of the other users' behaviour based on ratings and a social tagging tool, which allows users to add tags to

resources so that they can easily find them later and share them with other users.

TAGS AND SELF-ORGANISATION: A METADATA ECOLOGY FOR LEARNING RESOURCES IN A MULTILINGUAL CONTEXT

Self-organisation represents the idea that even if individuals follow simple rules, the resulting group behaviour can be surprisingly complex and effective. By studying the behaviour of social insects such as ants, termites or certain wasps, scientists have elicited three characteristics behind their success in carrying out complex tasks such as building a nest or finding a shortest route to a food source (Bonabeau and Meyer, 2001):

- Self-organisation (activities are neither centrally controlled nor locally supervised);
- Flexibility (the colony can adapt to a changing environment);
- Robustness (even when one or more individuals fail, the group can still perform its tasks).

Attention metadata (e.g. how do users search, what do users click on, what do they bookmark) was collected from users on the portal and a model on users' search-play-annotation behaviour was created. The following observations were gathered:

- Users discover resources and provide tags and ratings at the individual level, they comprise 16% of all the actions on the portal. These annotations are regarded as lower-level interactions that are executed on the basis of purely local information.
- This individual behaviour also modifies the environment and creates the Community browsing features such as tagclouds (e.g. global, resource-specific and personal ones) and lists of "most bookmarked resources" creating global patterns on the system level. On average, 21% of users search actions took advantage of these spatiotemporal structures.
- Tagclouds are an example of the spatiotemporal structures which emerge as a result of self-organisation. When a tagcloud, for example, influences the behaviour of other individuals in discovering new resources and further tagging and rating them, this is considered as a sign of stigmergy. 33% of all annotations were initiated through these structures.
- When other users start using these spatiotemporal structures as a social navigation aid, it can be understood as **positive feedback** to the system. This prompts convergence in the behaviour: it increases the frequency of use of the same resources and tags, and creates the emergence of patterns (e.g. "most bookmarked resources" and "top-used tags").
- **Negative feedback** is given to the system when a user, for example, does not find a relevant resource using a tag and thus chooses to use some other retrieval method. This is a control mechanism that counterbalances positive feedback in the system.
- **Amplification of fluctuations** is a counter-measure against too much positive feedback, which can lead to 'suboptimal convergence' and kill innovation, result of which could be no new emerging behaviours. Discovery

and annotations of new resources that have no previous annotations through “Explicit search” and “Browse by category” introduce new items to spatiotemporal structures, 67% of all annotations were produced this way. These annotations act as seeds from which new structures can nucleate and grow.

- **Multiple interactions** (e.g. on search behaviour, clicks, annotations) from users, both authenticated and non-authenticated, are recorded on the back-end of the LOR using attention metadata schema designed for social discovery processes. Individuals are able to make use of the results of their own activities (e.g. 2% of plays are generated by authenticated users as they replay the resources that they bookmarked), however, these emerging structures are also made available collectively to all the users which increased their use manifold (on average 28% of plays were initiated through these structures).

According to the ideas of self-organisation, ants, for example, are attracted to the shorter path to a food source because of its higher concentration of “pheromone”, a chemical that ants use to mark the path. Following the same logic, the users who are attracted by the annotations of other users should find the relevant resources with less effort. A measure for user’s efficiency in finding relevant resources has been defined in Chapter 5. It was shown that by taking advantage of the given Social Information Retrieval (SIR) methods on the portal, the users spent less effort in finding relevant resources. The average efficiency ratio went down from 4.4:1 to 2.8:1, meaning that with SIR methods, 2.8 searches were needed to find one relevant resource. However, it was not shown that by using Community browsing methods users were to discover more relevant cross-boundary resources. The cross-boundary resource means that the user and the learning resource discovered come from different countries, and/or that the content is in a language other than the user’s mother tongue.

A more flexible system

A flexible system in a multilingual context allows users and metadata to *adapt to a changing environment* which is created by the self-organised system. The flexibility of the learning resource portal in a multilingual context was studied. Different user behaviour was documented while interacting with the portal. It was found that 33% of the users contributed tags, whereas 32% of users never contributed tags themselves, but used them for retrieval. Moreover, 35% of users did not interact with tags at all. Chi-Square test for these differences is significant ($p< 0.001$). It thus has been shown that 59% of the users used the new emerging structures to discover resources, indicating that due to self-organisation on the portal, more flexible ways to access resources have been created.

The flexibility of the metadata (i.e. tags) to *adapt to a changing environment* was studied for its ability for the discovery of the resources. The logging analyses show that only 11% of the tags were clicked on. On average, each tag received 6.9 clicks; however, in reality, 20% of the top clicked tags generated

80% of the clickstream. This led to a study of how the supply of tags by users matches with the demand of tags by teachers.

A measure for “attractive tags” was created which compared the amount of clickstream (i.e. demand) on a tag to how many times it had been added by teachers (i.e. supply). If the number is above one (1), it means that the tag has generated more demand than supply. This means that the tag is “attractive”. If the number equals one, it means that there is an equal amount of demand and supply, and below one indicates that there is more supply than demand. 21% of tags were found “attractive” and 24% had an equal demand and supply. 55% of tags received fewer clicks than there was supply. Language-wise, within the “attractive” and “equal” tags, 28% are in a language other than English. The flexibility of the tags to *adapt to a changing environment* by accommodating users’ demand in a multilingual environment was demonstrated in showing that 45% of tags attracted more or an equal amount of demand than there was supply.

The relationship of (tag,item) was studied and how it can be used to create a more flexible interplay between different contexts, in this case separate content platforms. The research challenge was to demonstrate whether the end-user generated tags can create cross-references between separate pieces of content that reside in heterogeneous content platforms in a multilingual context. To study the possibility of interplay more than 20,000 tag applications from five different platforms in an educational context were collected (Calibrate, LeMill, OER Commons, LRE and delicious.com). About 30% of all the posts in the dataset are shared through common tags at least in two out of five different tagging systems. Using this interest-based structure, an aggregated “cross-platform tagcloud” was created using human-made bridges across two or more platforms in an educational context.

The idea of allowing users to access resources originating from different platforms through tags is complimentary to other forms of sharing learning resources and their metadata between repositories. The proposal of a “cross-platform tagcloud”, though, introduces three new aspects. First, it builds on the social interactions among users in terms of co-construction of knowledge as tags, and secondly, it uses them as a way to offer interplay between learning resource platforms. Third, it introduces the idea of accessing both institutional resources (usually subject to some quality control within a closed information retrieval system) and private collections of resources from various sources adding more flexibility for the end-users.

Lastly, studying the multilingual aspects of the relation (tag, item), a class of tags was found that are easily understood by users thanks to their similar spelling in many languages. These were typically names such as places (e.g. Europe, europa, evropa), persons (e.g. Pythagoras), topics (e.g. literature, matematika, chemie). Additionally, other tags were identified that hardly need translation (e.g. USA, AIDS, web2.0). These are loosely grouped under the umbrella of “travel well” tags, as they propose added value for multilingual users

and help users discover resources across language and country contexts (Chapter 3).

A more robust system

Robustness is one of the characteristics behind the success of social insects in carrying out complex tasks: even when one or more individuals fail, the group can still perform its tasks. In the context of a multilingual learning resource portal, the robustness is interpreted that even when one or more elements fail (e.g. LOM), users can still perform the task, i.e. discover and reuse learning resources across contexts (e.g. repository, language, country, curriculum). Thus, robustness can be considered as the robustness of the reuse chain and its elements, one of which is the metadata. It was studied by focusing on the relationships (user,tag) and (tag,LOM). The conventional metadata used is a LOM-based LRE Application Profile with multilingual controlled vocabularies.

Users' tagging behaviour was first studied to gauge its value. It was found that users tag in multiple languages; users mainly use their mother tongue and English. Within the sample, it was found that 29% of the tags were in English, although a very few users had English as mother tongue. A medium correlation (r=0.57) between the language of the content and language of tags was found. The tags that teachers add were mostly factual; they identify properties of the objects such as the topical area of the resource and other attributes, seldom any qualitative properties. More interestingly, 11.3% of distinct user-generated tags were found to exist in the multilingual LRE Thesaurus that was used for indexing purposes. These are called "Thesaurus tags", as they are end-user generated, but they also exist in the Thesaurus. The number of times "Thesaurus tags" were applied rises to 30.6% of all tags (i.e. the same tag added to many resources). On average, these tags were reused 11.8 times compared to other tags which were reused on average 2.4 times.

These "Thesaurus tags" have a potential to make the original LOM description more robust, particularly in cases where the original indexing has been poor or limited. Especially in the cases where the "Thesaurus tag" narrows down the current classification of the learning resource in question, ways to automate its addition as a new classification term for the resource become interesting. Moreover, these "Thesaurus tags" by users have a potential to be used as a "bridge" between existing descriptors and tags, and thus enhance the semantic interoperability within and across languages. The potential of tags to build robustness between natural language and controlled language was documented by the positive prospect of tags to become new non-descriptors for the multilingual Thesaurus. A non-descriptor provides the intra-language equivalence that facilitates access to resources that are indexed by using the thesaurus terms that do not translate well to the language that the end-user uses. For example, the tag "efl" (= "English as foreign language") could be expressed in thesauri terms as "English language" + "foreign language". When the user types a text search "efl", not only tagged resources would be retrieved, but also the ones with the above descriptors.

CONCLUSION AND FUTURE WORK

Similarly to the success of social insects in carrying out complex tasks such as building a nest or finding the shortest route to a food source, it has been shown that a learning resource portal with a social tagging tool shares characteristics of the success. Such characteristics are *self-organisation*, *flexibility* and *robustness*. Self-organisation represents the idea that even if individuals follow simple rules, the resulting group behaviour can be surprising complex and effective. It was shown that a learning resource portal with a social tagging tool exhibits characteristics of self-organisation namely through *positive and negative feedback,* by relying on *amplification of fluctuation* and through *multiple interactions* that make use of the results of other users' interactions. *Flexibility*, on the other hand was demonstrated by the users' and metadata's adaptability to a changing environment and a demonstration of *robustness* was that even when one or more elements of the original, multilingual LOM fail, the users can still perform the tasks, i.e. discover and reuse learning resources across contexts (e.g. language, country, curriculum, repository).

Thanks to the triple (user,item,tag) it has been shown that content, which comes from heterogeneous repositories that typically do not cross-reference each other via link-structures, but rely on conventional metadata for its discoverability, have such cross-references. Therefore, the link-structures created by the triple (user,item,tag) and its extension to (tag, LOM) open more sophisticated avenues for resource discovery across contexts (e.g. language, country, curriculum, repository). Moreover, the self-organisation aspect of a social tagging will help gauging a number of other persistent and/or transient social and temporal variables that are valuable for understanding the spatiotemporal structures that emerge. Future work focusing on using these underlying connections to create measures of learning resources' importance will offer a plethora of research challenges. Similar to the Google's Page-Rank algorithm, tags, creating underlying connections between seemingly random pieces of content in different languages (and from repositories in different countries), rely on humans' subjective idea of their importance for a given information-seeking task. Using this link-structure, and emerging spatiotemporal structures through self-organisation, propose a prospect for totally new ways to "organise the world's learning resources and make them universally accessible and useful", similar to what Google claims its mission statement is for world's information.

Samenvatting

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Een belangrijk thema van dit onderzoek is de centrale rol van social tagging en tags. In tegenstelling tot de conventionele metadatabeschrijving zoals Learning Object Metadata (LOM), zijn tags vrije, niet-hiërarchische sleutelwoorden die eindgebruikers associëren met een digitaal artefact, in dit geval een bron van kennis. Tags worden gevormd door tripletten (gebruiker, item, tag). Enerzijds beschrijven tags en tagging het gebruik, de aandacht en een aantal andere vaste en vluchtige eigenschappen van gebruikers en leermaterialen. Anderzijds kunnen tags en de onderliggende verbindingen van het triplet (gebruiker, item, tag) helpen deze eigenschappen te activeren om de vindbaarheid te verbeteren van leermaterialen binnen uiteenlopende contexten (vb.: taal, land, curriculum, repository). De belangrijkste hypothese is, dat het aspect van zelforganisatie in een social taggingsysteem op de portaal site van een kennisbron ervoor zorgt, dat aan de gebruikers efficiënter toegang wordt verschaft tot de leermaterialen en dat de door de gebruiker gegenereerde tags het systeem, dat opereert in een meertalige context, robuuster en meer flexibel maakt.

Sinds eind jaren ’90 zijn de digitale centra voor studiedoeleinden aan een opmars bezig. Deze centra met metadata en/of educatieve inhoud werden opgericht op regionaal, nationaal en internationaal niveau om digitale leermaterialen beschikbaar te stellen voor leraren en leerlingen van de lagere en middelbare school tot de hogere opleidingen en vakscholen. De inhoud delen, gebruiken en hergebruiken vindt gewoonlijk plaats in learning object repositories (LOR) en digitale bibliotheken. Recente studies tonen echter aan dat het aspect van hergebruik nog niet verwezenlijkt werd (besproken in Hoofdstuk 3). De laatste tijd zijn social tagging en bookmarkinstrumenten een eigenschap geworden van conventionele LOR’s en digitale bibliotheken. Ze voegen mogelijk een aantal dynamische mechanismes toe aan zo een systeem (zie ook Hoofdstuk 4, 6 en 7). Social tagging en de bijhorende producten – tags – kunnen worden beschouwd als een onderdeel van leermaterialen metadata ecologie. De term “metadata ecologie” duidt op de interrelatie van conventionele metadata (vb. LOM) en social tags, en hun interactie met de omgeving, en kan worden opgevat als het informatiecentrum in de breedste zin (vb. bronnen, metadata, interfaces en de onderliggende technologie) en de gebruikersgemeenschap (Hoofdstuk 5 en 6).

Er werd een reeks onderzoeken uitgevoerd naar een leermaterialenportaal, ook wel de Learning Resource Exchange genaamd. Hierna wordt hiernaar verwezen als portaal. De portaal werd ontwikkeld door het Europese Scholennet en zijn partners in de projecten MELT en Calibrate. Een versie van de LRE werd toegankelijk voor een beperkt aantal scholen met meer dan 30.000 open educatieve bronnen en bijna 90.000 items van negentien sponsoren uit Europa en elders. De portaal biedt verschillende zoekcategorieën: “Expliciete zoekopdracht” en “Zoeken op categorie”, die dankbaar gebruik maken van meertalige metadata en worden beschouwd als conventionele zoekeigenschappen. “Community browsing” echter, maakt gebruik van het gedrag van andere gebruikers op basis van scores en een

instrument voor social tagging, waarmee gebruikers tags kunnen toevoegen aan bronnen om deze later eenvoudig terug te vinden of te delen met andere gebruikers.

TAGS EN ZELFORGANISATIE: METADATA ECOLOGIE VOOR LEERMATERIALEN IN EEN MEERTALIGE CONTEXT

Zelforganisatie behelst de idee dat zelfs wanneer individuen eenvoudige regels volgen, het resulterende groepsgedrag verrassend complex en efficiënt kan zijn. Door het gedrag te bestuderen van sociale insecten, zoals mieren, termieten of sommige wespen, slaagden wetenschappers er in drie eigenschappen aan het licht te brengen achter hun succes bij het uitvoeren van complexe taken, zoals een nest bouwen of de kortste weg vinden naar een voedselbron (Bonabeau and Meyer, 2001):

- Zelforganisatie (activiteiten worden noch centraal gestuurd noch lokaal gecontroleerd);
- Flexibiliteit (de kolonie kan zich aanpassen aan een veranderende omgeving);
- Robuustheid (zelfs indien een of meer individuen falen, kan de groep nog steeds alle taken uitvoeren).

Aandachtsmetadata (b.v..hoe zoeken gebruikers, waarop klikken gebruikers, wat wordt aan de favorieten toegevoegd) werd verzameld onder de gebruikers van de portaal en er werd een model gecreëerd voor het zoek-speel-annoteergedrag van de gebruikers. Daaruit vloeiden de volgende observaties:

- Gebruikers ontdekken bronnen en geven tags en scores op het individuele niveau, deze omvatten 16% van alle activiteiten op de portaal. Deze annotaties worden beschouwd als interacties van een lager niveau op de portaal die worden uitgevoerd op basis van strikt locale informatie.
- Dit individuele gedrag wijzigt ook de omgeving en creëert algemene browsing functies zoals tagclouds (b.v. globaal, specifiek per bron en persoonlijk) en lijsten van “meest aan favorieten toegevoegde bronnen”, waardoor er globale patronen ontstaan op systeemniveau. Gemiddeld 21% van de zoekacties van gebruikers maakte gebruik van deze spatiotemporele structuren.
- Tagclouds zijn een voorbeeld van die spatiotemporele structuren, die ontstaan als gevolg van zelforganisatie. Wanneer een tagcloud bijvoorbeeld het gedrag beïnvloedt van andere individuen die nieuwe bronnen ontdekken en op hun beurt tags en scores toekennen, wordt dit beschouwd als een teken van stigmergie. 33% van alle annotaties werden gestart door deze structuren.
- Wanneer andere gebruikers deze spatiotemporele structuren gebruiken als een sociaal navigatiehulpmiddel, kan dit worden opgevat als positieve feedback aan het systeem. Dit leidt tot convergentie in het gedrag: het verhoogt de gebruiksfrequentie van dezelfde bronnen en tags en doet patronen ontstaan (vb. “meest aan favorieten toegevoegde bronnen” en “meest gebruikte tags”).

- Het systeem krijgt negatieve feedback wanneer een gebruiker een betreffende bron bijvoorbeeld niet vindt via een tag en daarom een andere zoekmethode gebruikt. Dit is een controlemechanisme dat tegengewicht biedt voor de positieve feedback in het systeem.
- Amplificatie van fluctuatie is een tegenmaatregel tegen te veel positieve feedback, wat kan leiden tot 'suboptimale convergentie' en innovatie kan tenietdoen, waardoor nieuw gedrag mogelijk niet langer naar voren komt. Het ontdekken en annoteren van nieuwe bronnen die geen voorgaande annotaties hebben door “Expliciet zoeken” en “Browsen per categorie” voegt nieuwe items toe aan de spatiotemporele structuren, 67% van alle annotaties werden op deze manier geproduceerd. Deze annotaties vormen zaadjes waaruit nieuwe structuren kunnen ontstaan en groeien.
- Meervoudige interacties (b.v. over zoekgedrag, klikken, annotaties) van gebruikers, zowel bevestigd als niet bevestigd, worden op de achtergrond in de LOR vastgelegd waarbij gebruik wordt gemaakt van aandachtsmetadata schema’s, ontworpen voor processen van sociale ontdekking. Individuen kunnen gebruik maken van de resultaten van hun eigen activiteiten (vb. 2% van het verkeer wordt gegenereerd door bevestigde gebruikers die de bronnen uit hun favorieten opnieuw afspelen), maar deze ontluikende structuren worden ook ter beschikking gesteld van alle gebruikers, waardoor hun veelvoud verhoogt (gemiddeld 28%).

Volgens de inzichten van zelforganisatie worden mieren bijvoorbeeld aangetrokken door een kortere route naar een voedselbron door de hogere concentratie aan “feromonen”, een chemisch product waarmee mieren een pad markeren. Volgens diezelfde redenering zouden gebruikers, die worden aangetrokken door de annotaties van andere gebruikers, de betreffende bronnen met minder inspanning moeten vinden. Een maatstaf voor de efficiëntie waarmee gebruikers relevante bronnen vinden, werd gedefinieerd in Hoofdstuk 5. Aangetoond werd dat door gebruik te maken van de bestaande Social Information Retrieval (SIR) methodes op de portaal, de gebruikers sneller relevante bronnen konden vinden. De gemiddelde efficiëntieratio daalde van 4.4:1 naar 2.8:1, dat betekent dat met de SIR-methodes, 2,8 zoekopdrachten nodig waren om een relevante bron te vinden. We konden echter niet aantonen dat door gebruik te maken van Community browsing methodes gebruikers in staat waren bijkomende relevante grensoverschrijdende bronnen te ontdekken. Met grensoverschrijdende ontdekking bedoelen we, dat de gebruiker en de ontdekte kennisbron uit verschillende landen komen, en/of dat de inhoud in een andere taal werd opgesteld dan de moedertaal van de gebruiker.

Een meer flexibel systeem

In een meertalige context laat een flexibel systeem gebruikers en metadata toe zich aan te passen aan een veranderende omgeving die wordt gecreëerd door het zelforganiserend systeem. De flexibiliteit van de portaal van leermaterialen in een meertalige context werd bestudeerd. Tijdens de interactie met de portaal werd variërend gedrag van gebruikers vastgelegd. Zo werd vastgesteld dat 33% van de gebruikers tags toevoegde, waar 32% van de gebruikers nooit zelf tags

toevoegde, maar ze wel gebruikte bij zoekopdrachten. Bovendien maakte 35% van de gebruikers in het geheel geen gebruik van tags. De Chi-kwadraattoets voor deze verschillen is aanzienlijk ($p < 0,001$). Dat toont dus aan dat 59% van de gebruikers de nieuw ontstane structuren gebruikte om bronnen te ontdekken, een indicatie dat door zelforganisatie op de portaal meer flexibele manieren werden gecreëerd om toegang te krijgen tot bronnen.

De flexibiliteit van de metadata om zich aan te passen aan een veranderende omgeving werd bestudeerd vanwege de mogelijkheid om bronnen te ontdekken. Dit werd onderzocht door te kijken hoe gebruikers in feite tags gebruikten bij hun zoektocht. Onze analyses van de logs tonen aan dat op slechts 11% van de tags werd geklikt. Gemiddeld kreeg elke tag 6,9 klikken; in werkelijkheid genereerde 20% van de meest gebruikte tags 80% van de klikstroom. Dit leidde tot de studie, hoe het aanbod van tags door gebruikers overeenstemt met de vraag naar tags door leraren.

Er werd een norm opgesteld voor “aantrekkelijke tags” die de hoeveelheid klikstroom (de vraag) voor een tag vergelijkt met het aantal keren dat de tag werd toegevoegd door leraren (het aanbod). Is dit getal groter dan een (1), dan genereert de tag meer vraag dan aanbod. Dat betekent dat de tag “aantrekkelijk” is. Is dit getal gelijk aan 1, dan is de vraag gelijk aan het aanbod, en lager dan 1 betekent dat er meer aanbod is dan vraag. We ontdekten dat 21% van de tags “aantrekkelijk” is en dat voor 24% de vraag gelijk was aan het aanbod. 55% van alle tags kreeg minder klikken dan het aanbod. In taalopzicht, wat betreft de “aantrekkelijke” en “gelijke” tags, was 28% in een andere taal dan het Engels. De flexibiliteit van de tags om zich aan te passen aan een veranderende omgeving door te voldoen aan de vraag van gebruikers in een meertalige omgeving werd aangetoond doordat 45% van alle tags meer of evenveel vraag aantrok dan het aanbod.

Er werd onderzoek gedaan naar de verhouding tussen (tag, item) en hoe die kan worden ingezet voor een meer flexibele interactie tussen verschillende contexten, in dit geval verschillende platforms met inhoud. De onderzoeksvraag was, aan te tonen of de tags gegenereerd door de eindgebruiker verwijzingen kunnen creëren tussen aparte inhoudselementen, die opgeslagen werden in heterogene platformen in een meertalige context. Om de mogelijkheid tot interactie te bestuderen, werden meer dan 20.000 tagtoepassingen uit vijf verschillende platforms in een educatieve context verzameld (Calibrate, LeMill, OER Commons, LRE en delicious.com). Ongeveer 30% van alle posts in de dataset worden gedeeld door gemeenschappelijke tags in tenminste twee van de vijf verschillende tagsystemen. Dankzij deze op interesse gebaseerde structuur, werd een geaggregeerde “interplatform tagcloud” gecreëerd met gebruik van door personen gebouwde bruggen tussen twee of meer platformen in een educatieve context.

De idee gebruikers in staat te stellen zich toegang te verschaffen tot bronnen uit verschillende platforms door tags, sluit aan bij andere vormen voor het delen van leermaterialen en hun metadata tussen repository. Het voorstel van een “interplatform tagcloud”, geeft echter aanleiding tot drie nieuwe aspecten. Eerst

en vooral steunt het op de sociale interacties tussen gebruikers wat betreft de co-constructie van kennis zoals tags. Voorts worden deze tags gebruikt als een interactie tussen platformen met kennisbronnen. Ten slotte introduceert dit concept de idee dat zowel institutionele bronnen (gewoonlijk onderworpen aan een vorm van kwaliteitscontrole binnen een gesloten databanksysteem) als privécollecties van kennis uit verschillende bronnen toegankelijk worden, waardoor de eindgebruikers meer flexibiliteit krijgen.

Ten slotte werden ook de meertalige aspecten van het paar (tag, item) bestudeerd, waarbij een type tags werd ontdekt dat eenvoudig begrepen wordt door gebruikers dankzij de gelijkaardige spelling in vele talen. Het gaat dan vaak om namen, zoals plaatsnamen (vb. Europe, europa, evropa), personen (vb. Pythagoras), onderwerpen (vb. literature, matematika, chemie). Daarnaast werden andere tags geïdentificeerd die helemaal geen vertaling behoeven (vb. USA, AIDS, web2.0). Deze werden losjes samengebracht onder de paraplu “travel well” tags, aangezien ze toegevoegde waarde bieden voor meertalige gebruikers en gebruikers in staat stellen bronnen te ontdekken over de grenzen van talen en landen heen (Hoofdstuk 4).

Een meer robuust systeem

De robuustheid is een van de eigenschappen achter het succes van sociale insecten die complexe taken uitvoeren: zelfs wanneer een of meer individuen falen, kan de groep nog steeds haar taken uitvoeren. In de context van een meertalige portaal voor kennisbronnen betekent robuustheid dat, zelfs indien een of meer onderdelen falen (vb. LOM), de gebruikers nog steeds hun taken kunnen uitvoeren: het ontdekken en hergebruiken van leermaterialen over de context heen (vb. taal, land, curriculum, repository). De robuustheid kan dus worden beschouwd als de robuustheid van de keten van hergebruik en de elementen waaruit die bestaat, zoals de metadata. Dit werd bestudeerd door dieper in te gaan op de waarde van de tags voor de beschrijving en de opzoekbaarheid van de bronnen door de verhouding (gebruiker, tag) en (tag, LOM). De conventionele metadata die werd gebruikt, is een LOM-based LRE Application Profile met meertalig gecontroleerde woordenschat.

Eerst werd het tagginggedrag van gebruikers bestudeerd om een beeld te vormen van de waarde ervan. Het bleek dat gebruikers taggen in verschillende talen; gebruikers maken voornamelijk gebruik van hun moedertaal en het Engels. In het voorbeeld bleek 29% van alle tags in het Engels te zijn, hoewel slechts zeer weinig gebruikers het Engels als moedertaal hadden. Er werd een gemiddelde collectie correlatie (r=0,57) ontdekt tussen de taal van de inhoud en de taal van de tags. De tags toegevoegd door leraren waren meestal feitelijk; ze geven informatie over de eigenschappen van de objecten, zoals het topografische gebied van de bron en andere kenmerken, maar zelden over kwalitatieve eigenschappen. Interessant genoeg werd 11,3% specifiek door gebruikers gegenereerde tags ontdekt in de LRE meertalige thesaurus, die werd gebruikt voor indexatiedoeleinden. Deze worden “Thesaurus tags” genoemd, omdat ze door de eindgebruiker werden gegenereerd, maar ook bestaan in de Thesaurus. Het aantal keren dat “Thesaurus tags” werden toegepast stijgt tot 30,6% van alle tags (dus dezelfde tag toegevoegd aan

meerdere bronnen). Gemiddeld werden deze tags 11,8 keer hergebruikt tegenover andere tags die gemiddeld 2,4 keer werden hergebruikt.

Deze “Thesaurus tags” kunnen mogelijk de originele LOM-beschrijving robuuster maken, met name in gevallen waar de originele indexatie zwak of beperkt was. Vooral wanneer de “Thesaurus tag” de huidige classificatie versmalt voor de betreffende kennisbron, wordt het interessant manieren te vinden om het toevoegen als een nieuwe classificatieterm voor de bron te automatiseren. Bovendien bevatten deze “Thesaurus tags” door gebruikers een potentieel voor gebruik als een “brug” tussen bestaande omschrijvingen en tags, waardoor ze dus de semantische integreerbaarheid verhogen tussen en over talen heen. Het potentieel vervat in tags om robuustheid op te bouwen tussen natuurlijke en gecontroleerde taal werd vastgelegd door het positieve vooruitzicht dat tags nieuwe non-descriptoren worden voor de meertalige Thesaurus. Een non-descriptor biedt het intrataal equivalent, waardoor de toegang vereenvoudigd wordt tot bronnen die werden geïndexeerd met behulp van de thesaurustermen die niet eenvoudig vertaald kunnen worden in de taal van de eindgebruiker. Bijvoorbeeld: de tag “efl” (= “English as foreign language”) kan worden uitgedrukt in thesaurustermen als “Engelse taal” + “vreemde taal”. Wanneer de gebruiker een zoekstring ingeeft “efl”, worden niet alleen bronnen met die tag weergegeven, maar ook de bronnen met de bovenstaande descriptoren.

CONCLUSIES EN TOEKOMSTIG WERK

Net als bij het succes van sociale insecten bij het uitvoeren van complexe taken, zoals het bouwen van een nest of het vinden van de kortste route naar een voedselbron, werd aangetoond dat een portaal met leermaterialen en een social tagging instrument sommige kenmerken van dit succes deelt. Deze eigenschappen zijn zelforganisatie, flexibiliteit en robuustheid. Zelforganisatie staat voor de idee dat zelfs wanneer individuen eenvoudige regels volgen, het resulterende groepsgedrag verrassend complex en efficiënt kan zijn. Aangetoond werd, dat een portaal met leermaterialen en een social tagging instrument eigenschappen vertoont van zelforganisatie, met name door positieve en negatieve feedback, door gebruik te maken van amplificatie in fluctuatie en door meervoudige interacties die gebruik maken van de resultaten van de interacties van andere gebruikers. Anderzijds werd flexibiliteit aangetoond doordat zowel gebruikers als metadata zich konden aanpassen aan een veranderende omgeving, terwijl de robuustheid werd aangetoond doordat zelfs wanneer een of meer elementen van de originele, meertalige LOM falen, de gebruikers nog steeds de taken kunnen uitvoeren: het ontdekken en hergebruiken van leermaterialen over de context heen (vb. taal, land, curriculum, repository).

Dankzij het triplet (gebruiker, item, tag) kon worden aangetoond dat inhoud uit heterogene repository die gewoonlijk niet naar elkaar verwijzen via link-structuren, maar steunen op conventionele metadata voor de toegankelijkheid, toch zulke verwijzingen bevat. Op die manier openen de link-structuren, gecreëerd door het triplet (gebruiker, item, tag) en de uitbreiding naar (tag,

LOM), meer complexe wegen voor het ontdekken van bronnen over de context heen (vb. taal, land, curriculum, repository). Bovendien draagt het aspect van zelforganisatie van een social tagging systeem bij tot het inschatten van een aantal andere vaste en/of vluchtige sociale en temporele variabelen, die een rol spelen bij het interpreteren van de spatiotemporele structuren die ontstaan. Toekomstig onderzoek met de nadruk op het gebruik van deze onderliggende verbindingen voor het creëren van een norm voor het belang van een kennisbron houdt heel wat onderzoeksvragen in. Net als het page-rankalgoritme van Google steunen tags, die onderliggende verbindingen creëren tussen ogenschijnlijk willekeurige elementen in verschillende talen (en uit repository in verschillende landen), wat betreft hun relevantie voor een betreffende zoekopdracht op de subjectieve inschatting door mensen. Gebruik maken van deze linkstructuur en nieuwe spatiotemporele structuren door het aspect van zelforganisatie, houdt een belofte in voor volledig nieuwe manieren om “de leermaterialen van de wereld te organiseren en universeel toegankelijk en nuttig te maken”, zoals ook Google claimt als zijnde zijn missie voor het verspreiden van wereldwijde informatie.

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Curriculum Vitae

Curriculum Vitae

Ms Vuorikari's first degree is Master of Education (M.Ed) from the University of Joensuu, Finland (Savonlinna Department of Teacher Education) with Minors in Media Education. She continued her post-graduate studies in Hypermedia completing a *diplôme d'études approfondies* (DEA) in the University of Paris 8, France. During her studies she has received several stipends (e.g. ISEP, Erasmus) to participate in international exchange programmes: in Fall '93 (Arkansas State University, US) and Spring '94 (the University of Wyoming, US) she studied in the College of Education (Gifted and Talented Education; multicultural education; classroom observing) and in the College of Fine arts (drawing; sculpting). The academic year '96-'97 was spent in the University of Caen, France and the following year '97-'98 in IUFM de l'academie de Versailles, France. In 1999 Riina Vuorikari undertook a five-month traineeship at the European Commission, in the Directorate General of Education and Culture.

Riina Vuorikari has worked in European Schoolnet (EUN) since 2000. She deals with a wide variety of issues ranging from digital learning resources, web 2.0 issues such as tagging and social networks to e-learning interoperability and metadata, as well as school collaboration. She has been involved in a number of EC-funded projects within the Information Society Programme (e.g. European Treasury Browser, OASIS, Calibrate, MELT) and EAC founded projects (e.g. European Quality Observatory, European Educational Portfolio Initiative, eTwinning, STEPS). Ms Vuorikari has authored several Insight Special Reports (Vuorikari, 2004b; Vuorikari, 2004c, Vuorikari, 2007b) and other related conference papers (Vuorikari, 2003a, Vuorikari, 2003b; Vuorikari, 2004a). She has participated in the specifications and standardisation work in CEN/ISSSS LTWS.

In 2005 Ms Vuorikari started working part time in order to pursue her PhD. Parallel to starting her pre-doctoral programme in KULeuven in the department of Computer Science, she continued working in EUN. She worked on e-portfolios, open source software issues and on quality aspects of e-learning. In e-portfolios, Ms Vuorikari contributed to the conceptual model and implementation of the "Scenario tool" (ePortfolio Scenario tool, 2005) for European Educational Portfolio Initiative and contributed to reports on e-portfolios targeted to European e-learning policy makers (Vuorikari et al., 2005; Vuorikari, Balanskat & Heath, 2006). In addition, she worked on open educational software and content (Vuorikari & Sarnow, 2005; Vuorikari & Sarnow, 2007) and social software (Vuorikari, 2005). In 2005-2006 Ms Vuorikari contributed to work on different aspects of e-learning quality in relation to the projects of European Quality Observatory and Quality Foundation. She contributed to the conceptual model of EQO, which later became a CEN/ISSS LTWS specification on Quality Framework for eLearning, as well as to the requirements, design and testing of European Quality Observatory database (EQO, 2005). She has co-authored two book chapters related to the quality of learning resources (Van Assche & Vuorikari, 2006; Vuorikari, Manouselis &

Duval, 2007) and co-edited the Insight Thematic Dossier on Quality Criteria (Anderson et al., 2005).

From 2006 onwards Ms Vuorikari contributed in the Calibrate project (Vuorikari, 2006) and worked in MELT where she helped conceive, conceptualise, design, implement and evaluate different aspects of social tagging which is explained in more details in the Section of “Practical implications”. From 2008 onwards Ms. Vuorikari started working on eTwinning, contributing to the requirements and design of the new eTwinning 2.0 platform (eTwinning, 2008). She co-ordinated a pilot and its evaluation on online communities of practice with more than 200 European teachers participated. In 2008 and 2009 she has ran workshops on social networks and open educational resources for eTwinning teachers in Europe. Recently, she acted as an advisor for diploma thesis on eTwinning social networks at RWTH Aachen, Germany, and contributed to the requirements and design of the first visualisation tool of eTwinning Social Networks (Breuer, Klamma, Cao & Vuorikari, 2009).

During her PhD studies, Ms. Vuorikari has participated in ProLearn Doctoral Summer School in 2005, in LearnIP Summer School in 2006, as a PhD student participant in Recommender’06 and in RecSys’07 doctoral symposium (Vuorikari, 2007a). She has also followed a course on Data mining and Latex in 2008.

Riina Vuorikari has co-chaired the workshop on Social Information Retrieval for Technology Enhanced Learning in three consecutive years (Vuorikari, Manouselis, Duval & Van Assche, 2007; Vuorikari, Kiesliner, Klamma & Duval, 2008; Vuorikari, Drachsler, Manouselis & Koper, 2009). She was a co-editor of the Special Issue on JODI (Vuorikari, Manouselis & Duval, 2009) and of eLearning Papers (Schaffert, Vuorikari & Carneiro, 2008). She has also been an invited speaker and expert in various e-learning conferences and workshops in Europe.

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