Helping Knowledge Cross Boundaries: Using Knowledge Visualization to Support Cross-Community Sensemaking

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Abstract

Knowledge sharing across community boundaries has been discussed in literature as an important source of new knowledge and innovation. Different studies point out the difficulties and specific requirements to be considered in cross-community contexts. In contrast, the development and empirical evaluation of concrete methods and systems incorporating these insights has been little addressed.

This paper discusses the main challenges of supporting cross-community knowledge exchange and presents an approach to addressing them based on collaborative knowledge visualization. The developed method enables the visualization of implicit structures of personal and community knowledge and their use for multi-perspective access to community information spaces. The results of an empirical evaluation in a comparative laboratory study suggest that this method provides valuable support for facilitating cross-community knowledge exchange.

1. Introduction

The notion of communities as informal social networks based on shared interests or practices has been used as an important unit of analysis of cooperative creation and sharing of knowledge [4, 17]. Existing work has largely focused on supporting knowledge sharing in quite homogeneous communities connecting participants with similar backgrounds.

At the same time, different theoretical and empirical contributions emphasize the need to support the cooperation and exchange of knowledge between different communities with highly specialized expertise and activities [4, 7, 16]. A common approach has been the establishment of shared community platforms and knowledge portals providing one central point of encounter for different communities, in order to stimulate cross-community knowledge flows. But appropriate support for such platforms is still missing.

They are typically based on unified knowledge taxonomies connecting different community spaces into one structure [2] enhanced with tools for exchanges within teams and communities (shared workspaces, awareness, messaging). In contrast, studies of the problem of knowledge sharing across community boundaries [2, 7, 16] identify special challenges and requirements to be considered in such heterogeneous situations. Similarly, HCI work on sensemaking emphasises special needs for supporting knowledge construction during information seeking in unfamiliar domains and ill-structured problems [13, 14]. But the development of systems and tools incorporating these insights is still lagging behind [16].

This paper presents an approach to addressing these issues based on a knowledge visualization method and system developed specifically for facilitating cross-community exchange of knowledge. First, the main problems of cross-community knowledge exchange are discussed with focus on knowledge exchange mediated through community information spaces. This is followed by a cross-community knowledge exchange model, integrating the framework of perspective making-perspective taking [1] with information sensemaking [14]. We then discuss how we addressed these requirements by developing a novel knowledge visualization method and using it to enable multi-perspective access to community information spaces. Finally, the results of an empirical evaluation in a comparative laboratory study are presented, which confirm the suitability of the developed method for facilitating cross-community knowledge exchange.

2. Barriers to cross-community exchange

To collectively construct and share knowledge, groups of people have to establish a shared cognitive and social context against which they can construct shared meanings of information [9]. In communities, this is given by a shared domain and interests, shared practice, common language and social interaction [17].

2.1. Thought worlds and interpretive schemas

Different communities inhabit different "thought worlds" [7] or "interpretive schemas" [1] which determine how their members interpret the meaning of information, artefacts and experiences. Knowledge from different communities is not only expressed in different terminologies, but the meaning of concepts and their use is also strongly context dependent. Not only are the same concepts are often used in different ways but the same phenomena are seen in light of different problems or opportunities [1]. This makes it difficult for knowledge to be shared by simply passing information, without insight into underlying, implicit community knowledge perspectives [16].

2.2. Low intensity of direct communication and lack of externalization

The main processes for sharing tacit knowledge include socialization and internalization [10]. Socialization requires extensive interaction and informal communication, occurring in distributed communities mainly through online channels (chat, messaging) Internalization occurs through following the community discourse and information exchange in the shared information space (e.g. discussion forums).

But since communication between members of different communities is rare and narrow (with the purpose of obtaining otherwise unavailable information) socialization cannot take place. The absence of a continuously shared domain of interests inhibits internalization: members of one community don't have the motivation nor resources for following the information exchange in other communities.

This is aggravated by the absence of explicit representations of community knowledge structures. Communities rarely create such representations. Existing attempts typically suffer from a biased or an overly generalized structure – due to the involvement of a small group or the need for community consensus [5]. Hence, community knowledge structures are highly implicit and invisible to non-members.

2.3. Ill-defined problems and information need

The need and motivation for accessing knowledge from unfamiliar communities occurs in practice when people face ill-structured problems that do not fit their familiar contexts. This is common in interdisciplinary work, scientific research and innovation processes in firms. Such situations require learning about potentially relevant but unfamiliar topics and knowledge domains in order to structure the problem and identify gaps and knowledge needed for a solution. This knowledge is often contained in different informal networks within and across organizations. Examples are strategy and new product development, business intelligence and self-directed learning [14, 7]. In such cases, the information need is very ambiguous and difficult to resolve through goal-directed search.

3. Requirements and a model of cross-community knowledge exchange

The basic requirements for supporting cross-community knowledge exchanges have been described in the model of "perspective making – perspective taking" [1], based on the relationships between knowledge and the language used by a community to develop, express and communicate this knowledge. Its main proposition is that, enabling knowledge exchange between different communities requires that shared semantic contexts constructed in intra-community activities (perspective making) be made visible and accessible to non-members (perspective taking).

3.1. Perspective making – perspective taking

Perspective making (PM) refers to processes through which members of a community express, develop and exchange knowledge. By explicating the meaning of existing concepts, creating new ones and establishing relationships between them, members of a community develop a shared perspective (interests, domain, vocabulary). This includes activities from collaborative problem solving to cooperative gathering and structuring of information to narrative exchanges.

Perspective taking (PT) refers to the development of an understanding of the knowledge perspective of an unfamiliar community. This comprises the understanding of implicit structures and contexts determining the meaning of information. Unfamiliar knowledge is internalized by contextualizing it within one's own thought world and expressing it in one's own terms (PM). Hence, cross-community knowledge exchange requires an interplay of perspective taking and perspective making: understanding of "what and how the others know" [2, 15], finding out how this is related to one's own knowledge and translating it into one's own terms.

3.2. Boundary objects and multiple views

A special form of artefacts that can support perspective taking are boundary objects: artefacts that

connect different perspectives of heterogeneous actors on a given problem or a domain of knowledge, without requiring the establishment of one shared perspective [15]. The simultaneous availability of different perspectives allows members of different communities to interpret the information contained in the shared object in different ways, appropriate for their specific needs. They can cooperate, exchange and develop new knowledge without giving up their own perspective.

Examples of boundary objects that can be used to support perspective taking are classification schemes and cognitive maps [1, 3]. Another kind of boundary objects are artefacts that make visible implicit knowledge structures of individual community members (ibid.). They are important because even within the same community, different members will often have different personal points of view. Visualising personal views of individual community members is thus an important prerequisite for providing insight into community perspectives.

The need for supporting the integration of knowledge from different socio-cognitive contexts is also emphasized by empirical studies of innovation processes in firms [7],[16]. Such examples show how the use of standardized concepts without awareness about differences in implicit understanding of different communities inhibits, instead of supporting effective knowledge exchange [7]. Thus, rather than aiming at bridging the differences between different perspectives by a single, unified view, the co-existence of different community perspectives needs to be supported [16].
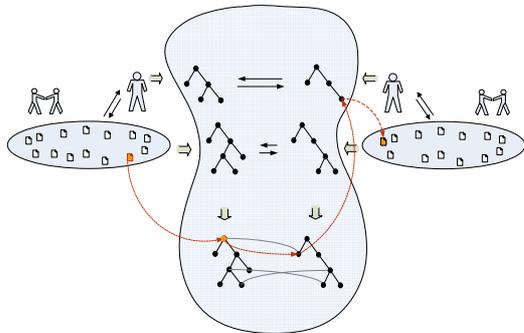
Fig. 1. Cross-community knowledge exchange model based on [3].

3.3. Sensemaking in information access

The interplay of perspective taking and perspective making can be linked to the process of information seeking in an unfamiliar community space with the so-called "sensemaking learning loop" [14]. The latter describes the process of knowledge construction through an interplay between searching for relevant information and searching for appropriate representations that contextualize and organize information into meaningful structures.

In order to make sense of a complex task the user creates representations of information structure (schemas) that capture the salient features of information needs of the task. Such schemas guide the search process by supporting the identification of appropriate concepts characterizing the information need and serve as templates for contextualizing retrieved information. Eventually, the instantiations of a schema filled with concrete information are used for accomplishing the task. The creation and use of such schemas is greatly facilitated by the availability of personal knowledge structures of other users [13]. In our context, they could allow members of different communities to contextualize unfamiliar information from different points of view (PT) .

3.4. Existing Support

Perspective making is well addressed by a range of community support solutions: from discussion forums and shared workspaces to collaborative filtering and recommender systems, to cooperative annotation [8]. In contrast, the support for perspective taking has been very limited up-to-date. Common approaches employ unified taxonomies or organization-wide ontologies as a means for making knowledge accessible across boundaries of different formal and informal structures [2]. Such focus on the establishment of a shared, unified view comes short of the need for simultaneous co-existence and coordination between different local perspectives [2, 7, 16].

Similarly, methods for explicit construction of community ontologies are limited by the need for negotiating and achieving community consensus. Ontology mapping methods allow the discovery of relationships between different conceptual schemes but require explicitly formulated formal models [6]. They don't consider the highly implicit nature and social characteristics of community knowledge creation, nor provide means for understanding the mapping criteria needed for perspective taking.

3.5. High-level cross-community model and requirements summary

In summary, the exchange of knowledge between different communities can be described through an interplay of perspective making and perspective taking, supported by boundary objects that make visible both personal and shared community

perspectives. This requires visualizing personal and shared community knowledge structures in a way that allows members of different communities to:

- Gain insight into implicit knowledge structures of unfamiliar communities (perspective taking),
- Discover relationships between knowledge from other communities and their own knowledge (perspective taking -> perspective making)
- Express the new knowledge in terms appropriate for their own personal and community perspectives (perspective making).

To develop a practical solution for supporting such a cross-community knowledge exchange model, four main requirement sets need to be considered:

- A method for capturing and visualizing implicit knowledge structures of groups of users needs to be developed. It should incorporate personal views of individual members, reflect shared community vocabularies and evolve with community use.
- The method needs to provide mechanisms for fostering the willingness of different communities to make their knowledge available to members of other communities.
- The resulting knowledge structures need to be usable for supporting information access and sensemaking in unfamiliar domains.
- They should be realized as a visual information interface supporting the contextualization of information from different perspectives and enabling the discovery of relations between them.

4. Visualizing implicit structures of personal and community knowledge

The main idea of our approach is to provide interactive knowledge maps that visualize implicit personal and shared knowledge structures of users of different communities and provide multi-perspective access to community information spaces. Thereby, we consider information seeking as a process in which users express and develop knowledge through their interaction with information [14].

4.1. The Knowledge Map model

We introduce a special knowledge map model that provides both a visual representation of users' knowledge structures as well as a context within which the meaning of user interaction with information can be interpreted. In our approach a knowledge map is composed of two closely coupled elements: a Document Map and a Concept Map (Fig. 2).
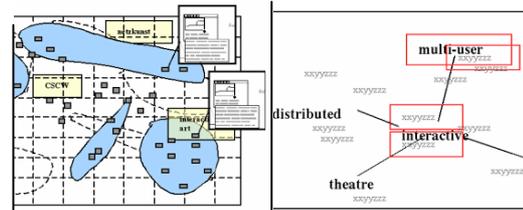
Fig. 2. The Knowledge Map model

The Document Map (Fig. 2, left) presents a personal or community information collection structured into clusters of semantically related objects. It provides a topical overview of the document space. The Concept Map (Fig. 2, right) displays groups of concepts used in similar contexts and relationships between them. This provides insights into the patterns of language use by a given user or community. Such a model both presents a specific semantic structuring of an information space to the user and provides an "explanation" of its meaning.

4.2. Eliciting personal points of view

To construct such maps based on users personal points of view we combine statistical text-analysis and self-organized clustering with methods for supervised learning of user-induced templates [11]. The user is presented with a system-generated structure which she can explore and rearrange as part of her normal access to information (e.g. selecting documents, creating and naming clusters). The resulting personal map reflects the user's personal point of view and new knowledge (perspective making). This template is learned by the system and can be used to automatically classify information into user-defined topics.

Through a statistical analysis of users' personal Document Maps, the system extracts a personal Concept Map displaying a network of most relevant terms „seen" from the user's perspective. By labeling clusters users draw a connection between a term and a set of documents. This allows us to infer relations between user-defined concepts and other terms used in the documents as well as other community concepts.

4.3. Aggregating personal views into shared community structures

By extending the described analysis to maps of all users from a given community, a concept map representing a shared community perspective is created. Cluster names used by members of a community represent the most important concepts. The association of concepts to documents illustrates their meaning by providing concrete examples of their use.

The degree of relatedness between different concepts is inferred from the similarity of document clusters they refer to. This is measured by a combination of a text-based similarity with a measure of document co-occurrences [11]. In this way, personal views are connected into a shared community structure.

The basic assumption of this solution is that by creating personal maps users express their knowledge about a specific topic or domain. Personal maps reflect a user's knowledge about the mutual relevance and similarity of documents as well as about document-concept relationships. Accordingly, analyzing and aggregating personal maps of a community of users reveals the implicit knowledge structure of the community in question (see [11] for details).

5. Providing multi-perspective access to community information spaces

The application of the described knowledge map method to supporting cross-community knowledge exchange has been realized in the following way. A multi-view knowledge visualization model allows simultaneous visualization and the discovery of relationships between different personal and community knowledge structures. These functionalities are implemented into a visual information interface, the Knowledge Explorer II enabling their use for structuring, exploring and navigating community information spaces from different points of view.

5.1. Multi-view knowledge visualization model

Fig. 3 depicts the elements of the multi-view visualization model. The Similarity View presents the inherent semantic structure of a personal or community information collection. It displays Document Maps grouping documents into clusters of semantically related content while preserving global inter-document similarity relationships. Depending on user choice, it can display maps representing topical structures of an unfamiliar community or reflecting the user's familiar personal or community structure.

The Ontological View allows the user to visualize and explore relationships between knowledge structures of different individuals and communities, through their Concept Maps. The Structuring View lets the user organize his information seeking results into personal maps (adding and grouping documents, naming clusters etc.) Search queries and the list-based display of search results are found in the Query View. The Detail View displays document information.
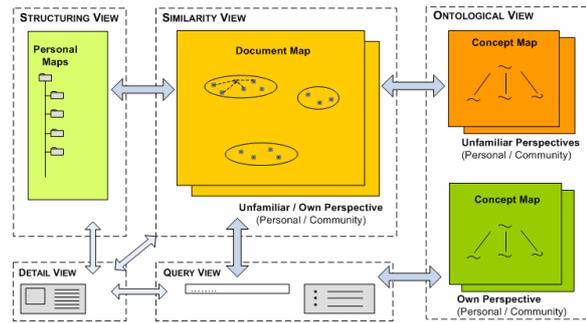

Fig. 3. Multi-view knowledge visualization model.

Such a model enables users to access an unfamiliar community information space from different perspectives. It allows simultaneous investigation of an unfamiliar community space on a document content level (similarity-based exploration), on a conceptual level (concept-based navigation) and based on relationships between unfamiliar and well-known conceptual structures (relation-based navigation).

5.2. The Knowledge Explorer interface

A concrete realization of this model in the Knowledge Explorer II Interface is depicted in Fig. 4 (version I was an early proof-of-concept, see [12]). Document Maps are visualized as a two-dimensional grid where documents are distributed by their similarity relationships and cluster membership. Documents are represented as gray dots and the color intensity falling-off from the cluster center represents the degree of a cell's membership to a given cluster. Concept Maps are visualized by a folder-tree model which reduces visual complexity and allows intuitive navigation.

A typical use flow starts with a search query which delivers a list of documents and document maps relevant for the users query (from a recommendation service [11]). The most relevant Document Map is opened in the central view, accompanied by the Concept Map of its author (right) and the user's personal Concept Map (left). Search results are contextualized by highlighting the documents in the Document Map and related concepts in the two Concept Maps [11].

The user can now inspect the search results within their thematic contexts in the Document Map, navigate by related concepts in the ConceptMap or create a new personal map to save and organize relevant documents identified through his exploration. He can easily switch between the desired combination of perspectives: to explore the viewpoint of the unfamiliar community or to navigate its information space from his personal or familiar community perspective (Fig. 4).

5.3. Semantic exploration and contextualized access to unfamiliar domains

The Document and Concept Maps of an unfamiliar community allow non-members to gain a quick overview of the community knowledge structure: the main topics, concepts and relationships between them. Through concept navigation in the Concept Map users can identify relevant documents while selecting documents in the Document Map visualizes related concepts. This supports perspective taking by helping the user to develop an understanding of the topics and the language used by an unfamiliar community. The visualization of concepts related to a given search result also helps him to learn to express his information need in terms suitable for the unfamiliar situation.

5.4. Multi-perspective navigation and discovery of cross-community relations

Cross-community relationships established through personal maps from different communities provide two ways for locating knowledge from one community in the context of the other: 1) they can be displayed and navigated in community maps and 2) the personal maps of their origin can be visualized. Using one's own personal or community Concept Map, the space of an unfamiliar community can be navigated by familiar concepts. Similarly, the selection of unfamiliar documents visualizes related concepts in the familiar structure. Selecting a familiar concept visualizes both the related documents and concepts in the unfamiliar Concept Map (Fig. 4). This suggests how concepts from different communities can relate to each other.

5.5. Contextualizing unfamiliar knowledge within personal perspectives

Instead of displaying community maps the user can choose to open a personal map of a given user. This presents only a specific portion of documents which both reflect personal knowledge of the map author and are relevant for a specific information need. Applying a personal map to the information space of an unfamiliar community will classify unfamiliar documents into thematic clusters defined by the map author. The classification of new documents is based on their similarity to documents already contained in the map. This effectively results in the categorization of an unfamiliar information space based on user's criteria of document membership to a given topic.

On one hand, this helps the user to discover how knowledge reflected in documents from the unfamiliar domain relates to his own knowledge (persp. taking → persp. making). On the other hand, personal maps of different users represent different representation schemas that can guide the information seeking process: suggesting concepts or documents relevant for a specific need or serving as dynamic templates for contextualizing unknown information (sensemaking).

5.6. Expressing personal knowledge and relating it to the knowledge of others

Users express the knowledge developed in the information seeking process by organizing documents into personal maps. By adding documents from maps of others to one's own maps, a user establishes relationships between his concepts and those of others.
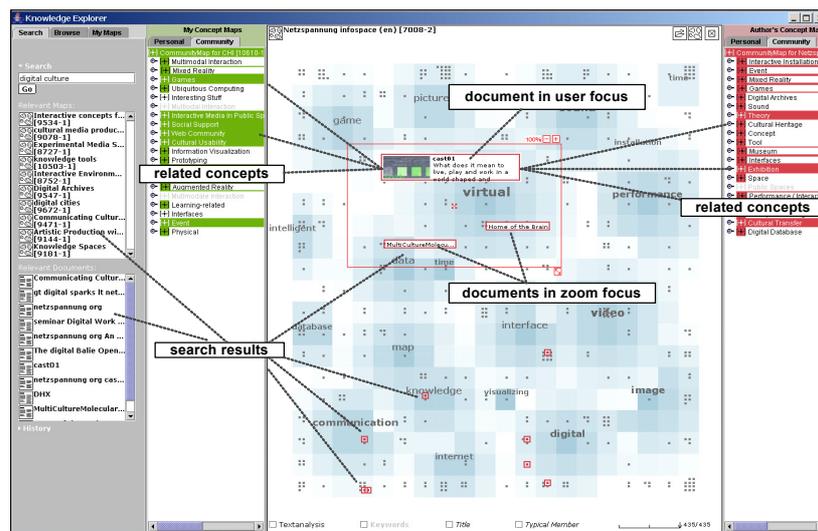

Fig. 4. The Knowledge Explorer interface

For maps from the same community, this creates the relationships between personal views in the same community. When documents are added from maps of other communities, the user expresses the discovered relationships between concepts from different communities in his own terms (persp. taking → persp. making). The motivation for sharing one's maps with other communities is based both on the reputation mechanism (map authors are named) and on an immediate benefit for the author: through the use of his maps relations are established between his concepts and the topics and documents of others. Thus, the map author gains access to the knowledge of other users.

6. Evaluation in a laboratory study

The suitability of the developed knowledge visualization method and interface for facilitating cross-community knowledge exchange has been evaluated in a comparative laboratory study. To this end, the prototypical implementation of the Knowledge Explorer system has been compared to a standard information seeking system without knowledge visualization (Google search +Mozilla). The main hypothesis has been that the developed knowledge visualization method and its realization in the Knowledge Explorer interface better support the identification and understanding of relevant knowledge in unfamiliar community information spaces than a standard reference system. This hypothesis has been examined in three forms:

H1) Users of community knowledge maps perform better than users of the reference system.
H2) Users of personal knowledge maps perform better than users of the reference system.
H3) Users of personal knowledge maps perform better than users of community maps.

6.1. Measuring the quality of knowledge access

Based on the theoretical analysis in Chapter 3, the quality of cross-community knowledge access can be assessed by three main criteria:

- How well could users gain insight into knowledge structures of unfamiliar communities?
- How well could they discover relationships between the knowledge of an unfamiliar community and one's own community knowledge?
- How well could users accomplish typical sensemaking tasks occurring during information seeking in unfamiliar community domains?

These effects are assessed from the objective task solutions by the following operative measures:

- Document retrieval effect,
- Quality of topical structuring,
- Learning effect.

6.1.1. Document retrieval effect. Document retrieval effect is described by the well-known measures of precision and recall. Precision is the ratio of the number of relevant documents retrieved by the user and the total number of documents retrieved by the user. Recall is the ratio of the number of relevant documents retrieved by the user and the total number of relevant documents in the collection (ref. solution).

6.1.2. Quality of topical structuring. The quality of topical structuring is given by the number and relevance of topics used for structuring the retrieved documents. This is measured by applying precision and recall to concepts that users have used as semantic descriptors of document groups in their solutions.

Topical precision describes the ratio between the number of relevant concepts and the total number of concepts used by a user in a given task solution. Topical recall measures the ratio of relevant user topics to all topics in a reference solution. Based on the concept origin we distinguish between cross-community topical precision and intra-community topical precision. The first measures the use of concepts from the unfamiliar community and the latter the use of concepts from the own community.

The reference solution for topical structuring includes the points of view of both communities and their relevant importance. Thereby, the topical reference solution is not *the* unique correct structure but a set of relevant topics out of which different combinations are possible and equally valid. Hence, topical recall is only a relative comparison measure.

6.1.3. Learning effect. The learning effect measures the extent to which users were able to internalize the knowledge discovered in accomplishing the tasks. This verifies whether users really understood the new concepts used in their topical structuring solutions. It is measured by a qualitative questionnaire asking users to name concepts and topics related to specific aspects of the task they accomplished. User answers are measured in terms of topical precision and recall.

6.2. Experimental design

Following the experimental simulation method, test users were presented with scenarios and tasks similar

to a real-world situation. A sample of two very different communities has been selected such that they still exhibited some intersections in their interest domains. First, members of the first community (C1) used the system to solve a set of tasks in the familiar domain (Experiment I). This elicited their personal and community knowledge structures. These maps were then visualized and used by members of the other community (C2) to solve tasks in the unfamiliar domain by accessing the first community's information space (Experiment II). In the second experiment, participants were divided in three groups. The first group (group A) used the Knowledge Explorer with the shared community map of the Community C1 (hypothesis H1). The second group (group B) used the Knowledge Explorer with personal maps from the Community C1 (hypothesis H2). The third group (group C) used a standard information seeking system without knowledge visualization (Google Search + Mozilla Bookmarks, hypothesis H3).

6.2.1. Test collections and participants.

For the community C1, 7 test participants from the media art, design and technology community *netzspannung.org* have been chosen. They represented a community sample concerned with artistic and cultural uses of interactive technologies. All participants were experts in media art and design. The test community space included selected portions of the netzspannung.org information space (435 documents).

For the community C2, research assistants, PhD and master students at the Chair of Interactive Systems and the Chair for Cooperative Systems of the University of Duisburg-Essen and at the Fraunhofer Institute for Media Communication, were recruited (by email, forum announcements and personal invitation). This resulted in 18 qualified participants (3 groups of 6 participants each) representing a sample of the HCI community, concerned with the development and evaluation of interactive systems and techniques. The HCI community space consisted of selected archives of ACM CHI conference proceedings (604 documents). All three test groups in community C2 had a comparable average level of HCI expertise and no or little familiarity with the domain of community C1.

6.2.2. Task design and course of the experiment.
Users were first presented with familiar topics and required to identify relevant documents in their own community information space. In this way personal and community knowledge structures were elicited. The tasks in the actual test phase of Experiment II presented users with four ill-defined tasks and information needs that could not be solved within the

users' community of origin. The first task presented users with a broad, ill-defined information need in the unfamiliar community space ("Find relevant documents for the topic 'Interactive Systems for Digital Culture' and organize them into subtopics").

This was the main cross-community task for which participants were allocated the longest completion time (40 min) and on which we focus here (the results of the secondary tasks do not diverge). Prior to this task the participants had been given an introduction to the experiment and a demonstration of the test systems. They had also completed an exercise for trying out the system (10min) as well as a set of three intra-community tasks in the familiar community space during the initialization phase (25min).

The reference solution has been constructed based on personal maps created by members of the netzspannung.org community in Experiment I and discussion with domain experts. Since this reflected only the point of view of the media art & design community, it was expanded by a solution created by a HCI expert well familiar with the netzspannung.org information space as well. In our case, with respect to topical structuring a higher cross-community topical precision signified a better solution: it implied a higher level of understanding of knowledge from the unfamiliar community space.

6.3. Task results: quality of knowledge access

Given the small sample size (N=6,6,5; one drop-out) we don't apply statistical significance tests but use descriptive statistics and exploratory data analysis to interpret the test results.

6.3.1. Document retrieval effect.
With respect to the document retrieval effect, groups A and B using the knowledge visualization system (Knowledge Explorer) achieved comparable document recall but a significantly higher precision than the group using the reference system without knowledge visualization (Fig. 5). In addition, the group using Knowledge Explorer with personal maps achieved better results than the group using the Community Map configuration.

With comparable amount of retrieved relevant documents, higher precision indicates a higher level of acquired understanding of the unfamiliar community domain by the users of the Knowledge Explorer. This supports our hypotheses stating better support of cross-community knowledge access for community maps (H3) and personal maps (H4) than an information seeking system without knowledge visualization.
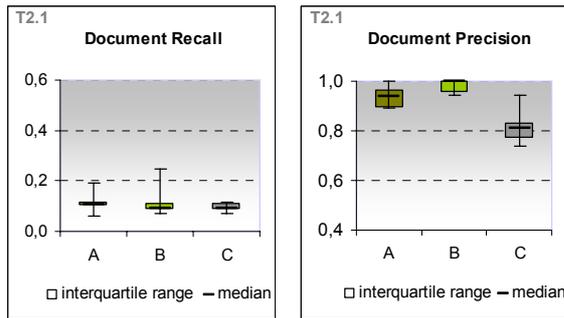
Fig. 5. Document retrieval effect results

6.3.2. Quality of topical structuring. Both Knowledge Explorer groups also exhibit better quality of topical structuring than users of the reference system (supports H1, H2). The median number of topics used for structuring the task solution is much lower for the users of the reference system than for both Knowledge Explorer groups (2 vs. 4 topics).
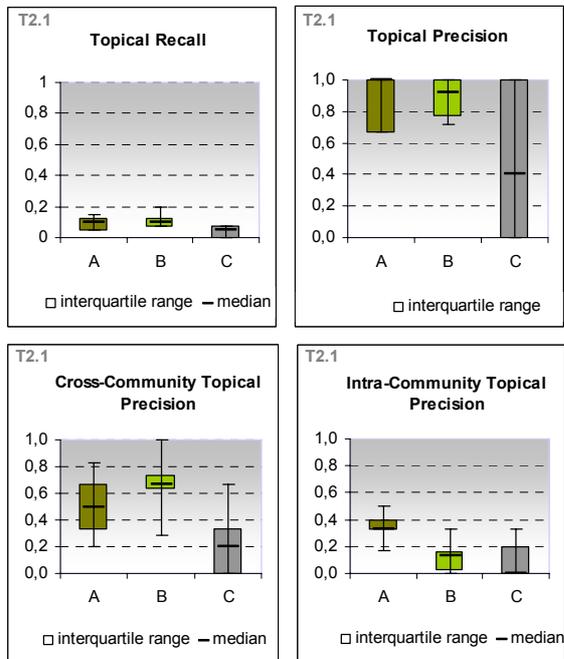
Fig. 6. Quality of topical structuring results

Topical recall and cross-community topical precision are the lowest for the Google users where several users created no topics at all. Their difficulty in finding appropriate topics is confirmed by the user questionnaire feedback. All Google users complained about the difficulty of understanding the unfamiliar community vocabulary and identifying relevant topics.

The main difference in topical structuring between the two Knowledge Explorer groups lies in the higher use of previously unfamiliar concepts by users of personal maps (group B) whereas the users of community maps (group A) largely used familiar HCI concepts in organizing retrieved documents (Fig. 6, supports H3).

6.3.3. Learning effect. The results of the learning effect questionnaire provide a similar picture. Topical recall and precision of user answers are very high for both Knowledge Explorer groups and very low for the Google group (Fig. 7). In particular, the Google group performed much worse on the question assessing the acquired level of understanding of the unfamiliar concepts from the unfamiliar community (Q1) and on the question assessing the level of cross-community knowledge integration (Q3).

The Google group was able to match the performance of Knowledge Explorer groups on the questions concerning related concepts from the own domain (Q4). The answers explain why: users in this group were hardly able to acquire concepts from the unfamiliar community and focused on identifying those concepts that they could recognize based on their existing background knowledge. Thus, with respect to the learning effect both Knowledge Explorer groups performed better than Google users. Users of personal maps (group B) also exhibited better results than users of community maps (group A).

7. Conclusions

We have presented a theoretically-grounded approach to supporting cross-community knowledge exchange through knowledge visualization. The proposed method realizes dynamic knowledge maps that elicit and visualize personal and shared knowledge structures of different communities. We have shown how such knowledge maps enable multi-perspective access to community information space and how this supports the interplay of perspective taking and perspective making.

The evaluation of a prototypical implementation in a concrete interactive system confirms the adequacy of the developed solutions with respect to the theoretically-grounded requirements of the cross-community problem. The better quality of knowledge access compared to a reference system suggests that such knowledge visualization can provide valuable support for cross-community exchange of knowledge.

Due to the explorative character of the study (small sample size) no claims regarding statistical significance could be investigated. Further investigations with larger samples and/or longitudinal studies would contribute to verifying the external validity of the presented findings.

Q1: Which topics are related to "digital culture" in netzspannung.org?

Q3: Which kinds of interactive systems for digital culture exist in netzspannung.org?

Q4: What are related CHI topics?
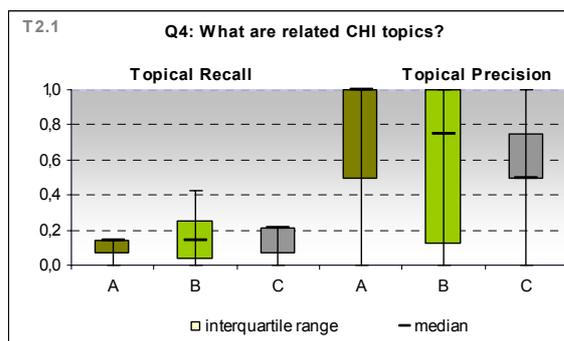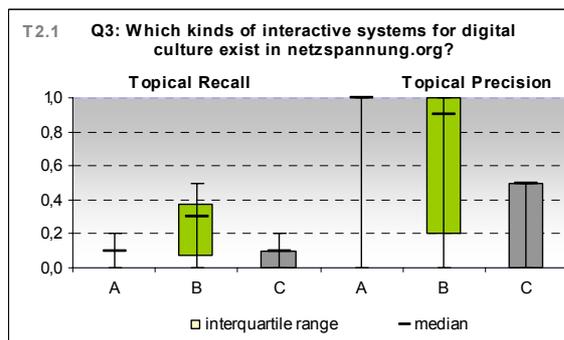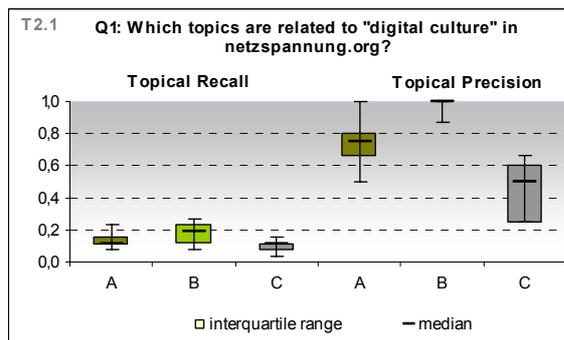
Fig. 7. Results of the learning effect questionnaire

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