A Web-based Environment for Supporting Learning Communities in Distance Education – Use in Computer Science Education

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Abstract. In the context of this dissertation, issues related to design and development of educational environments that support collaborative learning and contribute to the active engagement of learners in knowledge building are studied. Specifically, the dissertation is placed in the context of supporting the learning process by utilizing the Internet and especially the Environments which support Electronic Learning Communities by leveraging social software technologies for access to information and knowledge creation. In the frame of this thesis the development of innovative techniques to support the creation, management, operation and interconnection of electronic communities was studied. A Web based educational environment CRICOS (CReate Interconnected COmmunitieS) was designed and implemented, based on the theory of learning communities and particularly communities of practice, which supports members of different communities in collaborative knowledge creation

Keywords: Learning Communities, Communities of Practice, Social Tagging, Collaborative Filtering, Social Navigation

1. Introduction

Online communities provide the ground for knowledge creation, social negotiation of meaning and learning through the collective participation of their members. In order to participate effectively into these processes community members need guidance to find and synthesise information. Over the past few years several community-driven

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technologies have been developed to address this issue [1]. The role of these technologies is dual fold in the sense that they focus on creating communities by bringing people together and also they exploit the community around an individual as a valuable resource to guide information seeking.

Collaborative filtering systems recommend data items to a user by taking into account the opinions of other users [2]. Instead of recommending data items because they are similar to items the user preferred in the past (content-based recommendations) collaborative approaches generate recommendations about data items that users with similar interests liked in the past [3]. Social navigation systems help users to navigate in a community information space by making the aggregated behaviour of the community visible. The concept was introduced by Dourish and Chalmers as moving "towards" a cluster of other people or selecting objects because others have been examining them [4]. Social tagging is one of the latest popular approaches for information management and sharing. The approach became popular on the Web as part of the social bookmarking systems [5]. Social bookmarking systems allow users to create personal collections of bookmarks and share their bookmarks with others. Moreover users of these systems may organize their collection by entering keywords which are meaningful to them. This type of manual indexing is called tagging with index terms referred to as tags.

Several of the above mentioned technologies have been applied in the field of e-learning. CoFIND [6], [7], is a resource sharing system which allows students to provide feedback about resources and classifying them using several topics. The system encourages not only the tagging of resources according to topics, but also with pedagogical metadata known as qualities, which are then used to supply ratings on the resources. EDUCO [8] is a collaborative learning environment which visualizes the information space as clusters of documents. The documents change their color according to how much they have been read in relation to other documents. Live users presented in the learning environment as coloured dots located next to the documents that they are currently viewing. The system supports both synchronous and asynchronous communication among users. Knowledge Sea II [9] focuses on helping students of introductory programming courses to find relevant readings among hundreds of online tutorial pages distributed over the Web. The system represents clusters of pages in varying shades of blue by taking into account both number of visits and time spent on every page.

In the context of facilitating knowledge creation among the members of different communities with the use of community-driven technologies the design of a web-based environment is proposed, referred to as CRICOS (CReating Interconnected COmmunitieS) [10], [11], [12], which supports knowledge sharing within and across communities. The information space of each community is structured as a semantic network of nodes such as thematic categories, concepts, resources or members of the community. The users instead of tagging resources with keywords they can relate them with one of the existing nodes. Moreover, the web-based environment incorporates communication facilities to enhance the dialogue among the members of a community. The CRICOS environment incorporates a recommendation mechanism which is based on the integration of collaborative filtering and social navigation approaches to support community members to find the appropriate information. The first results from a study are encouraging regarding the usability and usefulness of the

provided facilities and revealed the users positive attitude to the CRICOS environment.

2. The CRICOS Environment

The CRICOS web-based environment was constructed with the aim of improving knowledge creation and sharing among the members of communities. Three main features of the environment support this:

- A flexible information space which is designed so as to maximize the ability of the members of a community to create and improve both its content and its organization.
- Facilities that support the discourse in the community by enhancing the communication among its members
- A recommendation mechanism based on collaborative filtering and social navigation approaches, which helps the members to find the appropriate information.

2.1 The Information Space of CRICOS

With the aim to move towards more community organized information spaces, in CRICOS the information space of each community is structured as a semantic network. Nodes represent thematic categories, concepts, resources or members of a community. Edges represent the relationships of nodes and can be labeled with a type. Members of a community structure the information space by contributing and placing new information in relation with information that is already presented in the information space. Thus, the information space evolves with the evolution of the community. This design approach structures the information space as a network of information nodes and creates very rich navigation opportunities [13].

The domain of a community in CRICOS is represented as a hierarchy of thematic categories and a semantic network of concepts. The first forms the common taxonomy of the community and is maintained by experienced members called "category editors". The role of a Category editor is given to members who have a certain level of knowledge of the thematic category (in the case of a course this role could be given to the teachers or tutors) and thus are responsible for the relevance of resources and concepts that are classified in their thematic category. The semantic network of concepts is constructed collaboratively by the members of the community who introduce concepts and their relationships. Instead of tagging resources a member can relate his resource with the available concepts. In the case that the resource cannot be related with the available concepts the member can introduce a new one. This approach provides to the community a certain level of flexibility upon the classification of the shared resources. A community can be based for the classification of resources on a defined taxonomy of thematic categories, on a folksonomy of concepts introduced by the members or on a mixed approach which synthesize taxonomy and folksonomy.

Resources may be located locally or externally in the WWW. A member who contributes a resource categorizes it according to one of the thematic categories. Moreover, the contributor may semantically link the submitted resource with other resources, concepts, thematic categories or members of the community. In order to

provide a semantic link a member may choose among several types of semantic relationships that other members have created or create a new type according to his perspective. Thus a member can represent his perspective of the knowledge stored in the repository not only by providing the content of his resource but also by locating his resource in the information space. Consequently, the information space of the community becomes a combination of the multiple perspectives that members have upon the community's domain. This approach supports the construction of meaningful structure overlays on stored resources and provides to the end-user valuable contextual information.

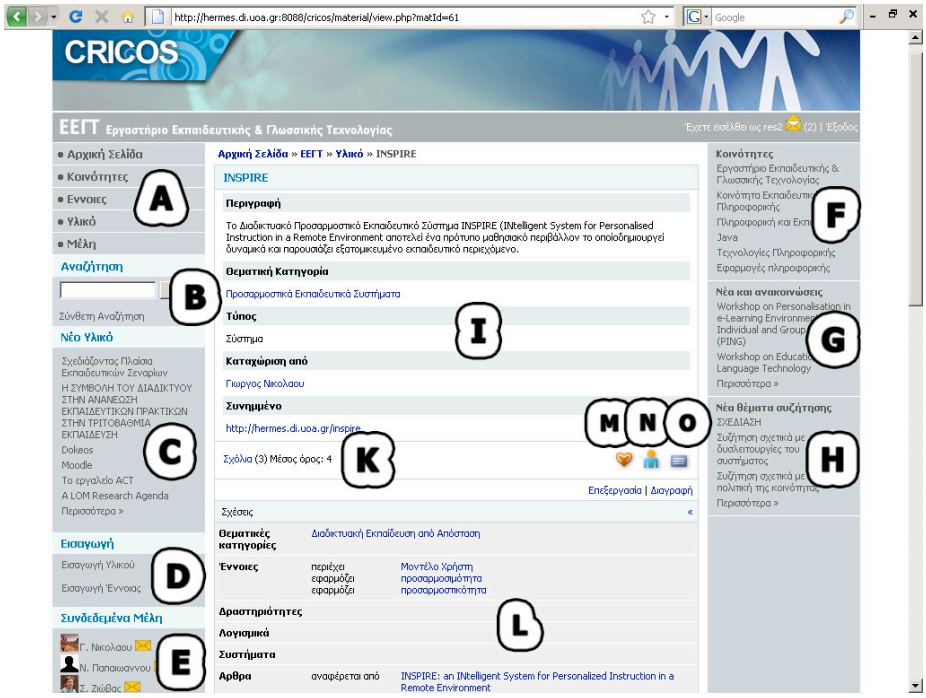

Fig. 1: A Snapshot from a Page Presenting Information about a Resource

In Figure 1 a screenshot from a page which displays information about a resource is presented. The left and right sidebars are always available to the end-user while navigating the information space. The left sidebar is divided into five blocks. The first block (A) provides links to the alternative starting points for navigation such as communities, concepts, resources and members. The second block (B) allows the user to search the information space. The third one (C) provides links to the recently uploaded resources. From the fourth block (D) the user can add a resource or a concept by following the relevant link. The last block (E) presents a list with the users who are online. The right sidebar contains one block (F) with links to the hosted communities, one (G) with the news and announcements and one (H) with the recently added discussion topics.

The main section provides useful information about the content and context of the resource. The upper side of the section (I) includes the title, the description and the type of the resource, the thematic category it belongs to, the name of the member who contributed the resource and a link to the resource itself. A link to the user comments and the average rating of the resource (K) is also available to the visitor. In order to provide information about the context of the resource the environment aggregates all the user-defined relations which include the resource and presents the links to the other relevant resources along with the type of the relation grouped by concepts, resources and members (L). For each link the type of the relation is also presented. For example a learning environment can be associated with several academic articles. The type "referred by" can denote articles which have references to the learning environment and the type "described in" articles which provide details about the learning environment. A user who discovers the resource can give his opinion on it by adding a comment and/or providing a numerical rating on a 1 to 5 rating scale (M). The user can also directly recommend the resource to one or more members who appear in his friends list (N). In this case each of the user's friends will receive a message with a link to the recommended resource. Moreover the user may add the resource to his personal collection and classify it in one of his familiar categories (O).

2.2 Communication Facilities

The environment supports the communication between its members via discussion forums and messages. Each discussion forum contains several discussion topics, organized into several threads. Each thread is hierarchically organized in a messages tree with the aim of presenting the overall structure of the conversation to the reader. A discussion forum can be attached to a community, a category or a resource. Members who are responsible for the above components have a moderator role in the attached discussion forums. With this approach even a simple member of the community may moderate a forum and engage in discussion with other members regarding the uploaded resource. In order to connect the parts of the dialogue with the community's domain we have introduced a mechanism which allows members to relate their post with the existing concepts. Thus when a member visits a concept he can have access not only to the related concepts and resources but also to the related posts. With this approach the browsing possibilities of the end users are broadened to both the content and the dialogue that took place in the community.

A messaging mechanism facilitates the communication among the users of the environment as well as the communication among the environment and the users. The message box of a user can receive messages from other users, friendship and group invitations, friends' recommendations and system messages. System messages include personalized system recommendations to the user e.g. a recommendation for a recently uploaded resource which matches user interests and requests for user approval on modifications that concern the user's model e.g. add a new thematic category to his interests.

2.3 Recommendation Mechanism

To allow users to obtain information that fits to their needs, knowledge or interests CRICOS keeps a user model for each user. The user model maintains and constantly

updates information that includes user membership and roles in communities and groups, user interests, user relationships and user activity. User interests are represented as a list of thematic categories in which the user is interested. User relationships are represented as a list of the users with whom the user has a relationship and for each user the type of relationship (e.g. friend, belonging to the same community, belonging to the same group). User activity is a log of the actions performed by the user.

Two main issues were taking under consideration while designing the recommendation mechanism. The first issue was concerning the calculation of the utility of a resource. Most of the collaborative filtering systems are based on explicit ratings (e.g. a 1-5 rating scale). This approach provides more accurate description of the user's opinion about a resource but requires extra effort from the user in order to provide the rating. Implicit ratings could be inferred by observing the user behaviour with a resource. However these approaches may lead to imprecise ratings.

The CRICOS environment follows a hybrid approach for recommending resources. The utility of a resource is calculated by aggregating both explicit and implicit ratings. Explicit ratings are provided by users who rate the quality of a resource on a 1 to 5 rating scale. Implicit ratings are inferred by observing the user behaviour with a resource and collecting the relevant data. Data from observations include the number of visits on the resource's page, if and how many times the user directly recommends the resource to others and if the resource is included in the user's personal collection. Both explicit and implicit ratings are combined into a single estimated rating which represents the utility of the resource for a particular user.

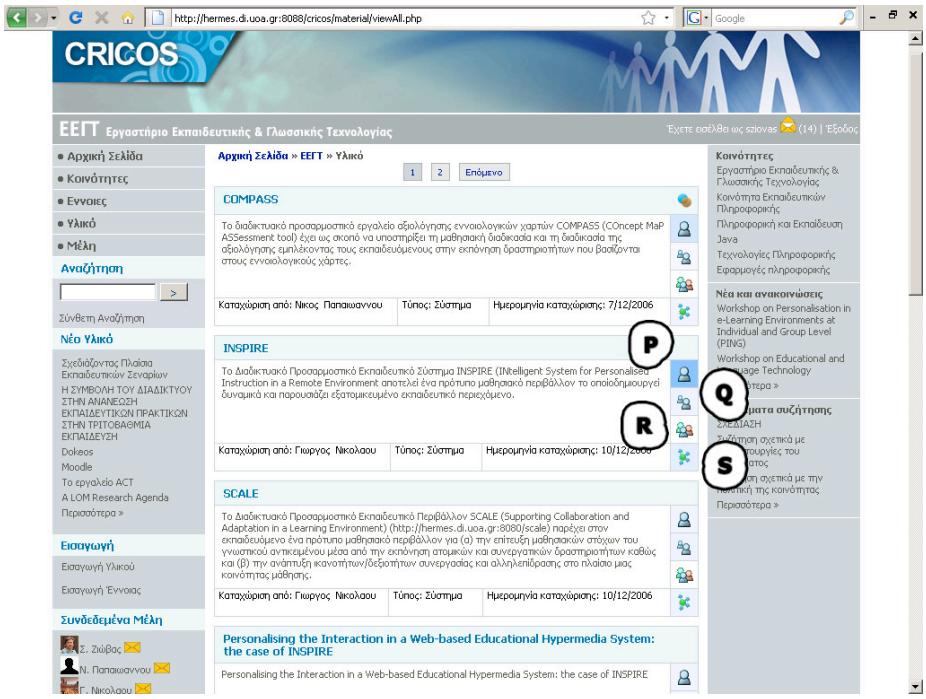

Fig. 2: A Snapshot from a Page for Browsing the Available Resources

Besides the utility of a resource for a single user, CRICOS averages the estimated ratings for two clusters of users that their opinions about the resource could be valuable for the user; user's friends and users with similar interests. The level of trust of the user on the system's recommendations was the second issue which was taking under consideration. Most of the systems that use collaborative filtering approaches they base their recommendations on the opinions of a group that has similar tastes with the user. The user should trust the recommendations without knowing the users of this group. In order to provide another hint on the utility of a resource besides the rating of the users with similar interests we provide also the rating of the user's friends.

CRICOS utilizes the above mentioned information to provide visual cues that help a user to find the most appropriate resources. For the visualization of the estimated ratings the environment follows an approach similar to that employed in Knowledge sea [9] For example in Figure 2 the environment presents the resources of a community and recommends relevant resources according to their utility for the user, for his friends and for other users who have the same interests. The estimated rating is represented by the background color of the box that includes the relevant icon: me (P), my friends (Q), users who have the same interests with me (R), the higher the rating the darker the color.

Regarding the quality of the available information, besides the provided rating mechanism we expect that the number of links to a resource will reflect its quality. This information is presented to the user when he browses the catalogue of resources

in the background color of the relationships icon (S), the higher the number of relationships the darker the color. On the same page an icon indicates whether a resource is a boundary object. Boundary objects are realised as resources or concepts of a community that have relationships with resources or concepts of another community. The relationships are provided from users who are members of these communities (brokers) and they are the contributors of at least one resource or concept that takes part in the relationship.

3. The Empirical Study

An empirical study was conducted aiming to investigate (i) the perceptions of students concerning the usability of CRICOS and (ii) the attitude of students towards community-driven technologies and the CRICOS environment. The empirical study took place in the context of the "Distance Learning" postgraduate course offered by the Department of Informatics and Telecommunications of the University of Athens. Fourteen postgraduate students participated in the study, which lasted eight weeks in total. The students where grouped into two groups. Each group used CRICOS in order to create a community on a domain of their choice and contribute educational material appropriate for distance learning. The project was carried out in three phases.

During the first phase (duration: 1 week) students had to submit a scenario concerning the framework of their work. The scenario included the domain of the community, the assigned roles of the members (e.g. category editors) and the types of the resources (e.g. activities, quizzes). One group decided to build a community around the domain of "Information Technologies" and the other around the domain of "Java Beans". First the scenario was uploaded to CRICOS, then it was discussed by the students on the attached discussion forum and based on this dialogue the scenario was revised. During the second phase (duration: 4 weeks) the students had to share their knowledge on the community's domain by exploiting the facilities of CRICOS. The students structured the information space of the community by adding the thematic categories, the concepts and the resources. During the third phase (duration: 3 weeks) the students of each group visited the community of the other group and acted as newcomers with the aim of learning the community's domain.

Upon the completion of the third phase, students were asked to fill and submit two questionnaires concerning the evaluation of the CRICOS environment. The first questionnaire was based on the Computer System Usability Questionnaire (CSUQ) [14]. The questionnaire consists of nineteen usability questions to which the respondent has to disagree or agree using a seven-point scale, ranging from 1 (strongly disagree) to 7 (strongly agree). The questionnaire has been extended with four additional elements in order to measure some specific characteristics of CRICOS (see Table 1, questions 9, 10, 18, 19). The second questionnaire was designed to obtain the participants' perceptions of the usefulness and usability of the specific features of CRICOS and it consisted of the following dimensions: structure and organization of the information space (11 items); social navigation facilities (12 items); member's information (5 items); communication facilities (12 items); recommendations provided by the system (8 items); facilities for interconnecting communities (7 items). The range of all the question items was from 1 to 5. Additionally open-ended questions were also included in the questionnaire to obtain users' comments and suggestions to improve the facilities of each dimension. A page

was reserved at the end of the questionnaire for students to provide general opinions and suggestions for the improvement of the system.

Discussion

The analysis of the responses of the CSUQ questionnaire showed that CRICOS rank high in terms of usability (Table 1). However there are some items that signal some improvements to the system. Question 11 (The system gives error messages that clearly tell me how to fix problems) has a mean score of 5 (std. dev. =1.47) which is the lowest score of the questionnaire. Relatively low is also the score of question 13 - The information (such as on-line help, on-screen messages and other documentation) provided with this system is clear – which has a mean score of 5.23 (std. dev. =1.09). These suggest that students need better guidance from the system and better suggestions to the errors they encountered during their work.

Table 1: Results Concerning the Usability of the CRICOS Environment (Scale 1-7)

No	**Question item**	Mean	**SD**
1	Overall, I am satisfied with how easy it is to use this system.	5,71	0,73
2	It is simple to use this system.	5,31	1,25
3	I can effectively complete my work using this system.	6,21	1,05
4	I am able to complete my work quickly using this system.	5,86	1,1
5	I am able to efficiently complete my work using this system.	5,17	1,27
6	I feel comfortable using this system.	5,93	1,38
7	It was easy to learn to use this system.	5,36	0,93
8	I believe I became productive quickly using this system.	5,21	1,63
9	**It is easy to communicate with other users of the system**	5,77	1,09
10	**The system facilitates the collaboration with other users**	6	1,24
11	The system gives error messages that clearly tell me how to fix problems.	5	1,47
12	Whenever I make a mistake using the system, I recover easily and quickly.	5,67	1,23
13	The information (such as on-line help, on-screen messages and other documentation) provided with this system is clear.	5,23	1,09
14	It is easy to find the information I need.	5,36	1,08
15	The information provided with the system is easy to understand.	6,14	0,95
16	The information is effective in helping me complete my work.	6,23	1,17
17	The organization of information on the system screens is clear.	5,64	1,39
18	**It was easy to receive information from other users of the system**	6,46	0,78

19	**The system allows me to share knowledge with other users**	6,69	0,63
20	The interface of this system is pleasant.	6,29	1,14
21	I like using the interface of this system.	6	1,3
22	This system has all the functions and capabilities I expect it to have.	5,54	1,2
23	Overall, I am satisfied with this system.	5,93	0,73

Some of the results from the analysis of the second questionnaire are presented in Table 2. From the results, it is obvious that the students found most of the provided facilities useful. A considerable number of students believed that a community's domain could be represented effectively in the CRICOS environment and the organization of the information space facilitates the access to the resources of a community and also the contribution of new resources. Regarding the recommendations provided by the environment, it seems that the students preferred more direct approaches for recommendations such as the possibility to receive systems messages whenever resources which are relative to their interests are uploaded (Question 9 – mean score = 4,79) than the indirect approaches of social navigation (Question 13 – mean score = 3,29, Question 14 – mean score = 3,5).

Table 2: Results Concerning the Attitudes of Students Towards the CRICOS Environment (scale 1-5)

No	**Question Item**	**Mean**	**SD**
1	Do you believe that a community's domain is represented effectively in the CRICOS environment? 1=not at all, 5=a lot	4,21	0,58
2	Do you think that the multiple perspectives which the members of a community have about the community's domain are effectively represented in the information space of CRICOS? 1=not at all, 5=a lot	4	0,78
3	Do you think that the organization of the information space in CRICOS facilitates the access to the information resources of a community? 1=not at all, 5=a lot	4	0,96
4	Do you believe that the organization of the information space facilitates the user to contribute information resources according to her knowledge and experience? 1=not at all, 5=a lot	3,69	0,75
5	The possibility to have discussion forum at a community is considered as … 1=not useful, 5=very useful	4,5	0,85
6	The possibility to have discussion forum at a thematic category is considered as …1=not useful, 5=very useful	4,29	0,91
7	The possibility to have discussion forum at a information resource is considered as …1=not useful, 5=very useful	4,64	0,5
8	The facility concerning the exchange of messages between users is considered as … 1=not useful, 5=very useful	4,57	0,85
9	The facility concerning the messages sent to a user by the system whenever new, relative to her interests, resources	4,79	0,43

	are uploaded is considered as … 1=not useful, 5=very useful		
10	The possibility to view the resources, concepts, thematic categories and members that other users consider as relevant with a resource you are viewing is considered as … 1=not useful, 5=very useful	4,57	0,65
11	The possibility to view the concepts that other users consider as relevant with the post you are reading is considered as … 1=not useful, 5=very useful	4,64	0,5
12	The information regarding your actions upon a resource as it is visualized with the relevant icon is considered as … 1=not useful, 5=very useful	3,57	1,02
13	The information regarding your friend's actions upon a resource as it is visualized with the relevant icon is considered as … 1=not useful, 5=very useful	3,29	1,07
14	The information regarding the actions upon a resource of the users who have similar interests with you, as it is visualized with the relevant icon is considered as … 1=not useful, 5=very useful	3,5	1,16
15	The information regarding the number of the relations of a resource as it is visualized with the relevant icon is considered as … 1=not useful, 5=very useful	4,07	0,92

As far as the analysis of the open questions is concerned, a considerable number of students expressed the opinion that the environment should incorporate facilities for synchronous communication. Also, 43% of the students expressed their need to be informed by email whenever new messages are received in their message box of the CRICOS web-based environment.

4. Conclusions and Future Plans

In the context of this thesis, we presented CRICOS, a web-based environment, which utilizes several community-driven technologies to support knowledge creation and sharing within interconnected communities. The environment incorporates a flexible information space which is designed so as to maximize the ability of the members of a community to create and improve both its content and its organization. Moreover, the environment provide communication facilities to support the discourse in the community and a recommendation mechanism, based on collaborative filtering and social navigation approaches, that helps community members to find the appropriate information. The empirical study we conducted in the context of the evaluation of the CRICOS environment reveals the positive attitude of the students towards the community-driven technologies and the CRICOS environment. The results concerning the usability of the environment and the facilities provided, indicating that CRICOS can support effectively the members of a community to share their knowledge about the community's domain. Our future plans include the improvement of the facilities provided according to the student's suggestions.

References

1. Ziovas S., Grigoriadou M. and Samarakou M. (2009). Supporting Learning in Online Communities with Social Software: an Overview of Community Driven Technologies, *Advanced Learning*, Raquel Hijon-Neira (Ed.), ISBN: 978-953-307-010-0, InTech

2. Schafer, J. B., Frankowski, D., Herlocker, J. & Sen, S. (2007). Collaborative filtering recommender systems. In: Brusilovsky, P., Kobsa, A., Neidl, W. (eds.) *The Adaptive Web: Methods and strategies of Web Personalization*. LNCS, vol. 4321, (pp. 291–324). Springer, Heidelberg

3. Burke, R (2007). Hybrid Web recommender systems. In: Brusilovsky, P., Kobsa, A., Neidl, W. (eds.) *The Adaptive Web: Methods and Strategies of Web Personalization*. LNCS, vol. 4321, (pp. 377–408). Springer, Heidelberg

4. Dourish, P., and Chalmers, M. (1994). Running out of Space: Models of Information Navigation, in *Proceedings of Human Computer Interaction*, Glasgow, Scotland.

5. Hammond, T., Timo, Hannay, Lund, B., and Scott, J. (2009). Social bookmarking tools (I), *D-Lib Magazine*, 11(4).

6. Dron, J., Boyne, C., Mitchell, R. & Siviter, P. (2000). CoFIND: steps towards a selforganising learning environment. In: Davies, G., Owen, C. (eds.) *Proceedings Of WebNet'2000, World Conference of the WWW and Internet* (pp. 75 – 80), San Antonio, Texas, US: AACE.

7. Dron, J. (2006). "The way of the termite: a theoretically grounded approach to the design of e-learning environments," *International Journal of Web Based Communities*, 2(1), 3 – 16.

8. Kurhila, J., M. Miettinen, P. Nokelainen, H. Tirri. (2002). EDUCO - A Collaborative Learning Environment Based on Social Navigation. In *Proceedings of the 2nd International Conference on Adaptive Hypermedia and Adaptive Web Based Systems* (pp. 242-252). Malaga, Spain: Springer, Verlag

9. Farzan, R. and Brusilovsky, P. (2005). Social navigation support through annotation-based group modeling. In: L. Ardissono, P.Brna and A. Mitrovic (eds.) *Proceedings of 10th International User Modeling Conference* (pp. 463-472). Berlin: Springer Verlag.

10. Ziovas S, Grigoriadou M. (2008). "Knowledge Sharing within and across communities: The CRICOS system", in Proceedings of the 8th IEEE International Conference on Advanced Learning Technologies (ICALT2008), pp. 562-563, Cantabria, Spain

11. Ziovas S, Grigoriadou M. (2008) "CRICOS: A web-based system for creating interconnected communities", in *International Workshop on Social and Personal Computing for Web-Supported Learning Communities* (SPeL 2008) at the 2008 International Symposium on Applications and the Internet (SAINT 2008), pp. 313-316 Turku, Finland, Jul. 28- Aug. 1 2008

12. Grigoriadou, M. & Ziovas, S. (2006). Crossing the boundaries between communities of practice – A virtual environment for knowledge sharing. In E. Pearson & P. Bohman (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications* 2006 (pp. 1568-1573), Chesapeake, VA: AACE.

13. Ziovas, S., Grigoriadou, M., & Samarakou, M. (2010) "Supporting Knowledge Sharing with Community-Driven Technologies: The Case of CRICOS", *The International Journal of Learning*, 2010, Vol. 17, Issue 1, pp 397-410.

14. Lewis, J.R. (1995): IBM Computer Usability Satisfaction Questionnaires: Psychometric Evaluation and Instructions for Use. *International Journal of Human-Computer Interaction*, 7(1), pp. 57–78.