Concept Mapping from a Perspective of Gendered Diversity

Sigrid Schmitz **Elisabeth Grunau**
Institut für Informatik und Gesellschaft
Abt.1/Kompetenzforum [gin]
Friedrichstr. 50
D-79098 Freiburg
schmitz@modell.iig.uni-freiburg.de grunau@modell.iig.uni-freiburg.de

ABSTRACT
Concept maps represent web diagrams to structure, explore and acquire knowledge in non-hierarchical and multi-related formats. They can be used to facilitate navigation in complex and related knowledge domains. With respect to current discussions on the use of these technologies at supporting constructivist and collaborative learning approaches in blended learning and e-learning settings, we carried out an empirical study to analyse a) the effectiveness of concept maps in promoting knowledge acquisition, b) task specific dependencies, and c) gender aspects in the use of concept maps based on a diversity oriented gender concept. This concept includes interacting factors on the navigation strategy of participants in a web-based information system, e.g. level of computer literacy or strategy preferences in real life navigation, amongst others. Based on some results from this empirical study we discuss requirement for the design of concept mapping technology and its benefits and limits for interdisciplinary gender studies.

Keywords
Concept mapping technology, knowledge acquisition, web-based information system, navigation, empirical study, gender aspects, gendered diversity, constructivist e-learning, collaborative work, interdisciplinary gender studies

INTRODUCTION

Concept mapping is a technique for visualizing the relationships among different terms or information sources in a less hierarchical order than hyper-trees or mind maps. The use of concept maps for knowledge visualization aims at “supporting cognitive processes in generating, representing, structuring, retrieving, sharing, and using knowledge.” [1: 168]. A concept map consists of nodes that contain items, or concepts. The relationship between the concepts is shown in linking arrows, which can be labelled to explain the relationship between the concepts, e.g., “is part of”, “results in”, “relates to”, etc. Additionally, with links from concepts to URLs, data-files, graphics and else these maps can be used to distribute information packages.

The facilities of digital concept mapping tools may help learners to navigate complex knowledge domains and to improve knowledge acquisition in resource based learning environments [2]. Some concept mapping tools also allow for group working in order to share information and to develop concepts, their relationships and the maps collaboratively and discursively [3]. Taken together, there is an upcoming discussion on the use of concept mapping technologies for constructivist and collaborative learning in blended learning and e-learning settings, as it allows learners to acquire knowledge from different viewpoints, to model and transfer knowledge schemata collaboratively, to discuss concepts and relationships, and to gain a better meta-cognitive understanding of a knowledge domain.

In parallel, in gender studies the use of non hierarchical learning approaches – constructivist and collaborative – have been proposed widely. Non-hierarchical, mutual interrelated knowledge spaces and related learning concepts, so the discussion, should support interdisciplinary knowledge acquisition and discussion [4]. Thus, concept mapping technology may provide interdisciplinary gender studies with useful tools for electronically and face to face learning, respectively. However, besides the broad discussion in gender studies on the advantage of non-hierarchical, collaborative learning approaches we have little empirical evidence,

a) whether non-hierarchical, multi-related knowledge spaces in fact promote interdisciplinary knowledge acquisition and discussion,
b) whether there are actually gendered preferences for these learning approaches,
c) what other aspects interact in a gendered approach to concept mapping (e.g. age, culture, previous experience, motivation, learning style, amongst others), and
d) what requirements has the design of concept mapping tools to account for from a perspective of gendered diversity, i.e. based on concepts of *not* simplifying and reifying female/male dichotomies.

With a background in gender & e-learning analyses and in the evaluation of e-learning systems [5], we started a research on these questions. We were interested in navigation strategies in resource based knowledge system and we aimed to find some answers to the following questions: Do different forms of knowledge visualization support information retrieval in different tasks settings, e.g. in searching for single information versus searching for related information? Do different groups of learners prefer different forms of web navigation? And, if so, are these differences gender-related?

For the latter question, in particular, we started with investigating at least two interacting factors that may influence a gendered use of electronically tools for navigation. First, computer literacy may be a crucial factor to limit the use of the more uncommon arrangement of concepts and relations in concept mapping navigation. Secondly, the use of real world navigation strategies is being discussed to influence navigation in virtual environments as well [6]. Real world navigation strategies are distinguished between the route and the survey strategy. The route strategy refers to the preferred use of landmarks and route directions in way finding, whereas the survey strategy refers to the use of geographical cues and maps. Gendered constructions of stronger preferences for the route strategy in females against stronger preferences for the survey strategy in males can be explained in part by gendered experience [for overview, 7].

KNOWLEDGE AQCUISITION IN A WEB-BASED INFORMATION SYSTEM

We created a hypertext information system consisting of about 40 single sites with information about trees to investigate the use of different navigation strategies when searching for information in this knowledge domain.

The information sites all have the same structure (fig.1): The headline of the site and a fitting picture are placed on the left side, whereas the right side presents the informational text.

Figure 1. Example of information site lime-tree.

The users navigate within the system with the help of a *hierarchical navigation* or a *concept mapping navigation*. Both navigational settings can be entered first from a starting page. The hierarchical navigation is visualized along a directory/subdirectory of the site names. The concept map navigation is aided by an interrelated network of concepts of the site names (fig.2). Particular terms can be centred with their related terms interactively.

Figure 2. Detail of the concept mapping navigation tool with lime-tree centred.

On top of each information site, users can decide per mouse click on a link whether to continue with the hierarchical or the concept map navigation. Thus, changes in navigation strategy are possible at any time.

Subjects

30 participants, aged from 26 to 51 years, 15 females and 15 males, took part in the study. All, except two, had a degree in higher education. The professions ranged over a broad area: students (2 females, 3 males), educational/social sector (5 females, 2 males), technical/ICT/natural science professions (2 females, 4 males), social science professions (2 females), service sector (3 females, 5 males), physiotherapists (1 female, 1 male).

Procedure

First, the participants had to fill in a pre-questionnaire on bibliographical data (age, educational background, profession), self assessment of computer literacy (5 questions), and real world navigation strategies (4 questions on the use of the route strategy, 3 questions on the use of the survey strategy[1]).

After they had acquainted themselves with the navigation tools in a priming session the participants had to answer

[1] Evaluated questionnaires were used from [7].

different task questions with help of the information system. Two sets of task questions were prepared: single-information questions (task 1-3) for which the answer could be found on one information site and related-information questions (task 4-6) for which information had to be sampled from different sites. The subjects were matched for beginning with the one or the other task setting.

After having answered the task questions participants assessed additional information about their navigation behaviour. This post-questionnaire comprised questions on what navigation the participants started with, why they had chosen a particular navigation strategy, whether they had changed strategy and for what reasons, and how they rate the benefits and limitations of hierarchical or concept mapping navigation.

Data Acquisition

The navigation behaviour was being recorded by a screen recorder. Each information site that a subject opened throughout the course of a task was registered precisely, as well as the time for opening and reading the site. Consequently, the *number of sites opened* and the *search time* could be calculated in relation to the two task sets (single-information questions, task 1-3 / related-information questions, task 4-6).

Additionally the recordings provided information whether a site had been opened with one of the two navigation tools, i.e. using hierarchical visualization or using concept mapping visualization. *Preference scores* were calculated as percentage of opening the concept mapping navigation site in relation to total number of navigation sites opened (CM / CM+H) for each of the task sets. A score of 1 reflected navigation behaviour exclusively with the concept mapping tool. A score of 0 indicated navigation solely with the hierarchical tool, vice versa. Scores between 0 and 1 showed mixed use of the navigation tools including switches between them with preferences in one or the other direction.

Results

Task Categorization and Order of Tasks

First, we had to evaluate whether our categorization in single-information tasks and related-information tasks was warrantable, and if there were effects of beginning with one ore the other task setting in information retrieval.

There was a strong effect of the task set (task 1-3 / task 4-6) on the number of sites opened (GLM[2], F = 112.37, p < 0.001), and the time needed for search (GLM, F = 100.46, p < 0.001). Subjects opened more sites (mean = 16.07, SD = 5.59) with a longer search time (mean = 1368.4 s, SD = 523.9) in the tasks concerning related-information questions, compared to a less number of sites (mean = 4.67, SD = 1.75) and minor search time (mean = 363.9 s, SD = 145.7) in the task sets for single-information questions. The order of task sets revealed no significant effect on the number of sites opened (GLM, F = 0.26, p = 0.61), nor on time needed for search (GLM, F = 1.15, p = 0.28), and there were no significant interactions between task set and task order concerning the number of sites opened (GLM, F = 0.80, p = 0.38), or time for search (GLM, F = 0.00, p = 0.96), respectively. Thus, the categorization of two differing task sets (single-information questions and related-information questions) could be confirmed, whereas the order of beginning with one or the other task set had no influence. Consequently, the groups differentiating in the order of tasks sets where taken together in the following analyses.

Navigation strategies

The use of hierarchical and/or concept mapping navigation tools showed a high diversity across participants, reflected in a broad variance of the preference sores (CM) for concept mapping navigation (fig.3). The preference scores were submitted to a 2(task set) x 2(gender) analysis of variance. Preference scores did not differ significantly between the task sets (F(1,59) = 1.02, p = 0.32), although there was a slightly higher amount of sites opened with concept mapping navigation in tasks with related-information questions (task 4-6). A strong correlation of subjects' preference scores between the two task sets (r = 0.677, p < 0.0019) was significant. Thus, notwithstanding the variety between subjects – some preferring hierarchical navigation throughout the whole task, others using concept mapping navigation more or less permanently and even others changing between the two navigation tools –, the correlation analysis indicated a permanency of individual use of navigation strategies (hierarchical navigation, concept mapping navigation, or mixed) throughout the whole tasks.

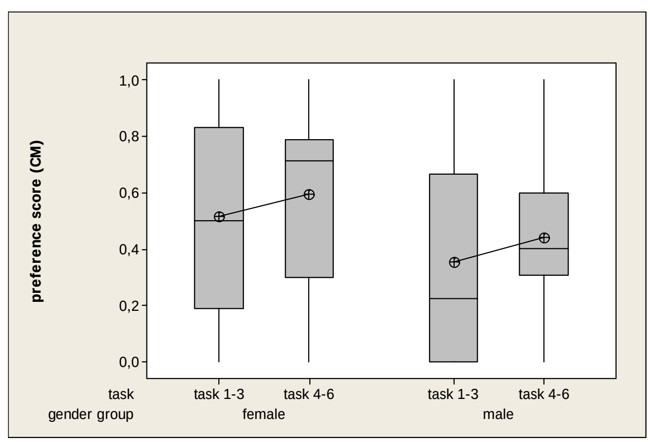

Figure 3. Preference scores for concepts mapping navigation in two task sets (single-information questions, task 1-3, related-information questions, task 4-6) and two gender groups (female, male); mean (⊕), median (─), upper and lower quartile (□), and standard deviation (|).

---

[2] A General Linear Model procedure had to be calculated for this statistical analysis, because the number of subjects for task order was not similar, 16 participants started with task 1-3, 14 participants started with task 4-6).

Gender effects

Females tended to prefer concept mapping navigation in both task sets more than males. This effect of gender, however, did not reach significance ($F(1,59) = 3.74$, $p = 0.06$). There were no interactions between gender and task sets on preference scores, and strong correlation of the preferences scores between the task sets held also within the gender groups (females: $r = 0.72$, $p = 0.002$; males: $r = 0.60$, $p = 0.02$).

Interacting factors

No effect of gender could be confirmed for self assessment of *computer literacy* prior to the tasks ($F(1,29) = 0.95$, $p = 0.33$). The level of self assessment of computer literacy correlated with preference scores for concept mapping navigation, indicating that subjects who assessed themselves with higher computer literacy preferred concept mapping strategy to a higher degree. However, this correlation could only be confirmed significantly in the male group (table 1).

The analysis of self assessment of *real world navigation strategies* on a preference scale (1-4) showed a significantly higher preference of females for route strategy (females: mean = 3.16, SD = 0.35, males: mean = 2.83, SD = 0.35, $F = 6.38$, $p = 0.02$) against a significantly higher preference of males for survey strategy (females: mean = 2.86, SD = 0.55, males: mean = 3.42, SD = 0.44, $F = 9.3$, $p = 0.005$). A negative correlation between route strategy and concept mapping navigation reached significance only in the female group (table 1), indicating that females with a stronger preference for route strategy in real world navigation preferred hierarchical navigation more than concept mapping navigation in both task sets.

Table 1. Pearson correlations between self assessment of computer literacy, of preferences for route and survey strategy in real world navigation, and preference scores for concept mapping navigation in the two task sets (single-information questions, task 1-3, related-information questions, task 4-6), females: n= 15, males, n=15.

	preference score tasks 1-3		preference score tasks 4-6	
	r	p	r	p
computer literacy				
all	0.31	0.10	0.30	0.10
female	0.19	0.47	0.24	0.38
male	0.55	0.03	0.56	0.02
route strategy				
all	-0.10	0.62	-0.32	0.08
female	-0.49	0.07	-0.64	0.01
male	-0.01	0.95	-0.32	0.19
survey strategy				
all	-0.06	0.75	-0.33	0.08
female	0.19	0.50	-0.11	0.70
male	-0.04	0.88	-0.42	0.11

Qualitative results

In the post-questionnaire the subjects were asked to give some information, why they had chosen a particular navigation tool, and how they evaluated the benefits and limitations of one or the other tool.

14 subjects (9 females, 5 males) stated that they had started with the concept mapping tool for navigation. All of them, except one, quoted that their decision was based on “curiosity” or the aim to “try something new”. One female stated that she had chosen the concept mapping tool because of its facilities for a faster search in information retrieval. 16 participants (6 females, 10 males) started with the hierarchical navigation. They explained their decision for using the hierarchical format of knowledge visualisation as it was more “common” or “familiar” (7) to them, by reason they had known it already “from practise” (5) or because information seemed to be more “clearly arranged” (5) for the search procedure.

The evaluations of the participants’ concerning the pros and cons of hierarchical versus concept mapping navigation revealed the following results. The visualization of terms in a hierarchical folder organisation was assessed “better to find facts” (4) “in searching answers on simple questions” (2). However, it was also stated that “one has to open more windows” (1) with a danger “to end in a cul-de-sac” (1). Some participants found the hierarchical navigation “more common” (4) and “easier to use” (5). Half of the users commented that the terms were “clearly arranged” (15) “because of the hierarchical ordering” (5). Limitations were stated for reason that in the hierarchical structure “relations are hidden” (3) and, therefore, knowledge acquisition was “slowed down for complex questions” (1).

In contrast, nearly half of the subjects assessed that the concept mapping navigation enables a better “overview over a knowledge domain” (11). However, concept mapping navigation also bears limitations to get lost “if concepts are related by too many terms and arrows” (5) or “if someone is not used to it” (3). It can be “confusing” (5) and “needs getting used to” (2). Benefits from concept mapping visualization are “the better detection of relations” (8) in “searching for complex questions” (1) or for those questions “that are not clear in advance” (1). Concept mapping is “able to visualize relations that are non-hierarchical” (2). It “motivates to develop new ideas” (1) and “associations” (1) and “motivates to read more about a knowledge domain” (1).

DISCUSSION

The empirical study on navigation strategies in a web-based information system about trees with help of two different navigation tools, i.e. with hierarchical or concept mapping visualizations of site names identified a high diversity of users’ preferences for one or the other navigation tool. A clear distinction could be confirmed between *task sets* to search for single-information questions or to search for related-information questions, respectively. Users needed less time and opened fewer sites to solve the single-information task sets than to answer the related-information questions. However, no clear differentiation was possible along the task sets concerning the preferred use of one or the other navigational tool. Besides a slight trend, it was not that the related-information task prompted the use of concept mapping strategy. Participants' decision for one or the other *strategy* rather seemed to be taken at the beginning of the tasks and remained more or less permanent throughout both task sets (predominantly hierarchically guided or preferring concept mapping navigation or mixed). The statements of participants after the experiment gave some more information on two underlying trends in primary decision making. Those participants who started with the hierarchical tool based this decision mostly on its high profile and familiarity with respect to their former experience. In contrast, subjects who started with concept mapping navigation were curious and motivated to try something uncommon. In addition, the final evaluation of benefits and limitations of both navigation tools by the participants also diverged, some stating the hierarchical visualization being more clearly arranged whereas others assessed concept maps to allow for a better overview. There were, however, some trends in the retrospective evaluation that hierarchical navigation aided search for simple facts in a better way whereas concept maps could show complex relations to a better extent. Some of these results could be due to the fact that our web-based information system consisted of a set of 40 sites only and was relatively simple to navigate in comparison to complex knowledge domains in the internet. Consequently, these results can only be first hints to analyse task specific dependencies on navigation strategies in further detail. One focus of further analysis will be the question of efficiency, i.e. the relations between the use of the navigational strategies and the amount of relevant information extracted from those sites concerning the related-information questions, in particular.

With respect to *gender aspects* a higher preference for concept mapping navigation was shown in the female participants group, in general. This maybe a hint that concept mapping and the presentation of information of knowledge domains in a related manner meets females demands to a higher degree. It has to be stressed, however, that there was a high diversity within this gender group as well as within the group of male participants. Interestingly, the assessment of computer literacy prior to the experiment yielded no differences between the gender groups. But those male participants who assessed themselves with lower computer literacy preferred hierarchical navigation – the common and familiar tool (see above) – more than those males with higher computer literacy. In the female subgroup these relations seem to vanish. It may be that more females decided on using concept mapping navigation more predominantly based on curiosity and interest about the new tool. Although there are some hints to that in the retrospective assessments of the first decision for one navigational tool, these conclusions remain a bit speculative. Again, these possible trends have to be analysed further with more complex recourse-based information systems.

There were also some hints that real world navigation strategy influences the construction of gendered preferences for navigation strategies in virtual information systems. The females in our experiment seemed to be influenced by preferences for route strategies (relying on landmarks and route directions more than on maps and geographical cues) more than males. That means, females with a strong reliance on route strategy preferred hierarchical navigation whereas females with a less route strategy preference were motivated strongest to explore concept maps for information retrieval. The males in our experiment seemed to be less influenced by their real world strategies.

Based on these results we promote to use the term of *gendered diversity* instead of gender & diversity, because both, gender and diversity, can not be separated and interact mutually in complex ways. As we included only two factors in our analysis further research has to account for other intersecting aspects. Possible candidates seem to be influences of profession, of motivation for sorted or unsorted information visualization, of favoured learning style or cultural aspects, amongst others.

Implications for the use of concept maps in learning environments

We used concept mapping technologies in our *interdisciplinary courses* of gender and science & technology studies with students from different scientific cultures as computer science or gender studies [8]. The technology was used to structure the complex knowledge domains in these interdisciplinary settings and to facilitate collaborative work among the students [4]. From our students' evaluations we could confirm some benefits of concept mapping for interdisciplinary learning processes with respect to complex knowledge domains. Concept maps facilitate the repetition of unfamiliar subject areas. They improve getting an overview and perceiving interrelations of key terms. They support the development of new ideas about a subject area and can help to visualise interdisciplinary discussion processes in groups because arguments have to be condensed into a concise format and the development of interrelated terms can be fixed in subsequent maps. However, concept maps turned out not to be the best solution to deepen knowledge in new subject areas. A combination of concept mapping tools, high quality linkage to resources and facilities for collaborative work including text work seem to be necessary for interdisciplinary setting.

Currently, there is some interesting work done in the development of concept mapping technology for constructivist and collaborative learning. One approach, for example, particularly focuses on the inclusion of collaborative work in higher education. The didactic concept of *progressive inquiry* was developed at the University of Helsinki in Finland [8]. It aims to facilitate expert-like working and includes the students from the beginning of a course in creating the context of the course, setting up research questions, constructing working theories, evaluating these theories critically, searching for information in complex knowledge domains, generating new questions and developing new working theories, with all steps combined iteratively. Teachers and students are to form a community of distributed expertise. They have to organise their collaborative work and responsibilities, share and discuss knowledge under different viewpoints. The aim is to support students "academic literacy, scientific thinking, and epistemic agency, particularly when integrated with the use of appropriate collaborative technology" [8: 3718]. Based on this concept of knowledge-creation in learning processes of higher education, currently a technical environment is under development in an EU project, called the *Knowledge Practise Environment* [9]. This web-based collaborative environment offers a set of combined tools to support working and learning activities. Beside facilities for shared text working and editing of documents, it offers "shared spaces" in form of concept maps to visualize, comment and tag resources. These concept maps can be arranged individually or in collective spaces by groups, and they can be linked to an integrated Wiki to support working groups in creating and structuring texts collaboratively. The tool KP-Lab (www.kp-lab.org/) is currently in a testing phase for courses in higher education. One interdisciplinary course will be carried out at our institute.

It depends on many aspects which concept mapping tools in combination with other e-learning facilities are the best for the respective learners in different contexts. Content, complexity and the structure of the information system as well as the task that has to be solved with the system seem to be of importance, but have to be analysed in more detail. We have to research even further the possible benefits and limits of concept mapping technology for interdisciplinary gender studies.

ACKNOWLEDGEMENTS

The project was supported by the Baden-Wurttemberg Ministry for Science, Research and Arts (AZ: 24-729.18). We thank Christoph Gaisbauer for developing the concept mapping tool and Christoph Heim for assistance in data acquisition and analysis.

REFERENCES

1. Tergan, Sigmar O., Keller, Tanja, and Burkhard, Remo A. Integrating knowledge and information: digital concept maps as a bridging technology. *Information Visualization 5* (2006), 167-174.
2. Miertschin, Susan L., and Willis, Cheryl L. Using Concepts Maps to Navigate Complex Learning Environments. *Proceedings of* SIGITE '07 (Destin, Florida, USA, October 2007), ACM Press, 175-181.
3. Basque, Josianne, and Lavoie, Marie-Claude. Collaborative Concept Mapping in Education: Major Research Trends. in Novak, Joseph, D., and Cañas, Alberto, J. (eds.). Concept Maps: Theory, Methodology, Technology. *Proceedings of the Second International Conference on Concept Mapping* 1 (2006), 79-86.
4. Nikoleyczik, Katrin, Schmitz, Sigrid, and Meßmer, Ruth. Interdisziplinäre und gendersensible Lehre: Inhalte, Didaktik und Technik. Zeitschrift für Hochschulentwicklung 3/2 (2008), 103-121.
5. Meßmer, Ruth, and Schmitz, Sigrid. Gender demands on e-learning. in: Morgan, Konrad, Brebbia, Carlos, Sanchez, Javier, and Voiskuonsky, A. (eds.). *Human Perspectives in the Internet Society: Culture, Psychology and Gender.* WIT-Press, Wessex (2004), 245-254.
6. Sjörlander Marie: Individual differences in spatial cognition and hypermedia navigation. in Dahlbäck, Nils (ed.). Exploring Navigation: Towards a Framework for Design and Evaluation of Navigation in Electronic Spaces. SICS Technical Report (March 1998), 61-70.
7. Schmitz, Sigrid. Gender Differences in Acquisition of Environmental Knowledge Related to Wayfinding Behavior, Spatial Anxiety and Self-estimated Environmental Competencies. *Sex Roles 4 (1999)*, 71-93.
8. Meßmer Ruth, and Schmitz, Sigrid. Bridging Disciplines: Gender Studies and Computer Science in an E-Learning Course. in Zorn, Isabel, Maass, Susanne, Rommes, Els, Schirmer, Carola, and Schelhowe, Heidi (eds.). Gender Designs IT. Construction and Deconstruction of Information Society Technology. VS-Verlag, Wiesbaden (2007), 134-147.
9. Muukkonen, Hanni, Lakkala, Minna, and Hakkarainen, Kai. Technology-Enhanced Progressive Inquiry in Higher Education. in Khorow-Pour, Mehdi (ed.). *Encyclopedia of Information Science and Technology*. IGI Global (2009), 3714-3720.
10. Markkanen, Hannu, Holi, Markus, Benmergui, Liisa, Bauters, Merja, and Richter, Christoph. The Knowledge Practices Environment: a Virtual Environment for Collaborative Knowledge Creation and Work around Shared Artefacts. *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications* (Chesapeake, VA 2008), 5035-5040.