Concept Maps: Theory, Methodology, Technology
Proc. of the Second Int. Conference on Concept Mapping
San José, Costa Rica, 2006

EFFECTS OF CONSTRUCTING CONCEPT MAPS ON THE QUALITY OF WEB-SEARCHED INFORMATION AND SUBSEQUENT INQUIRY PROJECTS

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Abstract. The study investigated whether the use of concept mapping as a preparatory stage for identifying relevant information on a given research subject on the web, improves search results. In addition we analyzed the effects of the search process on the quality of inquiry projects, prepared by sixth graders. 78 students from three classes participated in the study. They were assigned to 27 small teams (about three students in a team) for the purpose of preparing inquiry projects. The teams, balanced across classes, were randomly assigned to three intervention groups. One group was instructed in preparing concept maps for the purpose of searching the web to find relevant documents. The second group was instructed in preparing lists for the search purpose. The third, control, was instructed in identifying main ideas of texts. All the groups searched on the web and found a similar amount of documents. The map and the list groups found better quality documents than the control. An advantage for the map group over the list and the control was found in the inquiry projects. The map teams were superior over the list teams in integrating relevant concepts in their projects and producing more coherent projects as a result of their engagement in the mapping activity.

1 Theoretical background

Information retrieval is a process of searching for and identifying specific information amongst a large quantity of other items (Bates, 1987). In activating an information retrieval system, problem-solving and decision-making processes take place, based on negotiations between the searcher and the retrieval system (Borgman, 1987). The act of searching is a result of a matching between the need for information and its wording via a query. While information search technologies have improved significantly in the past decade, and information retrieval is faster, there is still not enough knowledge on aiding the development of web search skills. Therefore, there is a need for cognitive tools that assist learners in efficient information search on the web. One such tool is the concept map.

Concept maps are tools for organizing and representing knowledge (Novak, 2004). They are one of several types of graphic organizers (others are lists and tables, charts and illustrations), that supports the learner in organizing knowledge from self or external sources, such as texts or other materials (Jonassen, 1998). Concept mapping can be used at various stages of inquiry. They can be used during the preparatory stages of planning, or for searching information, by preparing a graphical outline, based on the learners' prior knowledge, of the required information in the web (Payton, 1999). Concept mapping can be also used in later stages of learning the retrieved documents, and during writing up the final inquiry report (Kozminsky & Nathan, in preparation). In this study, we'll explore concept maps constructed by students based on their personal knowledge as a preparation for information search on the web and for inquiry learning. Following the search, the concept maps are updated, using the new relevant information found on the web, and serve as a further search input or for preparing the learning assignments, such as preparing an inquiry project in the present study.

Concept mapping can be constructed individually or in groups. Researchers (Vilberg, 1996; Roth & Roychoudhury, 1993) recommend a cooperative framework as the preferred mode for using concept mapping. This study investigated the efficiency of search, and subsequently, the quality of inquiry projects of students who learned in a cooperative format.

In instructing students to search information in this study, we applied our method of Text Concept Mapping (Nathan & Kozminsky, 2004). Text Concept Mapping is an external graphic representation of the main content ideas of a learnt text and its rhetorical organization. Content and structural information nodes are graphically distinct by using different spatial forms and/or colors (see example map in Figure 1). This type of concept mapping assists in improving text comprehension and can be constructed either prior to reading the text, during the reading, or after reading is completed, depending upon the objectives of the learning process (Nathan, 2002).

Our hypotheses were that searching information on the web using a constructed concept map prior to preparing the inquiry project, is more efficient than searching for information using only a constructed list of concepts, which is less restrictive than maps (Collins & Ferguson, 1993), and more efficient than locating information on the web with no prior graphic tool preparation (Carnot, Dunn & Canãs, 2000). We expected also to find significant differences between the qualities of the inquiry projects, with an advantage for the concept map group.

2 Method

85 students from three sixth grade classes at an elementary school in Israel participated in the study. The research was conducted in two stages, during a total of 17 bi-weekly 45 minutes lessons:

(1) The training stage: First, background data were gathered and a reading comprehension test (Kozminsky, 1992) was administered (one lesson). In the second meeting, a questionnaire to obtain data about prior knowledge of using computers and the web was given, and then, a list of nine subjects for research projects was produced together with the participants (one lesson). In the third meeting, the students received instruction about preparing an inquiry project (one lesson), and after this meeting the students in each of the three classes were randomly assigned into one of three study groups: a *concept map* group, a *list* group and *control* group. The students were pre-assigned to 27 teams (nine teams in each group, about three students in a team), each of which carried out an inquiry on one of the nine subjects (e.g., disease, terrorism; fashion). In the fourth meeting all the groups received instruction and practice, relevant to their study conditions (one lesson): learning to construct concept maps or lists of concepts about the study subject, or general instruction on how to identify central ideas of a topic based on texts (control group). During the fifth – seventh meetings, all the groups received general instruction about how to search information on the web (three lessons), as well, using standard search engines (i.e. Google, Yahoo, etc.).

(2) The study stage: The participants in the concept map group constructed concept maps based on their personal knowledge about the chosen research question, and they then used the map to search for information on the web (e.g., Figure 1). After the search process was completed, the participants updated their concept maps with the new and relevant information (e.g., Figure 1).

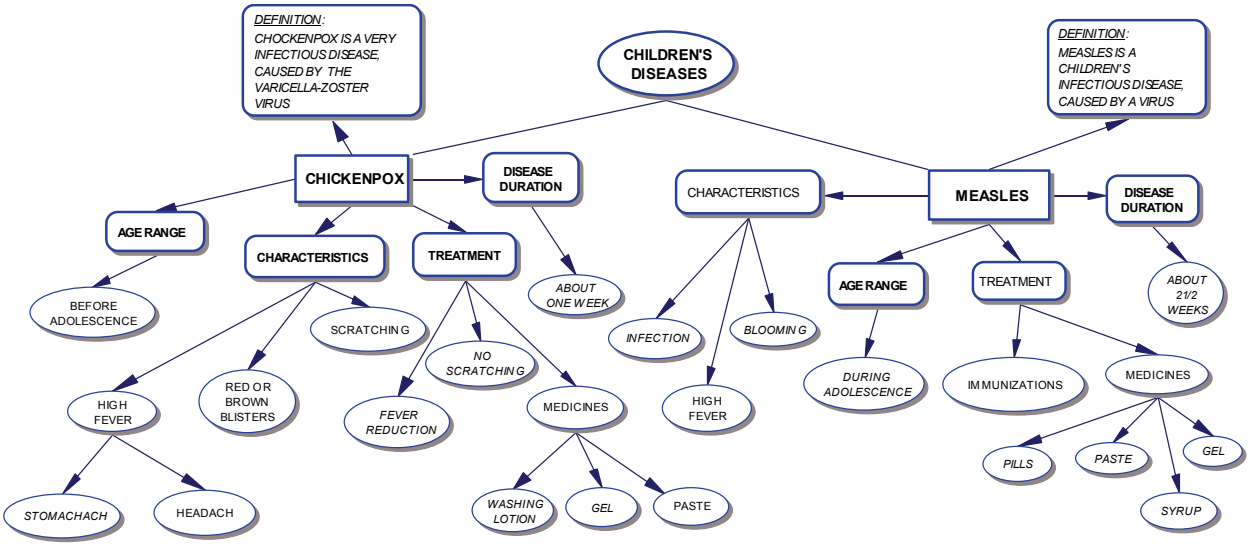

Figure 1: An example concept map of a team (translated) based on the inquiry question: What is the difference between chickenpox and measles? (The team's inquiry theme was "Diseases"). The map was constructed by the team before the search and updated following the search (*the concepts in Italics*). The different types of nodes were originally differentiated by also applying different colors. Here the entire differentiation is represented through different node shapes.

Participants in the list group drafted a list of concepts based on the research question, and used it to search information on the web (e.g., Figure 2). At the end of the search process, the participants updated their concept lists based on information items that they had located on the web (e.g., Figure 2).

1. The cancer disease
2. The influences of cancer
3. Hospital
4. People with cancer
5. Radiation
6. Chemotherapy
7. Smoking
8. *Cancer of lungs*
9. *Metastasis*

Figure 2: An example concept list of a team (translated) based on the inquiry question: What is the influence of cancer on different people? (The team's inquiry theme was "Diseases"). The list was constructed by the team before the search and updated after the search (*the concepts in Italics*).

The control group searched for information on the web as well. At the end of the search, the students in all the three groups completed preparing their projects (8 lessons).

3 Results

Seven students (mostly students with learning disabilities) that did not complete the study requirements, dropped from the analyses. There were no statistically significant differences among the students in the various groups regarding their reading comprehension ($F(2, 75) = .69$, $p = .50$), and experience in using computers and web usage (frequencies analyses). The students were pre-assigned to teams and there was no statistically significant difference among the three groups regarding the teams' sizes ($M = 2.89$, SD = .64, Range: 2 - 4, $F(2, 24) = 2.05$, $p = .15$).

We analyzed the number of information items that were obtained at the end of the search process and their quality, by evaluating the relevance of each item for the inquiry question on a 3 point scale: 0 – no relevance, 1 – indirect relevance, 2 – direct relevance. This evaluation was performed independently by two school teachers (Kappa = .70). The average evaluation of the two judges was used in the analyses. The results by the three groups are presented in Table 1. The results of the study indicate that following search, students who constructed concept maps or lists, identified items of better quality compare with the control ($F(2, 26) = 7.37$, $p < .01$, $\acute{\eta}^2 = .38$). No significant difference was found between the map and the list groups. There was no statistically significant difference between groups regarding number of items retrieved ($F(2, 26) = .31$), and a marginal difference for the sum of information quality ($F(2, 26) = 3.09$, $p = .06$, $\acute{\eta}^2 = .20$).

Group	Number of teams	Number of items	Average of quality per item	Sum of items quality
Concept mapping	9	3.00 (1.32)	1.97 (0.55)	6.22 (3.76)
List	9	2.67 (0.87)	1.65 (0.53)	4.44 (2.14)
Control	9	2.67 (0.87)	0.97 (0.6)	2.83 (2.52)
Total	27	2.78 (1.01)	1.53 (0.69)	4.50 (3.12)

Table 1: Average number of retrieved items, average item quality (0-2) and quality sum for the three study groups (and standard deviations)

We compared the number of concepts as well as the number of the relevant concepts before and after the search for the concept map and the list groups (see Table 2). Analyzing the total number of concepts, there are overall more than twice as many concepts in the concept maps compared with the lists ($F(1, 16) = 25.21$, $p < .001$, $\acute{\eta}^2 = .61$) and they increased after the search ($F(1, 16) = 19.42$, $p < .001$, $\acute{\eta}^2 = .55$). However, there was no statistically significant interaction regarding the change in number of added concepts after the search ($F(1, 16) = .95$, $p = .34$, $\acute{\eta}^2 = .06$). A

similar pattern was obtained regarding the number of relevant concepts. There are overall more than twice as many relevant concepts in the concept maps compared with the lists ($F(1, 16) = 22.60$, $p < .001$, $\acute{\eta}^2 = .58$) and they increased after the search ($F(1, 16) = 24.70$, $p < .001$, $\acute{\eta}^2 = .60$). However, there was no statistically significant interaction regarding the change in number of added concepts after the search ($F(1, 16) = .19$, $p = .67$, $\acute{\eta}^2 = .01$).

		Number of concepts		Number of relevant concepts	
Group	**Number of teams**	**Before search**	**After search**	**Before search**	**After search**
Concept mapping	9	16.11 (4.31)	22.56 (8.90)	14.00 (3.78)	17.78 (6.82)
List	9	6.56 (1.74)	10.67 (2.65)	5.44 (1.79)	8.61 (2.70)
Total	18	11.33 (5.86)	16.61 (8.83)	9.72 (5.26)	13.19 (6.89)

Table 2: Average number of total and relevant number of concepts (and standard deviations), before and after search, for the concept mapping and the list groups

The quality of the inquiry projects was also independently evaluated by two school teachers that were not involved in the inquiry, based on eight criterions (Kappa range: .58 - .92, Median = .83), each consisting three levels (1-3), as presented in Table 3.

Criterion \ **Level**	**Level I**	**Level II**	**Level III**
1. Inquiry question	No inquiry question is included in the project	No reference in the project to the inquiry question	The project is focused on the inquiry question
2. How information items are used in the project	No use of retrieved information items in the project, or, the items are irrelevant to the inquiry question	Partial use of retrieved information items in the project	The information items are integrated in the projects
3. Inquiry conclusions	No stated conclusion from the inquiry process	The project's conclusion does not relate to the inquiry question	There is a stated conclusion and it relates to the inquiry question and generalizations based on the new acquired information
4. Relations among sections of the project	No coherent relations among the sections	There are very few coherent relations among the sections	Coherent relations among the project's sections
5. Clarity of written expression	Unclear, vague or cumbersome expression	Few clear and precise expressions	Clear and precise expressions
6. Project structure	The project is partially structured, with missing sections or with no clear separation between sections	The project is structured but one of the important sections is missing	The project is well structured
7. Inclusion of pictorial information	No pictorial information included	Including at least one picture, without any reference to it in the project	Including at least one picture, with reference to it in the project
8. Aesthetic presentation	No appropriate graphical elements. Mostly in draft format, not printed and with no cover page	Few appropriate graphical elements. Clean, printed, with a cover page	Appropriate graphical elements. Clean, printed, with a cover page

Table 3: The criterions of the inquiry project's evaluation on three levels

The projects evaluations results are presented in Table 4. A multivariate ANOVA of the quality of the inquiry projects indicated an overall difference among the three groups ($F(16, 34) = 6.55$, $p < .01$, Wilks Lambda = .060).

Separate ANOVAs for each criterion indicated statistically significant differences among groups for all the criterions, except criterion 7: (1) Inquiry question: ($F(2, 24) = 8.13$, $p < .01$, $\acute{\eta}^2 = .40$); (2) How information items are used in the project: ($F(2, 24) = 35.34$, $p < .01$, $\acute{\eta}^2 = .75$); (3) Inquiry conclusions: ($F(2, 24) = 10.1$, $p < .001$, $\acute{\eta}^2 = .46$); (4) Relations among sections of the project: ($F(2, 24) = 57.33$, $p < .01$, $\acute{\eta}^2 = .83$); (5) Clarity of written expression: ($F(2, 24) = 4.72$, $p < .012$, $\acute{\eta}^2 = .28$); (6) Project structure: ($F(2, 24) = 15.3$, $p < .01$, $\acute{\eta}^2 = .56$); (7) Inclusion of pictorial information: ($F(2, 24) = .80$, $p = .461$, $\acute{\eta}2 = .06$); (8) Aesthetic presentation: ($F(2, 24) = 3.92$, $p < .05$, $\acute{\eta}^2 = .25$).

Post hoc comparisons ($p < .05$) between groups indicated that the quality of the inquiry projects of the concept map group was higher than the list group (criterions 2, 4); that of the concept map group was higher than the control (criterions 1- 6, 8); and that of the list group was higher than the control (criterions 1- 4, 6, 8).

Criterion		**(1) Inquiry question**	**(2) How information items are used in the project**	**(3) Inquiry conclusions**	**(4) Relations among sections of the project**	**(5) Clarity of written expression**	**(6) Written project structure**	**(7) Inclusion of pictorial information**	**(8) Aesthetic presentation**
Group	**N**								
Concept mapping	9	2.72 (0.44)	3 (0)	2.67 (0.5)	2.89 (0.33)	2.28 (0.57)	2.39 (0.49)	2.28 (0.44)	2.72 (0.44)
List	9	2.56 (0.53)	2.33 (0.5)	2.11 (0.78)	1.61 (0.42)	1.78 (0.56)	2.06 (0.17)	2.44 (0.46)	2.61 (0.49)
Control	9	1.89 (0.42)	1.44 (0.46)	1.39 (0.49)	1.11 (0.33)	1.5 (0.5)	1.33 (0.5)	2.17 (0.5)	2.11 (0.55)
Total	27	2.39 (0.58)	2.26 (0.75)	2.06 (0.79)	1.87 (0.87)	1.85 (0.62)	1.93 (0.6)	2.3 (0.47)	2.48 (0.55)

Table 4: Means (and standard deviations) of project evaluations (1-3) by criterions and by groups.

4 Discussion and Summary

We found differences among the groups in the quality of information obtained following the search on the web. The quality of obtained information of the concept map and the list groups was better than the control, whilst between the map and the list groups there were no significant differences in information quality. However, we noticed that the initial number of concepts included in the concept maps was significantly larger than the number of concepts in the initial lists. Apparently, the maps are better tools for brain storming prior knowledge than lists. Analyzing additional documents following search, did not reveal a differential increase in the number of concepts (total or relevant) added to the maps or to the lists. However, the differences between the maps or the lists formats are expressed in the quality of the inquiry projects. In two evaluation criteria (How information items are used in the project; relations among sections of the project) of the inquiry projects, there was an advantage for the map group over the list. We propose that a larger number of relevant information items that were included in the maps, were integrated in the projects, reflecting better understanding of the retrieved documents. Also, the relations among sections of the projects reflect relationships between concepts in the maps.

We should note that the experimental manipulations focused on guiding the students in constructing maps or lists for the purpose of activating prior knowledge, and they did not focus intensively on exercising and applying a comprehensive search model. Subsequently, we found that maps or lists were updated following search through addition of concepts, but they were not reorganized. Generally, no concepts were deleted following search and no list or map reorganization was noted.

This study exhibited differential effects of applying graphic organization tools during different stages of information search and information use. The locus of the effect was located in this study at the stage of information use. However, we propose to further study possible effects at the search stage under different schedules of applying search models with various cognitive tools. Such a study should trace the entire search process, including the construction and modification of the search queries.

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