Concept Mapping: Connecting Educators
Proc. of the Third Int. Conference on Concept Mapping
Tallinn, Estonia & Helsinki, Finland 2008

DOES THE FORM OF CONCEPT MAP NODES MATTERS?

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Abstract. Two studies examine the effect of the geometric forms of nodes of a concept map, presented prior to reading a text, on its comprehension. In the first study we varied the map interface. 162 students received a concept map to study. The map was presented in one of five interfaces: two bi-form interfaces (ellipses for content and rectangles for structure concepts, and vice versa), two uniform interfaces (ellipses or rectangles node frames), or a concept map without frames. Then a text was given to study without the map, and a comprehension test followed. Three texts were studied. The results indicated no comprehension differences between the two bi-form groups and neither between the two uniform groups. The comprehension scores were higher for the bi-form compared with the uniform interface. The no frame interface received the lowest scores. Before and after studying the texts, the students ranked their preferences for the various map interfaces. The preferences were in concordance to the overall comprehension results, regardless to the group conditions. In the second study we also compared an incongruent bi-form map to the other conditions using the same procedure. Incongruence hindered comprehension and was least preferred.

1 Introduction

In our work on concept mapping we noticed that the maps used by researchers and practitioners consist of concepts that are framed in rectangles, circles or other geometric forms. In our particular application of Text Concept mapping (Nathan & Kozminsky, 2004), we even use two forms to distinguish between content and structure concepts. We ask does form matters at all? Is a particular geometric form preferred in comparison to another form? Is a congruent assignment of form to nodes according to some predefined epistemology important? Therefore, in this study we examine the effect of the geometric forms of a concept map's nodes, presented prior to reading a text, on its comprehension. We also examine the preference of students to particular forms of nodes.

A concept map is a visual graph comprised of nodes containing concepts (verbal or visual descriptions) with links among them. The links are in the form of a line or an arrow with a verbal description (Gaines & Shaw, 1995). The nodes can assume various graphic shapes, depicting various types of information. The design of a concept map, which is based on Gestalt principles (affinity between concepts perceived also via distinguishing color, shape, and clustering), can make learning easier (Wallace, West, Ware & Dansereau, 1998). The visualization of mapping as an external representation, supplies cognitive support and reduces cognitive load from the learners' working memory (Sweller, 1994). The off-loading process enables the learners to invest more cognitive resources in the comprehension processes, thus leading to more meaningful learning (Novak, 2004). In this sense, concept mapping can be regarded as a mindtool (Jonnasen, 2000).

In our version of text's concept mapping, we distinguish in the map between *structure node*s that depict structural-rhetorical information of the text, and *content nodes* that contain the main content of the text (Nathan & Kozminsky, 2004) (see Figure 1). This is accomplished by applying a regular geometric distinction (Kosslyn, 1989): rectangles are assigned to structure and ellipses to content information.

Several studies investigated the role of different spatial configurations and link characteristics of concept maps in learning; some of them also analyzed the effects of the learners' abilities. O'Donnell (1994) reported that the use of a vertically organized concept (knowledge) map brings about an improvement in the achievements of learners who possess low-vocabulary abilities, compared to the effect of the use of the horizontally organized map. Map orientation did not affect high-vocabulary students. Also, the map's spatial configuration, format and link structure, affects encoding and retrieval of information in the map and is mediated by the user's spatial and verbal abilities (Wiegmann, et. al, 1992). For example, the use of embellished links such as arrows, labels, and barbed lines eases the tasks being carried out by those possessing high verbal abilities compared to their performance with unembellished links. In contrast, embellished links hindered performance of those with low verbal abilities.

There is a tendency to use various geometrical forms to distinguish different epistemological information in maps (e.g. Holley & Dansereau, 1984; O`Donnell, Dansereau & Hall, 2002). This is also the case in our use of text concept mapping, where different forms represent structure and content information. We'll report about two studies. In the first one **(**Kozminsky, Nathan & Cohen, 2006) we asked whether the use of a bi-form interface concept map is advantageous to the use of a uniform interface when the maps are presented before studying a text. In the second study we asked in addition about the effect of using bi-form maps that the forms are incongruent with the text's structure.

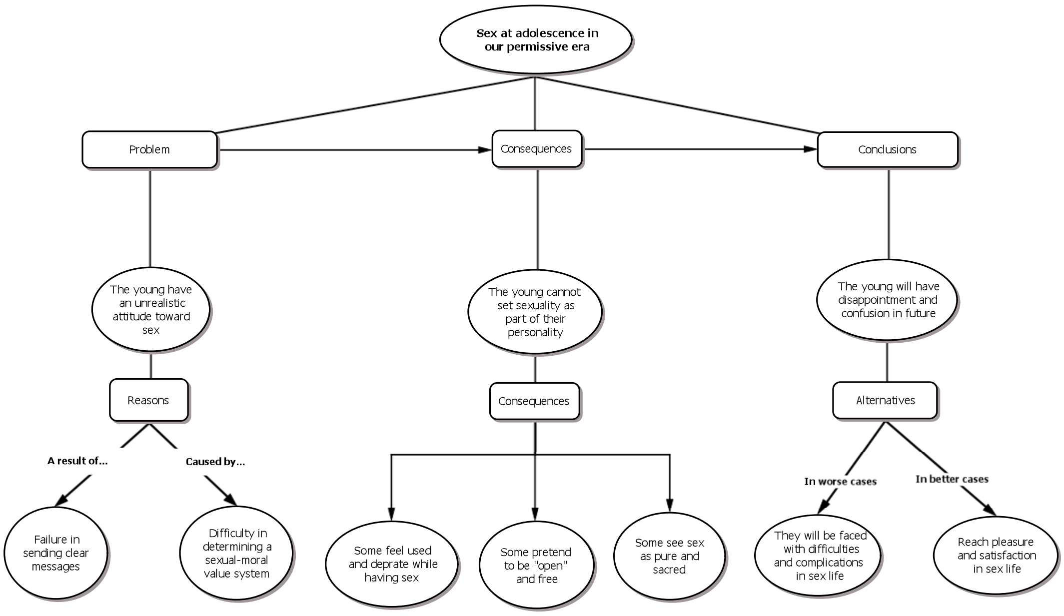

Figure 1: A text concept map. Ellipses represent content nodes and rectangles – structure nodes.

2 Study 1

162 students from an introduction to psychology course participated in the study. The students were randomly assigned into five experimental groups, each assigned a distinct map scheme: (1) Bi-form text maps: ellipses for content nodes, rectangles for structure nodes; (2) Bi-form text map: rectangles for content nodes, ellipses for structure nodes; (3) Uniform text map: rectangles for both types of nodes; (4) Uniform text map: ellipses for both types of nodes; (5) No frame: text map without a geometric forms surrounding content or structure nodes.

The study was conducted in three weekly sessions: In the first session, the students were randomly assigned to the five study groups and tested on reading comprehension, verbal and spatial abilities, and on their preference for a geometrical form of a concept map. All five map schemes for an example text were presented (see Figure 2), and the students were asked to rate their preferences for learning the text with each scheme on a 5-point scale (1-most preferred to 5-least preferred for learning).

In the second session, the researcher explained, separately to each group, the characteristics of the form the map and its components for an example text, according the group's study condition; then, the participants were asked to study another example text. First, they received for study the text's map for three minutes. Then they studied the text without the map (eight minutes); and finally, answered four questions (locating details, inference, identifying structure, and application, Raphael, 1982) without reference to the text or the map (six minutes), and received feedback about the correct answers. (2) In the third session, the students studied in their assigned groups three expository texts (235, 351, 540 words) with their text concept maps and answered four questions, in the same manner as they practiced in the second session. At the end of this session, the students were asked to provide again their preference for learning a text for each map scheme.

There was no statistically significant difference ($p < .05$ from now hence) among the groups in the initial reading comprehension, verbal and spatial ability scores. An analysis of variance was carried out on the overall comprehension scores of the texts and of each question type as a function of the various forms of the concept maps (see Table 1): (1) There was no statistically significant difference between the two bi-form groups and also between the two uniform groups; (2) Using concept map without geometric forms at all or a uniform interface, lead to lower comprehension compared with the bi-form groups. These differences were primarily manifested in memory for details and inference questions; (3) Using a bi-form map leads to higher comprehension scores than using a uniform map. These differences were manifested in memory, in text structure identification, and in application questions.

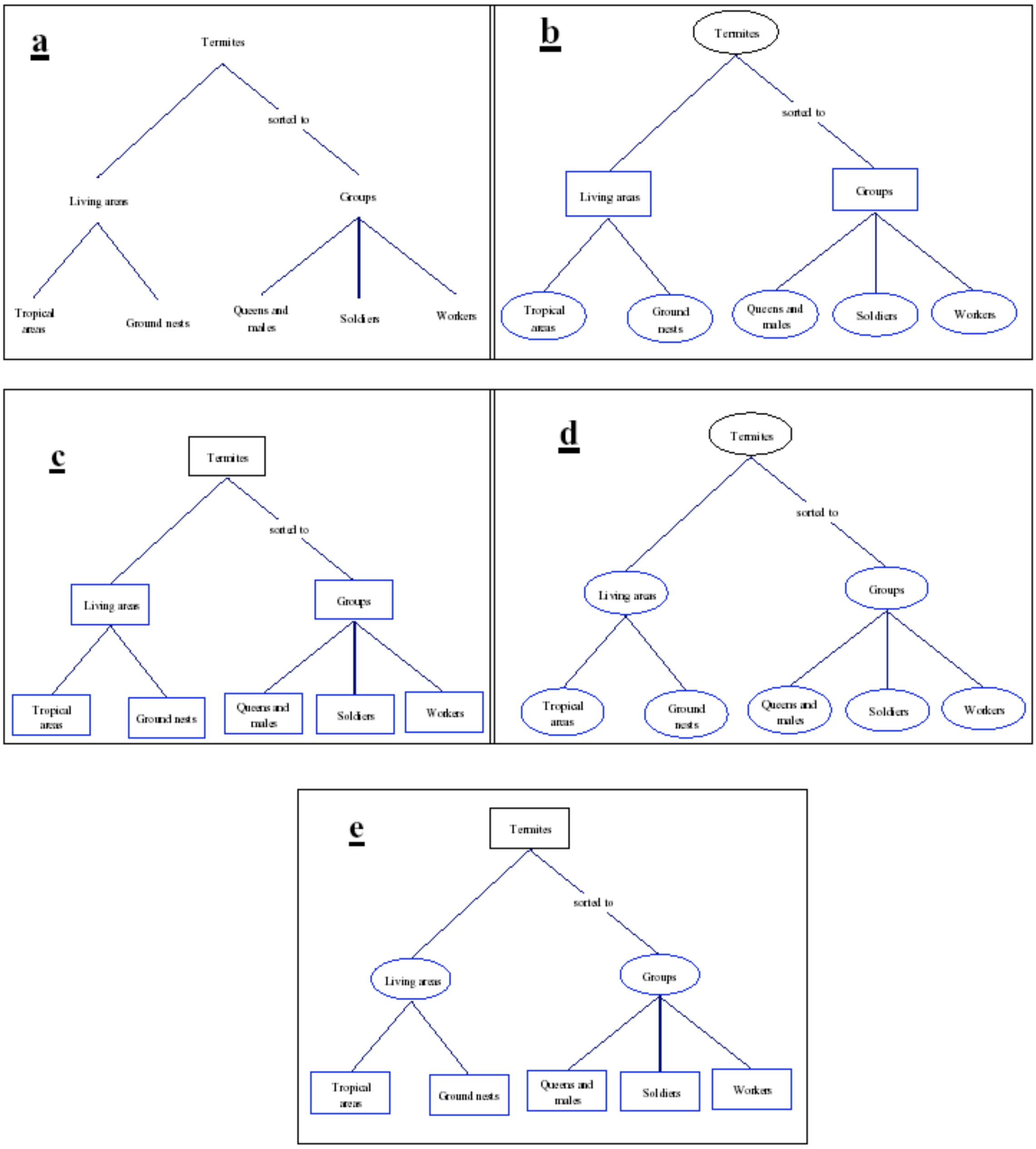

Figure 2. The five map schemes used the preference task. (a) No frame; (b) Bi-form maps: ellipses for content, rectangles for structure nodes; (c) Uniform text map: rectangles for both types of nodes; (d) Uniform text map: ellipses for both types of nodes; (e) Bi-form text map: rectangles for content nodes, ellipses for structure nodes.

The results support the hypothesis that a visual distinction between content and structure nodes in the map leads to comprehension improvement. This distinction was also preferred by the learners independent of their study condition. Therefore, there is congruence between the perceptual preferences and the cognitive performance.

So based on these results, we continued with a second study (which is still in progress), in order to verify whether the nodes' distinct functions and congruence affect text comprehension. Especially we questioned whether incongruent maps, in terms of form assignments to nodes' categories, will hinder comprehension and will affect perceptual preference.

Group	N	Total scores	Comprehension levels			
			Details	Inference	Structure	Application
I Content - ellipses Structure - rectangles	34	1.45 (0.27)	1.38 (0.39)	1.67 (0.38)	1.33 (0.35)	1.41 (0.54)
II Content - rectangles Structure - ellipses	34	1.39 (0.27)	1.49 (0.34)	1.63 (0.47)	1.31 (0.32)	1.14 (0.49)
III Content & structure rectangles	31	1.29 (0.34)	1.30 (0.30)	1.52 (0.48)	1.27 (0.44)	1.09 (0.55)
IV Content & structure rectangles	31	1.20 (0.34)	1.29 (0.27)	1.48 (0.27)	1.02 (0.36)	1.01 (0.55)
V No frames	32	1.16 (0.35)	1.14 (0.37)	1.33 (0.51)	1.09 (0.43)	1.09 (0.61)

Table 1: Adjusted mean scores (and standard deviations) in the comprehension test (range 0-2) for the study groups

As for map preference (see Table 2), there was a preference both before and after studying for a bi-form compared to a uniform or no-form interface.

Scheme	Before Intervention	After Intervention
I. Content – ellipses; Structure - rectangles	2.67 (1.25)	2.36 (1.27)
II. Content – rectangles; Structure - ellipses	2.50 (1.25)	2.31 (0.85)
III. Content & structure - rectangles	2.70 (1.14)	2.90 (1.14)
IV. Content & structure - ellipses	3.0 (1.15)	3.0 (1.00)
V. No frame	4.10 (1.49)	4.30 (1.25)

Table 2: Students' preference means for learning a text with each concept map scheme (N = 162) before and after the intervention (1-most preferred to 5-least preferred)

3 Study 2

43 students from an introduction to psychology course participated in the study. The students were randomly assigned into five experimental groups: (1) Congruent bi-form text maps: ellipses for content nodes, rectangles for structure nodes; (2) Uniform text maps: rectangles for both types of nodes; (3) Incongruent bi-form text maps: ellipse and rectangle forms, in their proportion to Condition 1, were randomly assigned to the map's nodes; (4) Text maps without any geometric forms surrounding content or structure nodes; (5) No map. The

procedure was as in Study 1. In the No Map condition the time allotted to study a text was a sum of the times allotted for map and text study in the map conditions. The students' preference for a geometrical form of a concept map was tested in concordance to the conditions of the second study. All four map schemes for an example text were presented (congruent bi-form, uniform, incongruent bi-form, and no frame), and the students were asked to rate their preferences for learning the text with each scheme on a 4-point scale (1-most preferred to 4-least preferred for learning).

The comprehension results exhibited a trend similar to Study 1 (not yet a statistical one). Especially we note that comprehension results following exposure to an incongruent or to a no-frame maps tend to be lower than the bi-form and uniform conditions. The preference results (see Table 3), also provided a similar (statistically significant) trend as was in the first study. In this study the order of preference was from the congruent bi-form, uniform. Incongruent bi-form, and no frame.

Scheme	Before Intervention	After Intervention
Congruent bi-form frame	1.86 (0.94)	1.71 (0.87)
Uniform frame	2.05 (0.87)	2.01 (0.85)
Incongruent bi-form frame	2.88 (1.25)	2.85 (0.99)
No frame	3.28 (0.91)	3.41 (0.53)

Table 3: Students' preference means for learning a text with each concept map scheme (N = 43) before and after the intervention (1-most preferred to 4-least preferred)

4 Discussion

We found in the first study that using a bi-form map leads to higher comprehension scores than using a uniform or a no-frame map. There was also a perceptual preference both before and after studying for a bi-form interface compared to a uniform one. The no-frame map received the lowest preference score. We propose that the bi-form concept map compared with the uniform map reduces “cognitive load" by providing additional information regarding the semantic role of each node type, and thereby releasing working memory resources for higher level thinking and study activities (McAleese, 1998). This "cognitive load" reduction is also noted by the learners as a perceptual preference for a bi-form interface. By a similar reasoning, we propose that incongruence introduces additional cognitive load, requiring the learner to decipher the nodes' correct roles.

As for explaining the frame/no frame effect we have to resort to basic attention theory. First, several examples of students explaining their perceptual preferences: "The bi-form map is the most preferred, since the different shapes have a different meaning, and this is not so in the other formats." "In the bi-form map subcategories are more noticeable." "A uniform format is more pleasant to the eye." "Better to study when the nodes are framed." The students' explanations refer either to some perceptual qualities (pleasant) or to the ease of locating information and assigning meaning conveyed by the frame. Intuitively, we understand that in complex maps, retaining only verbal labels can cause location confusion and lead to misreading of concepts, especially in scan mode. So, geometrical frames surrounding concept may improve distinction or memory for location (LaBerge, 1995), that are selective aspects of attention. Also the regular interpretation of the geometrical shapes, tunes the sensitivity control components of the attention system (Knudsen, 2007), so the comprehension is facilitated. More time can be dedicated to higher thinking processes.

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