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USING CONCEPT MAPS FOR INDIVIDUAL KNOWLEDGE EXTERNALIZATION IN MEDICAL EDUCATION

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Abstract. In this study it is investigated if students are able to comprehensively externalize their medical knowledge in concept maps. Assuming this it is expected that map performance measured by a map score correlates with the outcome of a previous knowledge test, and that subjects of an experimental group which is familiar with the topic of the mapping task (electrocardiography) receive a higher map score and produce more specific matters than subjects of a control group. Furthermore the effectiveness of incorporation of grown knowledge after a learning period is examined. 39 second year medical students who were enrolled in a lab course served as subjects for the study. The concept mapping task and a questionnaire on previous knowledge were conducted in a computer-based manner. Subjects mapped their knowledge successively before and after the lab course. Results showed significant correlations between previous knowledge and map scores. In addition students that were demanded to prepare the topic of the mapping task received higher map scores and externalized more specific concepts than a control group. The data analysis of the increase of map scores after a learning period revealed no significant results. Results suggest that concept maps seem to support individual externalization of medical knowledge.

1 Introduction

It is widely accepted that concept maps can help students to externalize their knowledge in a domain effectively (e.g. White & Gunstone, 1992) and evoke and support metacognitive activities (Novak, 1990). Moreover, concept mapping seems to be useful in supporting knowledge management, which is a very important concern in societies with rapidly expanding knowledge resources. The knowledge management model of Munich characterizes knowledge management as a process that can be described with the following categories: 1) knowledge generation, 2) knowledge representation, 3) knowledge communication and 4) knowledge use (Winkler & Mandl, 2003; Mandl & Reinmann-Rothmeier et al., 1999). This model can characterize the demands of knowledge management in organizations as well as for individuals. Tergan (2003) points out that computer-based mapping techniques can support all the different demands of an individual knowledge managment process.

Besides the potential uses of the concept mapping method for individual knowledge management, the topic of conceptual change becomes important. Pearsall, Skipper and Mintzes (1996) identified deep knowledge restructuring in concept maps of college-level biology students. In this study, a successive mapping method was used. This means that students map their knowledge in a specific domain more often than once to extend and correct their concept map in order to adjust it to their growing knowledge.

We think that in medical education there is a need for methods that promote the understanding of complex interrelations in a knowledge domain because especially in medicine knowledge integration is essential. Furthermore knowledge integration is an important medical skill when thinking of job routines like the diagnostic process. The use of concept maps can help students to externalize and integrate their understanding of a certain topic and manage it over a period of time by incorporating new ideas in their individual concept map. Fischer et al. (1996) used a computer-based mapping tool to support medical students in structuring complex information while solving diagnostic problems in a case based learning scenario. In this study students were able to cope with the mapping tool after a very short period of practice and they were able to represent a diagnostic case more coherently than a control group.

Our study focused on the use of Concept Maps for knowledge externalization. Are medical students able to externalize medical knowledge comprehensively in concept maps? Assuming this, it was hypothesized that the previous knowledge of the students correlates with the comprehensiveness of knowledge externalization in concept maps. In addition to that, students who are more familiar with the medical topic should externalize their knowledge more comprehensively than a control group and concentrate more on specific matters of the medical topic.

Furthermore, students who take part in a lab course on the topic of the concept map should effectively adjust their maps, due to their grown knowledge after the learning period, similar to the study of Pearsall et al. (1996). According to this, the second hypothesis of our study is that students who took part in a lab course on

the topic of the mapping task show a greater increase in their knowledge externalization than students of a control group.

2 Methods

1.1 Sample

Because of the exploratory character of the study a comparatively small sample was investigated. Subjects of the study were 39 (27 female, 11 male, 1 not specified) second year medical students who participated in a lab course in physiology. One group of 21 students was tested in the context of a lab course on the topic of respiration and served as a control group (CG). The experimental group (EG) consisted of 18 students who took part in the study in the context of the lab course on the topic of electrocardiography (ECG). 5 students were excluded from the analysis because of missing mapping data. The two groups were pre-existing lab course groups, therefore the assignment to the groups was non-random. The aim was to select the groups in a way that their achievement in a physiological entry test was similar.

1.2 Procedure

The study took place at the beginning and the end of a four hour lab course on respiration (CG) respectively ECG (EG). The EG was demanded to prepare for the lab course on the topic ECG with a special script, the CG was supposed to have only received general instruction about ECG in general studies (the CG was demanded for the lab course on respiration). Therefore students of the EG were suspected to be more familiar with the topic of ECG than the students of the CG. Furthermore it was expected, that EG members would be more familiar with the matter of heart electricity, because this area is very specific for the lab course of ECG. Students of the CG should be more used to concepts out of the area of heart mechanics due to their general studies.

At the beginning of the course, both groups were trained in a standardized manner in the use of a computer-based concept mapping tool, which is fit in the e-learning platform JaTeK (Java based Teleteaching Kit) used in medical education at the University of Kiel, Germany. This training lasted for about 10 minutes. Students who took part in the study had used a mapping tool once before, but in a less open, more standardized self-assessment task with concepts and labels for links given in advance. After the training, the students were asked to self-evaluate their previous knowledge in a short computer-based questionnaire on the topic of ECG. Slater et al. (1997) reported high correlations of self-evaluation of knowledge and testing knowledge in a common achievement test. After that the students were asked to create a comprehensive concept map on the topic of ECG. Each student created one concept map by himself. There were 5 concepts and 3 labels for possible links given in advance in order to help the students to start with their concept map. The students did not have to use the given concepts and labels for links and were encouraged to add their own concepts and links. This first working period with the concept map lasted for 20 minutes. At the end of the lab course students of both groups had the opportunity to work on their concept maps again for up to 15 minutes in order to correct and/or complete it.

1.3 Instruments

The self-evaluation of knowledge was recorded with a self-constructed questionnaire. A reliability coefficient (Cronbach´s alpha) was calculated and showed to be sufficient (α=0.77). Therefore the scores of the questionnaire were summed in order to get a total previous knowledge score. Items and descriptive data of the questionnaire are depicted in table 1.

Item	N	M	SD	r_{it}
The topic of “ECG” is easy for me.	39	2.59	0.68	0.49
I have dealt with the topic of “ECG” before.	39	2.56	0.82	0.62
I can explain how positive deflections in an ECG are evolved.	39	2.02	0.84	0.45
I can identify the heart position on the base of an ECG.	39	2.56	0.94	0.56
I know what the term „electrical heart axis“ means.	39	2.15	1.04	0.61
I am able to assign sections of an ECG to the corresponding action phases of the heart.	39	1.56	0.79	0.38
I am able to exemplify, how an isoelectrical line is evoked in ECG.	39	2.51	1.17	0.39

N: number of subjects; M: mean; SD: standard deviation; r_{it}:item-total-correlation (Pearson); Scale: 1=I do not agree, 2=I slightly agree, 3=I rather agree, 4=I fully agree.

Tab. 1: Items and descriptive data of the self-evaluation questionnaire.

The questionnaire and the concept map task were presented to the students in JaTeK. In this platform, a concept mapping template was used which enables the students to create new concepts and links in an easy way and to move the concepts on the screen very easily in order to arrange their concept map (Schanze, 2004).

1.4 Analysis of concept maps

Propositions of the student maps were compiled in a proposition list. Thus, the medical experts who scored the proposition were blind to the original concept maps of the students. 158 out of 442 propositions of the list were rated by two medical experts to determine interrater agreement.

Each proposition was rated using a proposition score and a proposition categorization. Higher proposition scores were given to more abstract or inclusive concepts and links that characterize causal or logical sequences (specified in table 2). The interrater agreement of the proposition score is 94%. The scorings were summed up for each student map to get two map scores per student: one for the map at the beginning of the lab course (map 1) and one score for the map at the end of the lab course (map 2). Propositions were categorized depending on whether they belong to the field of heart mechanics (HM), heart electricity (HE) or both (HM/HE). The interrater agreement of this categorization is 98%. Because of the high interrater agreement, the other propositions were assigned to one of both experts.

0	false or trivial (e.g. *isovolumic contraction interval / constitutes / systole)*
1	correct linkage of two rather concrete concepts (e.g. *aortic valve / is open while / ejection period*)
2	correct linkage of a rather concrete with a rather abstract concept; causal or logical sequence of two concrete concepts (e.g. *isovolumic contraction interval / is / isovolumic; ejection period / causes / opening of semilunar valves*)
3	causal or logical sequence of one concrete and one abstract concept or two abstract concepts; correct linkage of two rather abstract concepts; (e.g. *depolarization / causes / atrial contraction; Cabrera´s circle / helps to evaluate the / electrical heart axis*)

Table 2: Specification of proposition scoring scheme with examples.

3 Results

A t-test revealed that subjects of the EG with a mean score of 21.44 significantly describe themselves as having a higher previous knowledge than the CG with a mean of 17.22 [$t(32)=3.42$, $p<0.01$]. Students of the EG indeed seemed to be more familiar with the topic of ECG than students of the CG. As expected, the previous knowledge score correlates significantly with the score of the first (Pearson´s r= 0.43*) and the second concept map (Pearson´s r= 0.41*).

It was hypothesized that the EG should externalize their knowledge more comprehensively in concept maps and therefore obtain higher mapping scores in both maps than the CG. The corresponding two t-tests of the mean map scores produced significant results concerning this hypothesis for both, map 1 [$t(32)=2.23$, $p<0.05$] and map 2 [$t(32)=2.23$, $p<0.05$] (see table 3). Concept maps should also differ in specific matters of the medical topic between experimental groups. It was expected, that EG members would produce more propositions regarding heart electricity than the CG. A comparison of the mean proportions of propositions concerning heart electricity showed significantly more propositions with an electric matter in the maps of the EG than in the maps of the CG [map 1: $t(32)=2.11$, $p<0.05$; map 2: $t(32)=1.74$, $p<0.05$] (see figure 1).

	EG			**CG**		
	N	M	SD	N	M	SD
Proposition score map 1	16	17.44	9.03	18	11.67	5.90
Proposition score map 2	16	21.19	10.65	18	14.33	7.09
Differences of Proposition Score	16	3.81	2.93	18	2.67	2.85

Table 3: Means and standard deviations for t-tests on map scores.

The second hypothesis was that students of the EG should show a greater increase in their knowledge externalization than students of the CG. A comparison of the mean differences between the both mapping scores from the beginning and the end of the lab course showed no significance [$t(32)=1.17$, ns.] (see table 3).

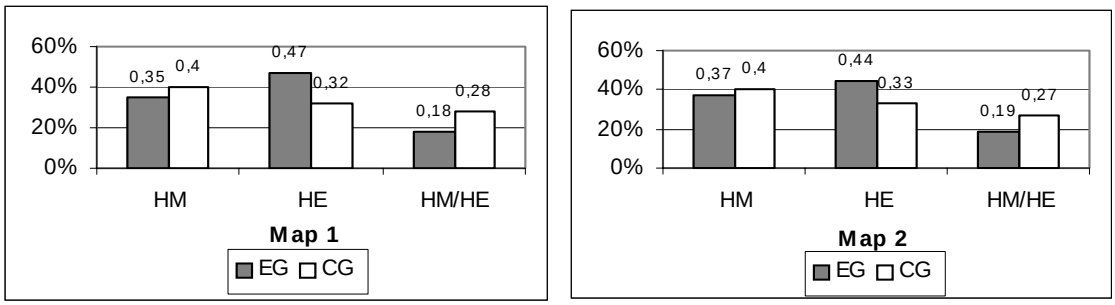

Figure 1. Proportions of HM, HE and HM/HE in map 1 and map 2.

4 Discussion

The first hypothesis has been confirmed. Students are able to externalize medical knowledge comprehensively in their own concept maps. Experimental subjects are also representing more specific matters of the topic ECG in their concept maps than control subjects. It has to be noted that the proposition scores of the EG show a greater SD than the scores of the CG, although this difference is not statistically significant. This is possibly caused by a variation in how intensively students had prepared themselves for the lab course.

The second hypothesis has not been supported by interference statistics. Nevertheless, descriptive data proposes that the EG shows a greater increase in proposition score than the CG. The effect size of this comparison is d=0.39, which demonstrates a small effect. It has also to be considered that the sample size is rather small in this study. In addition, due to the extra 15 minutes that were given to modify the map a mere addition of concepts could be expected for both groups. A further explanation for the failure to verify the second hypothesis might be that the treatment of the four hour lab course was not strong enough to cause a significant higher increase in the map score of the EG than in the CG.

To sum up, concept maps seem to support individual externalization of medical knowledge. Further research should be conducted in order to investigate if medical students also benefit from concept maps in the further process of knowledge management.

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