Concept Mapping: Connecting Educators
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SPONTANEOUS CONCEPT MAPPING AND ITS INFLUENCE ON KNOWLEDGE CONSOLIDATION IN GRADE 5

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Abstract. The present study deals with the implementation of concept mapping in grade 5 of German high school. Concept mapping was used as a means of knowledge consolidation. In order to check, if concept mapping positively affects a student's knowledge gain we compared two instructional treatments: a hands-on instruction with an additional concept mapping phase for knowledge consolidation and a hands-on instruction without a concept mapping phase. We implemented a knowledge test at three different times to assess students pre-knowledge, their short-term and long-term learning success. We also examined the "corrected complexity" of the cmaps on their effect on students' knowledge gain. In order to analyse which instructional type should precede a concept mapping phase we introduced as another treatment a teacher-centred instruction, followed by concept mapping. Our application of concept mapping positively affected a student's short-term learning success, but had no effect on his or her long-term learning success. We found a significant correlation between students' knowledge post-test scores and the "corrected complexity" of cmaps, but only if a hands-on instruction preceded the concept mapping phase.

1 Introduction

Concept mapping has often been used as an assessment technique of hands-on instructions (Novak, 1984; Rice, Ryan & Samson, 1998; Schaal, 2006; Yin, Vanides, Ruiz-Primo, Ayala & Shavelson, 2005). In our present study, concept mapping represents a hands-on knowledge consolidation method, helping our students to develop visual presentations of complex coherences and reflecting upon their newly acquired knowledge. It was used "spontaneously" (=the first time) in a 5th graders' natural science lesson after a (1) teacher-centred instruction and (2) a hands-on approach. In order to test whether concept mapping is an appropriate method for knowledge consolidation a third treatment was introduced: a hands-on instruction without concept mapping (treatment-3), Figure 1. For testing purpose, we compared treatment-2 with treatment-3. On the other hand, we compared treatment-1 with treatment-2, in order to test what kind of instruction should precede the concept mapping phase.

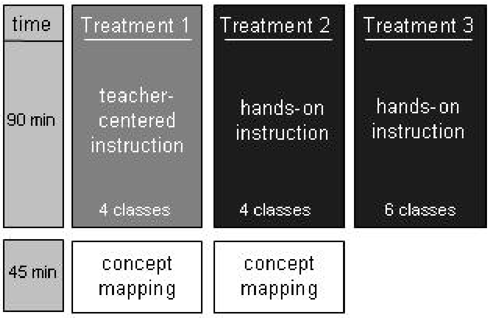

Figure 1. Treatment design and timeframe of the instructional period

2 Data collection

Altogether 397 5th graders from 16 natural science classes of German high school (highest stratification level [=Gymnasium] took part in our study. 162 of them participated in the actual concept mapping instructions, creating 81 concept maps in teamwork.

The concept mapping itself was mentioned as a knowledge consolidation phase after (1) a teacher-centred instruction and (2) a hands-on approach. Concept mapping was new to all of our pupils, and that is why we added a 10-minute introduction, before the actual cmapping phase started. Students had 35 min to complete their posters in teamwork. The specific subject was "water – basis of life". 31 pre-defined items were given to the students, but they were free to add new ones. The connections never were specified, our participants should find their own definitions. We created a knowledge test which consisted of 13 items, covering all discussed themes of the teacher-centred as well as of the hands-on approach. It was applied three times, one week before (K-1), immediately after the different treatments (K-2) and six weeks later (K-3), in order to test student's pre-knowledge, his or her short-term learning success and his or her long-term learning success, see Figure 2.

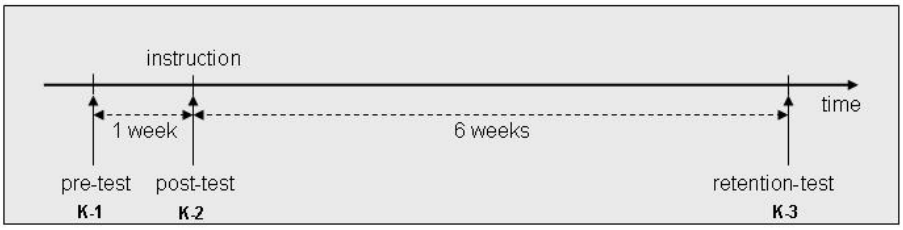

Figure 2. Knowledge-test design: Schedule of knowledge-test implementation (K-1, K-2, K-3)

3 Analysis

For every student, a pre-, post- and retention-test sum-score of all correct answers was calculated and analyzed to assess students' cognitive achievement. If students answered all items accurately they gained a maximum sum-score of 13 points per test. Consequently, every student's increase in knowledge, retention rate and decrease rate as well was recorded by calculating differential variables in the following way: increase in knowledge (K-2 minus K-1); retention rate (K-3 minus K-1); decrease rate (K-3 minus K-2). To test whether the concept mapping phase positively affects students' cognitive achievement and therefore presents an appropriate method for knowledge consolidation we compared the differential variables of treatment-2 with that of treatment-3.

Furthermore, we were interested in the level of concept maps' complexity in order to check whether the complexity correlates with students' cognitive achievement measured in the knowledge test. We defined complexity as the amount of connections which were autonomously made by the students within each concept map. Because students made a lot of different errors by connecting the pre-defined items we only got an "incorrect" complexity, containing methodical as well as content errors. For receiving the "corrected" complexity we had to exclude wrong connections, concerning the content. Therefore, we categorized the individual errors in error types. We defined six different error types and three possible reasons for errors, Table 1.

Table 1. Error type categories and possible reason for wrong connections

error types	description of error type	example for error type	possible reason for error
1	no connection – direction of arrow indicated	water ——► liquid	method and content not apprehended
2	no connection – no direction of arrow	water ◄——► liquid water —— liquid	
3	wrong connection – no direction of arrow	water ◄═ *cannot be* ═► liquid	
4	right connection – no direction of arrow	water ◄— *can be* —► liquid water — *can be* — liquid	method not apprehended
5	right connection – wrong direction of arrow	water ◄— *can be* — liquid	
6	wrong connection – direction of arrow indicated	water — *cannot be* —► liquid	content not apprehended

10 % of the already analysed CMaps were selected randomly and analysed again by the same corrector three weeks after the first analysis in order to test objectivity of the error type categorisation. A second person was instructed into the error category system and analysed the same randomly picked 10 % of CMaps again. We calculated the Cohen's Kappa (κ) coefficient and hence gained two scores, describing the level for intra-observer and inter-observer coincidence which is an indicator for the objectivity degree (Zöfel, 2002). Both the Cohen's Kappa-score for intra-observer objectivity and inter-observer objectivity was very high (intra-observer:

κ = 0.97; inter-observer: κ = 0.95). Wolf (1997) defines Kappa-scores between 0.41 and 0.60 as "moderate", between 0.61 and 0.80 as "substantial" and > 0.80 as "almost perfect". So objectivity of error type categorization was ensured and we were able to calculate the "corrected complexity" and to correlate the corrected complexity values with the sum-scores of the knowledge post- and retention-test.

4 Results

Inter-group analysis of knowledge pre-test showed no significantly differences in students' pre-knowledge between the three different treatments (Kruskal-Wallis test, chi-square = 4.270, $df = 3$, $p = .234$). Therefore, students' knowledge scores of all treatments were comparable to another. Our results revealed that the increase in knowledge was significantly higher in the hands-on approach with additional concept mapping phase compared to the hands-on instruction without a concept mapping (Mann-Whitney U-test, $Z = -2.610$, $p = .009$), Figure 3. Unfortunately, students of the hands-on plus concept mapping phase forgot more of their newly acquired knowledge than these students who perceived no additional concept mapping (Mann-Whitney U-test, $Z = -2.701$, $p = .007$), Figure 3. Therefore, no significant differences in retention rates between treatment-2 and treatment-3 were recorded.

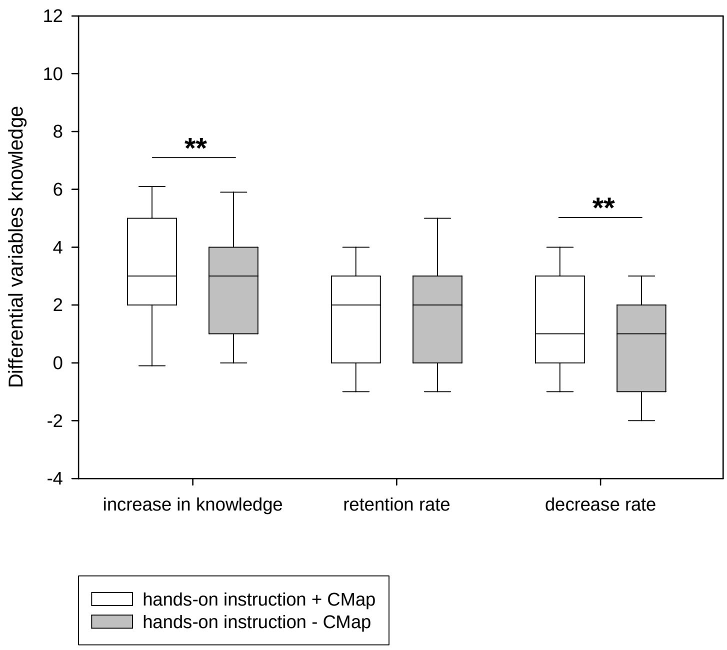

Figure 3. Between-group comparison of differential knowledge variables of treatment-2 (hands-on with concept mapping) and treatment-3 (hands-on without concept mapping); (* $p < 0.05$; ** $p < 0.01$, *** $p < 0.001$)

We detected a positive correlation between the corrected complexity and the knowledge post-test scores in the hands-on approach (treatment-2) (Spearman: $r = 0.307$; $p = 0.01$), but not in treatment-1 (teacher-centred with concept mapping approach).

5 Summary

The analysis of retention rates revealed that the spontaneous concept mapping didn't show an effect on long-term knowledge gain but enhanced students' increase in knowledge. Although this method was totally new to all of our 5th graders, concept mapping had a positive effect on knowledge achievement, even the first time it was introduced. The examination of the corrected complexity supports this positive learning effect of concept mapping. The more connections the students made in their concept maps the better they performed in the knowledge post-test. This correlation did not exist in the teacher-centred group. These results imply that concept mapping is an appropriate method for knowledge consolidation, but only associated with a precedent hands-on approach.

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