Clearing House
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Short Review

Learning with Concept Maps: A review after 42 years of research

How can we promote learners' deeper understanding of content? Concept maps are a promising possibility. Since the 1970s, teaching-learning research has been investigating the extent to which knowledge acquisition and content understanding is promoted with the active engagement of learning content while creating one's own concept maps or working with pre-made concept maps. The meta-analysis "Studying and constructing concept maps: A meta-analysis" by Schroeder, Nesbit, Anguino, and Adesope (2017) summarizes these findings and demonstrates the effectiveness of using concept maps compared to other methods in the classroom.

INTRODUCTION. Concept maps visualize concepts and connections within a topic or subject area in the form of a network. While the nodes of the network represent important concepts or content, the connecting lines or arrows show their relationship or connections. Teaching-learning research assumes that working with concept maps promotes a deeper understanding of content and connections - regardless of whether learners create the concept maps themselves or work with pre-made maps. At the same time, concept maps can help to actively shape learning. They encourage learners to explore new content areas with a focus on their basic structures and to connect new information with existing knowledge.

META-ANALYSIS AT A GLANCE

Focus of the study	Effectiveness of the concept map method
Target group	Secondary school students
Average effect size	Mean positive effect $g = 0.58$ in favor of learning activities with concept maps
Further findings	Concept maps are conducive to learning in all subjects; both when maps are created by the students themselves and when students work with pre-made maps

Concept maps have therefore been used strategically for learning and teaching since the 1970s. Moreover, new studies are continuing to emerge, which increasingly test interactive (digital) forms of this teaching strategy. The meta-analysis analyzes all studies that have appeared since the first uses of the method and compares working with concept maps to other learning activities in order to determine how effective they are and under which circumstances it is worthwhile to use concept maps.

WHAT IS THIS STUDY ABOUT? Based on studies conducted between 1972 and 2014, the meta-analysis examined the effectiveness of using concept maps for learning success. The authors used the knowledge tests administered in the primary studies for this measure.

For study selection, the authors focused exclusively on experimental studies that compared learning activities *with* concept maps to different learning activities *without* concept maps. The meta-analysis only included study designs which ensured that there were no systematic differences between participants in the different study conditions, even before the learning activities took place.

In total, the authors could draw from 63 studies with 142 independent effect sizes. A large proportion of the studies were from STEM subjects (78%) and secondary education (41%). In addition, the authors used moderator analyses to determine the extent that effectiveness was influenced by various factors. The moderator variables are presented and described in the individual findings.

WHAT DID THIS STUDY FIND? The meta-analysis revealed a positive overall effect of medium size ($g = 0.58$). Thus, students who learned with concept maps performed better overall than the comparison group. A heterogeneity test showed that the effect sizes differed significantly between the primary studies. Moderator analyses showed the extent to which the moderator variables (see individual findings) could account for these differences. Concept maps had a positive effect on learning outcomes in both STEM and non-STEM subjects, with no significant differences in effects. Moreover, no differences in the effect on learning were found among the different types of concept maps or whether they were used in individual learning or group work.

Significant findings emerge, however, with regard to the form of use and the respective comparison activity. Effect comparisons with similar learning activities, such as working with outlines, lists, and texts, yielded smaller effects ($0.29 < g < 0.48$) than the comparison activity involving lectures/discussions ($g = 1.05$). Further, when learners construct maps themselves, they show higher average effects ($g = 0.72$) than when they work with pre-made maps ($g = 0.43$).

While creating maps was found to be equally effective across age groups, working with existing maps was more effective at the secondary level (grades 4-8: $g = 0.82$: grades 9-12: 1.24) than for university students ($g = 0.32$). A shorter duration of use (less than one week) was associated with smaller effects ($g = 0.36$) than when the maps were used for more than one or more than four weeks ($g = 0.68/0.72$).

Effect sizes also differed by geographical region in which the studies were conducted. Medium to large effect sizes were achieved by studying maps in Asia, Europe, and the Middle East ($0.46 < g < 1.04$), and small to medium effect sizes were achieved in the United States and Canada (studied/constructed: $g = 0.25/0.49$). An overview of all results from the moderator analysis can be found in the overview of all individual findings.

HOW DOES THE CLEARING HOUSE UNTERRICHT EVALUATE THIS STUDY? The *Clearing House Unterricht Research Group* evaluates the meta-analysis using the following five questions, guided by the Abelson criteria (1995):

How substantial are the effects? The medium-size overall effect (according to Cohen) of $g = 0.58$ indicates that learning with concept maps is, on average, more effective than the alternative learning activities studied. This effect size can be illustrated as follows: When 100 people learn with concept maps, about 20 of them achieve a better learning outcome than when they learn with alternative activities.

The design of the selected studies ensures that the measured changes are actually based on the different learning conditions, since they take different preconditions of learners into account. The positive effect is also relatively robust against comparable learning activities, such as learning with texts, outlines, or lists. Moreover, the effect is especially evident in contrast to teacher-centered formats.

However, one aspect which is essential for classifying the findings is not illuminated. It remains unclear how the learning effects were measured in detail. It is known from previous research (Cheung & Slavin, 2016; Slavin & Madden, 2011) that the use of standardized vs. non-standardized tests can play a significant role. Since more detailed information is lacking here, it cannot be ruled out, for example, that the use of non-standardized measurement methods favored the intervention group and thus effects could have been overestimated.

How differentiated are the results? The meta-analysis takes a differentiated approach with respect to school subjects and grade level and shows that there are no differences between subject-matter categories (STEM vs. non-STEM) and that the effects according to grade level only differ significantly when studying pre-made concept maps. With respect to the success criterion, the authors state that they also allowed studies that considered effects on attitudes, interest, transfer, etc. in the search. However, the effect sizes that are subsequently included in the analyses refer exclusively to knowledge acquisition.

How generalizable are the findings? The authors tested a number of important moderator variables to determine the extent to which the overall effect was generalizable to different conditions. It turns out - as detailed above - that the overall effect provides good guidance in some cases, such as for different subject areas or different types of concept maps. When it comes to conditions such as the learners' grade level or the duration of use, the findings differ significantly and the specific values for the individual moderator levels (e.g., intermediate, secondary, or post-secondary education levels) provide a more reliable orientation value than the overall effect.

The meta-analysis also sheds light on larger contextual conditions such as instructional contexts in different geographical regions. Although the majority of the studies here were conducted in the U.S. or Canada, the meta-analysis provided initial evidence that the method of concept maps is not used equally effectively throughout the globe.

What makes this meta-analysis scientifically relevant? The present meta-analysis is significant in that it provides a necessary update to an earlier analysis conducted in 2006 (see Nesbit and Adesope, 2006). Since then, numerous primary studies have appeared that examined additional contexts of use, features of concept maps (e.g., animated maps), and different conditions of comparison. Thus, the current analysis is able to add 75 effect sizes beyond the previous 67, so that a total of 142 independent effect sizes were included in the meta-analysis.

Beyond that, however, the meta-analysis was not able to provide any theory-related contributions, since hardly any theoretical assumptions were specifically tested in the available primary studies. The authors therefore make concrete suggestions on how such a review could be implemented in the future.

How methodologically reliable are the findings? The disclosure and justification of the methodological procedure largely corresponds to the standards criteria of common requirement guides (e.g. APA Meta-Analysis Reporting Standards). Individual steps of the preparation process, such as the search for relevant primary studies and the study selection, fully comply with these criteria. With regard to the information on the comprehensibility of the coding and the statistical analyses, some decisions could have been presented more precisely and transparently. A detailed assessment can be found in our rating sheet.

CONCLUSION FOR CLASSROOM PRACTICE. Actively shaping learning means encouraging learners to think about content, structures, and contexts. They should therefore cognitively elaborate learning content instead of merely memorizing it. Concept maps are a concrete way to support these cognitive processes and help learners focus on the essential structures of learning content.

Although this meta-analysis does not examine such processes in detail, the findings from over 40 years of research underscore the effectiveness of concept maps. They show that it may well be worthwhile to include learning activities with concept maps in the classroom from time to time instead of the teacher giving a lecture or students working with texts and summaries.

This is true regardless of whether the subject is in STEM or not, and can lead to good learning outcomes, especially at the secondary level. The findings also show that it pays off if a little more time is available for this activity and learners can work with their concept maps for more than a week.

EXAMPLE STUDY

The study by Haugwitz, Nesbit, and Sandmann (2010), conducted in Germany, compared two alternative teaching strategies: using concept maps and writing short essays. Both alternatives encouraged students to be active learners and to create summaries of information in small groups.

The study was conducted in a biology class on the topic of the heart and circulatory system with 248 students from seven high schools. Students were free to form small learning groups of three to five students and were then randomly assigned to one of two alternatives.

In five learning sessions, the students worked through the content using various learning materials and summarized the information, either in concept maps or in short essays. The central concepts were given, but the groups had to find the connections themselves. Each session ended with a short knowledge test on the content of the day. The students in the concept map condition received a short training session on creating concept maps (15 min) before the start.

The results showed that students in the concept map condition made significantly more connections between different learning content and achieved higher performance on subsequent knowledge tests than students in the control condition, i.e., writing essays. The study also demonstrated that low-ability students, in particular, benefit from creating concept maps, even when they collaborated with other low-ability students.

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LINKS.

To the meta-analysis from Schroeder et al., 2017.

To the study example from Haugwitz et al., 2010.

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