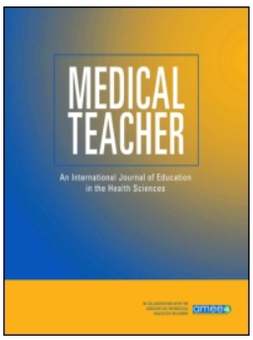

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Group concept mapping: An approach to explore group knowledge organization and collaborative learning in senior medical students

Dario Torre, Barbara J. Daley, Katherine Picho and Steven J. Durning

Department of Medicine, Uniformed Services University of Health Sciences (USUHS), Bethesda, MD, USA

ABSTRACT

Introduction: Group concept mapping may be used as a learning strategy that can potentially foster collaborative learning and assist instructors to assess the development of knowledge organization in medical students.

Methods: Group concept maps were created by 39 medical students rotating through a fourth year medicine rotation. The group maps were developed based on a clinical vignette. Descriptive statistics and thematic analysis of students' evaluations were performed.

Results: Evaluations indicated that students enjoyed the collaborative nature of the exercise and the knowledge sharing activities associated with it. Group maps can demonstrate different knowledge organization

Discussion: Group concept mapping can be used to explore students' organization and integration of knowledge structures in a collaborative setting. Additional research should focus on how group mapping and learning progresses over time and, whether group mapping can help identify curricular strengths and needs.

Introduction

In today's health care environment, collaboration that promotes working together both within and across health professions is essential. A major challenge facing educators in the health professions is how to teach learners to engage in collaborative activities that will ultimately produce positive outcomes in the patient care arena.

Collaborative learning is an instructional method where students work together in small groups toward a common goal (Johnson and Johnson 2009). Collaborative learning has been shown to improve learning outcomes, fostering the integration of individual knowledge structures with those of others (Springer et al. 1999). As such, it can be considered a form of active learning. Active learning, then, promotes students' engagement in meaningful activities, fostering an active construction of knowledge and encouraging students to think and reflect upon their learning (Armbruster et al. 2009). The use of learning tools that allow active participation, interaction between group members, co-construction of knowledge and sharing of cognitive processes becomes an important goal for the growth and development of health professionals (Frohna et al. 2006).

Knowledge organization is believed to play a pivotal role in clinical reasoning (Charlin et al. 2000). There is evidence that although the quantity of knowledge is at an appropriate level for students, their level of knowledge organization may be poor, thus affecting their ability to solve problems and achieve a correct diagnosis (Bordage 1994). Knowledge is organized into mental frameworks, concepts or schemas that contribute to problem solving abilities (Charlin et al. 2007). Knowledge structures that are highly organized can be activated in relevant clinical situations and allows for the processing of information, discriminating among diagnoses and treatment options, thus promoting effective problem solving in a group setting.

A tool that provides learners with the opportunity to demonstrate their knowledge organization in a group setting is a concept map. A concept map is defined as "a schematic device for representing a set of concept meanings in a framework of propositions" (Novak and Gowin 1984, p. 15). Concept maps are a collaborative learning tool that reflects one's understanding, knowledge and knowledge organization for a given topic. Concept maps have been used to promote critical thinking, meaningful learning, and active learning in medical education (West et al. 2000; Daley et al. 2016). Concept maps help to make understanding explicit so that it can be reviewed and

Practice points

- Group concept mapping is an interactive learning strategy to foster collaborative learning.
- Group concept mapping can assist instructors to assess the development of knowledge organization in medical students.
- Medical students indicated that group concept mapping was valuable to understand themeaning of relationships among concepts.
- Medical students reported group concept mapping as a useful strategy to shareknowledge about a topic within the group.

CONTACT Dario Torre dtorre0@gmail.com Associate Professor of Medicine, Uniformed Services University of Health Sciences (USUHS), Bethesda, MD, USA

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examined by teachers and shared with peers (Daley and Torre 2010).

Group concept mapping (Kinchin et al. 2008) creates unique opportunities to engage in collaborative activities and provides considerable insight into active learning and understanding the organization of knowledge. It allows learners to observe the differentiation of knowledge and learn from each other, thus feeling more inclined to collaborate, articulate and elaborate on their learning. The joint development of a concept map allows students to visualize multiple aspects of a clinical problem **(**Van Boxtel et al. 2002**).**

The purpose of this study was two-fold:

i. To evaluate senior medical students' perceptions of the learning value of group concept mapping, and,
ii. To explore the role of group concept mapping in the co-construction and organization of knowledge about differential diagnosis, diagnostic work-up, and integration of basic and clinical sciences.

Methods

Participants included 39 fourth-year medical students rotating through a medicine sub-internship. Twelve to 14 students were enrolled in a 1-month rotation from January to March, 2014. These 12 to 14 students were randomly assigned into small groups of three to four learners who completed a group concept map during their 1-month rotation. At the beginning of each monthly rotation, medical students received a 45-min introduction to concept mapping. The same teacher provided the introduction to all groups and included an introduction to CmapTools, a computerized software program for creating concept maps (Florida Institute for Human Machine and Cognition, 2016; http://cmap.ihmc.us). Fourteen group concept maps were completed based on a clinical vignette depicting a 56-year-old male patient who was a smoker with a 2-month history of dyspnea, orthopnea, cough, weight loss and physical findings of elevated jugular venous pressure, a systolic ejection murmur (aortic stenosis), bilateral lung crackles and bilateral leg edema.

The students were tasked with constructing a group concept map about the case; focusing on differential diagnosis, clinical manifestations, diagnostic and therapeutic approaches, along with integration of clinical and basic sciences. They were asked to construct the map using CmapTools, share it via email with their group during the rotation, make changes, and, then send it to the course director by the end of the rotation.

The processes by which the students worked together throughout the development of the maps were ultimately determined by each group. Since the groups were formed randomly, the first task most groups engaged in, was meeting face to face at the beginning of the course during orientation. From there, they reviewed the case and decided on the process for creating the map. Since the maps were created in CmapTools, each student downloaded the free CmapTools software on their computer. This allowed the groups to use an online process and to share the maps back and forth between group members in an asynchronous format. In order to provide students with the opportunity to select their own group process, students were neither required nor expected to report whether they collaborated face to face, online or used a combination of these two modalities. Students were queried in their final course evaluations about how they interacted and communicated with each other throughout the development of the concept maps.

A 1-h session was scheduled at the end of the rotation in which students presented the group maps to their peers. Students then engaged in a discussion, facilitated by the instructor, about the map content and the group learning process used in developing the maps. At the end of the course, students were provided with a 15-item evaluation form of the concept mapping activity. While the concept mapping activity was not part of their grade, it was a required learning activity of the course.

The evaluations results were analyzed using descriptive statistics. A thematic analysis of the open-ended question responses was performed by two authors (D.M.T. and B.J.D.). Themes were identified using an inductive iterative approach.

The analysis of concept maps in this study was based on Ausubel's (1968) assimilation theory of learning and Novak and Gowin's (1984) scoring model. In Ausubel's theory (1968) cognitive structures are hierarchically organized where more inclusive and more general concepts are linked to more specific subordinate concepts. According to the scoring model developed by Novak and Gowin (1984), scoring criteria include,

i. the hierarchy of the map, (interrelationships from more general to more specific concepts),
ii. propositions (linking words between concepts),
iii. cross links (connections between segments of the map with different levels of hierarchy), and,
iv. examples.

Using this framework, authors (D.T. and S.D.) examined the students' group concept maps based on initial hierarchical organization of each map. The initial concept was identified (for this vignette either the chief complaint of shortness of breath or 56-year-old male with shortness of breath), then the next most inclusive or general concepts was examined (e.g. cardiac system) and the subsequent links to more specific, subordinate concepts (e.g. coronary artery disease or physical findings or diagnostic work up of a specific disease). Authors reviewed the content of the map, the number of concepts and accuracy of links between concepts in each map, and the variation in maps between groups. Discrepancies between reviewers were resolved by discussion until consensus was reached. This study received IRB approval as an exempt protocol.

Results

Ninety-five percent of students completed the evaluations (37/39). Eighty-four percent had never used the CmapTools before ($n = 31$). Even though the process for creating the maps was left to the students to decide, more than half of students made changes to sections of the map constructed by another student (60%; $n = 22$), communicated those

changes to their peers (84%; $n = 18$), and discussed the final version of the map with the group (57%; $n = 20$).

The great majority of students ($n = 33$, 89%) felt that the input of other members of the group in the construction of the map was valuable to their learning and 81% indicated that concept mapping was useful in understanding the meaning of relationships among concepts. Approximately 72% ($n = 27$) reported that concept mapping facilitated their learning along with the integration of basic and clinical sciences concepts.

Major barriers to the use of group concept mapping were: difficulty learning the software, an inability to make changes to the map synchronously while communicating with other members of the group, and initiating the construction of the map.

Valuable learning activities identified in the evaluation included:

i. working in groups,
ii. learning from other students,
iii. sharing ideas, and,
iv. observing the development of the map over time.

Students' suggestions for the future were to introduce concept mapping earlier in the curriculum and provide a starting point for the map.

Additionally, all the maps created were shared among students at the end of each rotation to show students the content and structure of the maps completed by the other groups. The students completed 14 group maps. The median number of concepts per group map was 67.5 with number of concepts per map ranging from 41 to 192.

Interestingly, two main patterns of knowledge organization about the given clinical scenario were identified. Figures 1(A,B) demonstrate how concept maps can facilitate and potentially allow groups of students to differentiate such knowledge organization. These two maps were completed by two different groups of students. The maps demonstrate a visual representation of the knowledge structures held by each group and show interesting differences in knowledge organization related to clinical reasoning.

In Figure 1(A), the main concept, dyspnea, placed at the top of the map, is directly linked to three potential and likely differential diagnoses for the clinical scenario (CHF, COPD and Lung cancer). Then, the group created meaningful connections among clinical features, diagnostic workup, expected findings of imaging (e.g. CXR in CHF and COPD) and treatment for each of the diagnoses. An integration with basic sciences is evident in one section of the map and relates to the pathophysiology of the renin angiotensin system in the context of congestive heart failure.

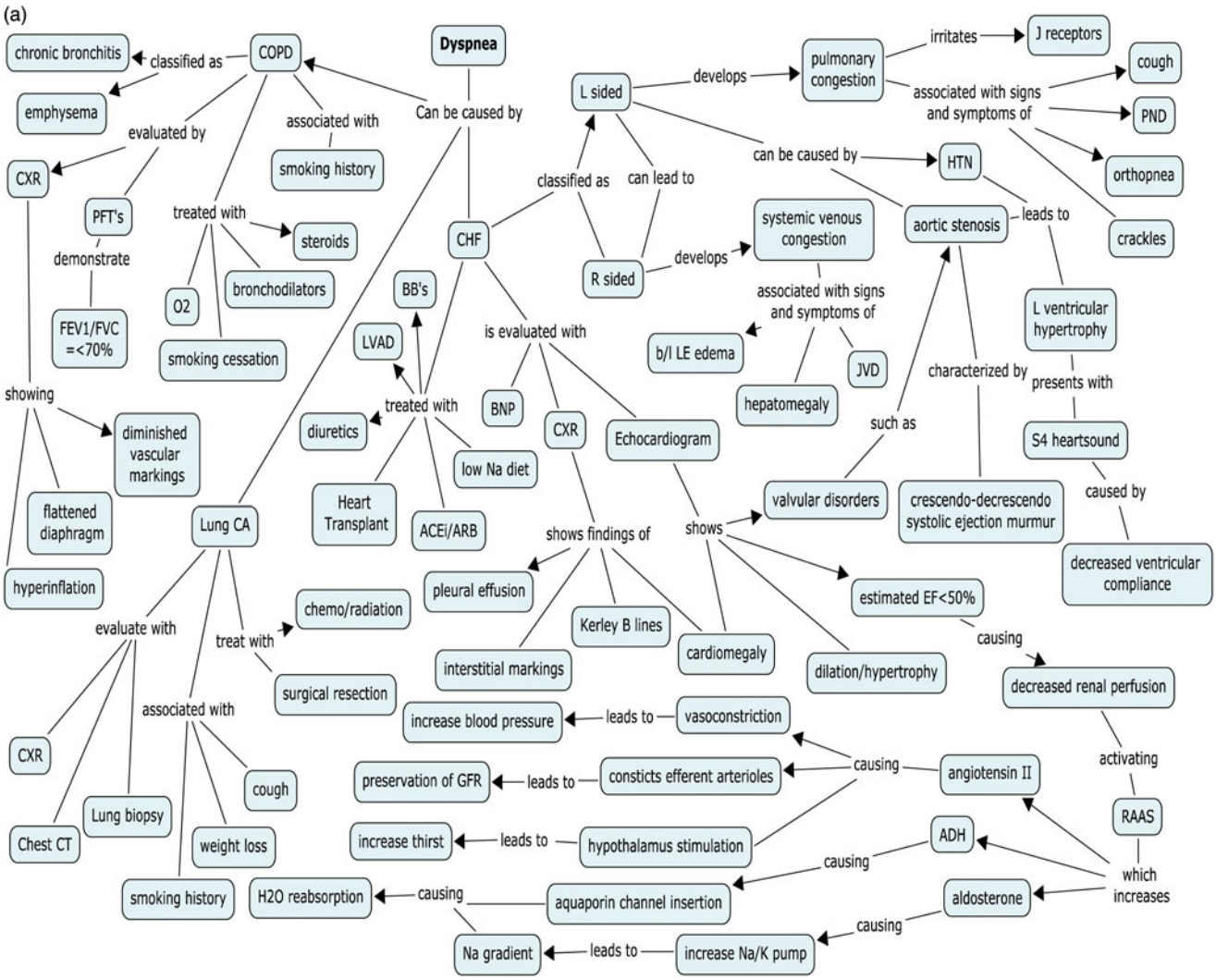

Figure 1A. Group concept mapping, collaborative learning.

(b)

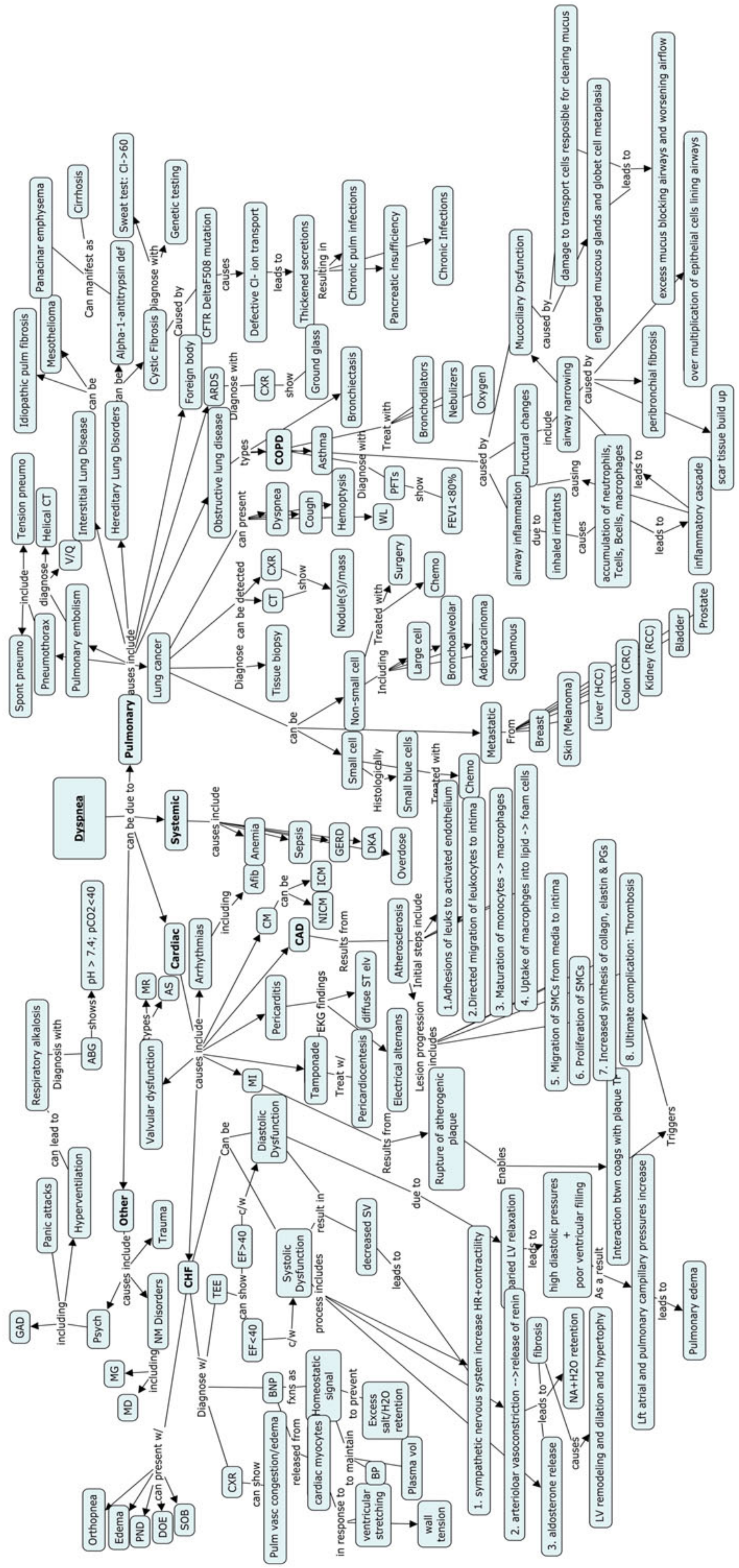

Figure 1B. Continued.

Contrast that with Figure 1(B), and it is evident that the approach of the group is different. The main initial concept, dyspnea, is also placed at the top of the map, and yet, is first connected to a number of organ system concepts (cardiac, pulmonary) and then linked to a number of diseases that may be part of the differential diagnosis (cardiac is related to MI, Pericarditis, CHF, atrial fibrillation, cardiomyopathy). For each organ system identified, the group elaborates at least three to four potential diseases. Additionally, the group depicts concepts of pathophysiology related to congestive heart failure and pathology and histology concepts linked to coronary artery disease.

Overall, it appears that Figure 1(A) focuses more directly on the most likely diseases in the differential diagnosis, whereas, Figure 1(B) shows an approach linked to organ systems then connected to a broader list of diseases. The organization of knowledge of the two groups is quite different, yet neither lacks meaning or understanding of the clinical problem and related topics. The overall knowledge organization depicted in the 14 group maps corresponds with one of the two knowledge organization patterns described here. Yet, there was variation in the total number of concepts. Eight maps showed a knowledge organization consistent with a differential diagnosis hierarchically linked to the most likely diseases (Figure 1(A)), whereas six maps were consistent with a differential diagnosis hierarchically constructed by organ system (Figure 1(B)). It is important to recognize that the groups created a knowledge organization structure that had meaning to them, and as such, would allow them to access this information in their clinical practice.

Discussion

This approach demonstrated students' knowledge and its organization related to the differential diagnosis, clinical features and treatment of diseases. The maps also demonstrate the linking of basic and clinical sciences. Students enjoyed and valued group mapping as a collaborative learning opportunity. They also valued the knowledge sharing and meaning making activities that were part of the group process.

As shown by the structure of the maps, teachers may gain a unique insight into the students' knowledge organization related to clinical topics. Instructors could, in real time or asynchronously, delve into students' understanding of important clinical tasks such as formulation of a differential diagnosis, while at the same time detecting misconceptions and identifying diagnostic or therapeutic errors. The concept maps create a scaffold for students to make meaning, share information and learn from each other. Additionally, instructors can see how different groups organize their knowledge and could use the maps to facilitate discussions about clinical cases.

This study has limitations. First, the software, even though very useful in creating the maps and making changes over time, created an initial challenge for the students. In the future, it would be important to provide students with a brief training on this software. Second, some students indicated that they could not make changes to the group map synchronously. The technology has now been improved so that synchronous changes are easier within the cloud version of the software. Third, it is difficult to assess which student worked on which part of the map, unless we asked students to annotate their names to a particular map section. Also we could not report with certainty how negotiation of meaning took place within each group. However, the final map created by each group demonstrated a set of meaningfully and well interrelated concepts suggesting that co-construction of knowledge and collaborative learning may have indeed occurred during development of the maps. In addition, students' evaluations reported that the majority of students engaged in communication and discussions with other group members about co-creation of different sections of the maps.

Fourth, this study was performed with senior medical students at a single institution using one specific topic related clinical vignette. A larger sample of learners from different institutions and topics, could provide a more meaningful longitudinal information about learners' progression and organization of knowledge.

Our study demonstrated that group mapping can be a useful tool in exploring group negotiation of meaning. In addition, group mapping can be used to inquire about the mechanisms by which individual knowledge structures are integrated into that of the group. Future studies should explore how students' knowledge organization depicted in concept maps correlates with their actual clinical performance in a patient care setting.

Conclusions

Group concept mapping is one tool that has the potential to foster collaborative learning while developing an understanding of knowledge organization on the part of students. Additional research should be aimed at examining the progression of the group's learning over time and exploring how knowledge organization of a group of learners changes throughout the medical school curriculum. Future inquiries should also focus on the use of group mapping to inform curriculum design and to assess its potential role in the clinical setting at the point of care.

Glossary

Concept map: A concept map is a schematic device for representing a set of concept meanings in a framework of propositions (Novak and Gowin 1984, p. 15).

Collaborative learning: Instructional method where students work together in small groups toward a common goal (Johnson and Johnson 2009).

Knowledge organization: Mental systems used to organize concepts and principles into meaningful units.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

Notes on contributors

Barbara J. Daley, RN, PhD, is Professor of Adult & Continuing Education at the University of Wisconsin, Milwaukee. She teaches

course in adult learning theory, organizational learning, and qualitative research.

Katherine Picho, PHD, is assistant professor in the Department of Medicine. She teaches courses in measurement, assessment and evaluation.

Steven Durning, MD, PhD, is Professor of Medicine and Pathology at the Uniformed Services University of the Health Sciences (USUHS). He directs the Introduction of Clinical Reasoning Course and is a general internist.

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