Perspective

Strides in Development of Medical Education

Journal of Medical Education Development Center

2015; 12(3):564 -569

Concept Maps and Meaningful Learning in Medical Education

Amin Beigzadeh[1], Fariba Haghani[2]*

1. *PhD candidate in Medical Education, Research Center for Health Services Management, Institute for Futures Studies in Health, Kerman University of Medical Sciences, Kerman, Iran*
2. *Associate Professor, Department of Medical Education, Medical Education Research Center, Isfahan University of Medical Sciences, Isfahan, Iran*

• **Received:** 25 Aug, 2015 • **Accepted:** 27 Sep, 2015

Medical educators are now required to apply teaching strategies that facilitate deep learning rather than teaching students to memorize by rote. As the practice of medicine has undergone changes due to the proliferation of knowledge and the increase in the complexity of medical education, effective learning becomes much more a question of how students can learn in a meaningful way. In this regard, concept maps as a teaching and learning strategy which support meaningful learning are well known. Concept maps can be used to bridge the gap between what students already know and what they do not know leading to critical thinking and problem solving in a variety of clinical practice settings. Therefore, we conducted this study to introduce concept maps as an extremely valuable technique, to highlight concept mapping as a potential pedagogical strategy which fosters meaningful learning, and to provide information on constructing concept maps.

Scientists believe that learning, a complex cognitive process, can occur in all individuals with different ages. Learning approaches can be divided into two spectrums based on the degree of understanding that a learner may have for new information. In this regard, "rote learning" and "meaningful learning" constitute the two end sides of the spectrum. Rote learning can be defined as a condition that the learner has no understanding of the new information and acquires new information mainly through verbatim memorization. In this run, the conceptual meaning of the knowledge which is memorized is not addressed and the new information cannot be linked to relevant concepts that the learner already knows. The resultant is the transfer of little or no information into the long-term memory (1,2). Conversely, meaningful learning can be defined as a condition that information is understood very well by the learner. At this end of the spectrum, the conceptual meaning of the new information is clear and the new knowledge can be linked to related concepts already known to the learner and this leads to self-directed learning. Evidence shows that meaningful learning is more efficient and lasting (3) because of the integration and linkages made with prior knowledge and this facilitates the transfer of new information into long term memory. Taken this into account, we should highlight that due to the rapid changes in the science of medicine and the practice of medical education, there is a strong desire to educate competent practitioners in a way to equip them with necessary skills and competencies to meet the needs of the society in general (4). In this regard, medical students must be trained based on meaningful and integrated approaches. Meaningful learning, the ability to understand and relate relevant medical concepts by linking them to prior knowledge, is of great importance to medical students. Furthermore, critical thinking, clinical reasoning, and clinical problem solving are of great significance in the

education of future doctors (4). Concept maps are educational tools that encourage meaningful learning. One of the major goals of medical educators is fostering meaningful and self-directed learning among medical students (5). This matter is highly important as medical students are required to learn basic and clinical sciences in a meaningful and practical way to be able to apply their knowledge in a more effective way. In medical education, basic science contents are daunting challenges in order to be linked with clinical scenarios for beginning learners who have limited or no clinical exposure (6). Therefore, helping students to learn in a meaningful and integrated way can be an efficient strategy to enhance long-term retention and deeper understanding among medical students. In addition, the huge amount of information during the training period of medical students is another force which should drive medical educators towards alternative teaching and learning strategies to enable medical students to retain this vast amount of information, making them able to integrate critical thinking and critical reasoning skills and solve a range of complex clinical problems (7). Consequently, concept maps are one such teaching and learning strategy. Pinto and Zeitz believe that concept maps assist medical students to organize and integrate information, assess existing knowledge, and gain insights into new and existing knowledge. More importantly, concept maps can help medical students relate basic science concepts to clinical presentation of the patient (5). As there seems to be changes in the practice of medical education and the need towards integrated and meaningful learning methods, we believe that medical education must be more responsible towards educating medical students based on integrated and meaningful strategies in their future career as practitioners in the community. Thus, medical students should learn in ways that will facilitate their future clinical practice. Taking these important matters into consideration, effective educational strategies should be used in the development of medical practitioners. Therefore, we conducted this study to introduce concept maps as an extremely valuable technique, to highlight concept mapping as a potential pedagogical strategy which fosters meaningful learning, and to provide information on constructing concept maps.

Our perspective regarding the use of concept maps in medical education revolves around 3 main categories and we try to discuss A) the insight into the effectiveness and applicability of concept mapping in terms of meaningful learning and B) provide information on constructing concept maps. These three categories which will be explained more in details are:

1. What are concept maps;
2. Concept maps as a strategy for meaningful learning;
3. How can concept maps be made;

1. What are concept maps?

The concept map, a valuable strategy for meaningful learning, was first developed by Joseph Novak and Bob Gowin at Cornell University in 1972 (3). Concept maps are used to organize and represent knowledge and are premised on Ausubel's assimilation theory of learning. Based on Ausubel's theory, learning occurs by the assimilation of new concepts and propositions into existing concept and propositional frameworks held by the learner (8). A concept map can be defined as a schematic device for representing a set of concept meanings embedded in a framework of propositions (3). In this regard, our learning is premised upon concepts by linking new concepts to what we already know (9). Concept maps are usually enclosed in circles or boxes. The concepts in circles or boxes are linked by a connecting line. There are words on the lines which are called linking words or linking phrases which specify the relationship between the two concepts. Concept maps are

placed in a hierarchical fashion and differentiated as learning grows. In this regard, the most general concepts are placed at the top of the map and less general concepts are arranged hierarchically below. When a learner applies concept maps as a learning strategy he is making an intentional effort to link, differentiate and relate concepts to one another (10). Another important characteristic of concept maps is the inclusion of cross-links between concepts. Cross-links help us see how a concept in one domain of knowledge represented on the map is related to a concept in another domain shown on the map. Concept maps as a visual road map of key ideas can be created by hand with paper and pencil, or computer-based software programs can be used to create them. Figure 1 illustrates an example of a concept map that describes the structure of concept maps (11).

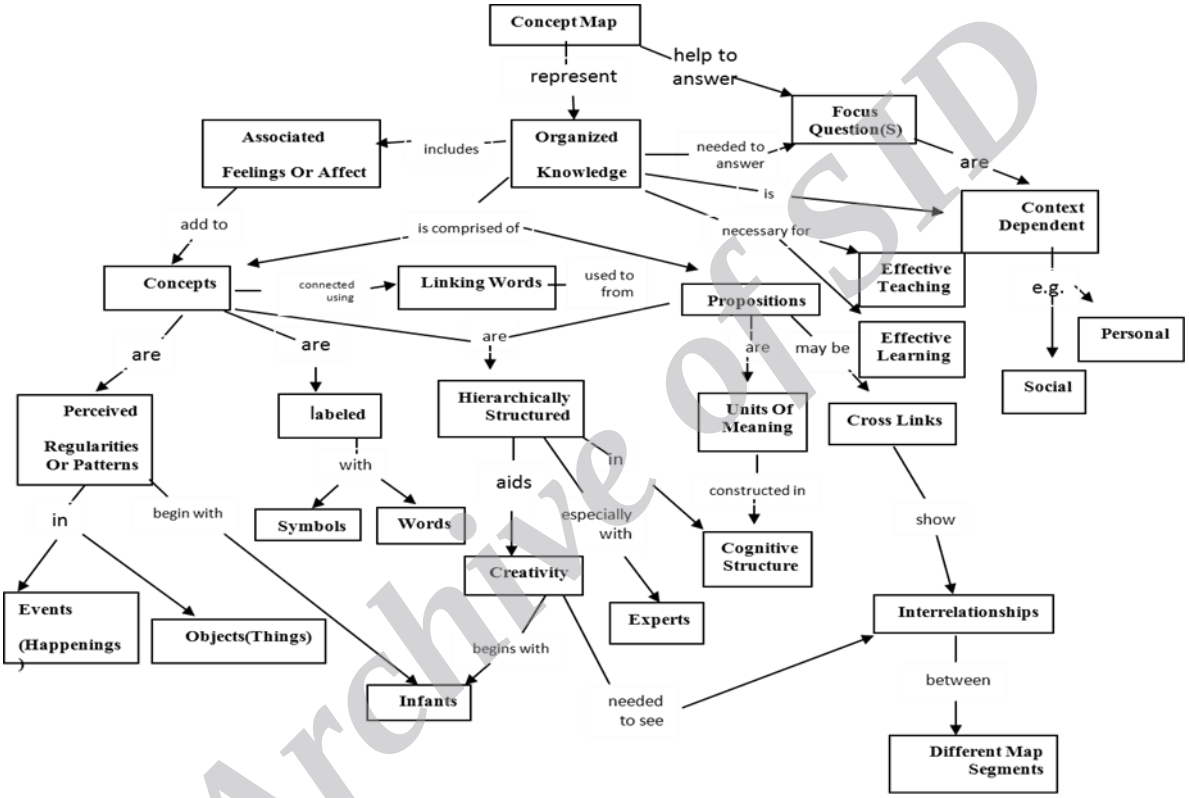

Figure 1: A concept map showing the key features (Novak JD, Canas AJ. The Theory Underlying Concept Maps and How to Construct Them. Technical Report, Florida Institute for Human and Machine Cognition 2006).

2. Concept maps as strategy for meaningful learning

Meaningful learning skills are very important for medical students as they need to keep abreast of the rapid changes in science and the practice of medicine. Thus, in order to have competent doctors, there is a need to train medical students in ways to become life-long meaningful learners. Clearly, based on different researches, one strategy that can lead to meaningful learning is concept mapping (3, 12, 13, 14). Based on the indicated studies, by using concept maps integration between basic medical science and clinical scenarios can be achieved. Also, students would be able to move from superficial thinking patterns to holistic patterns as the linkage between new knowledge with previous knowledge is made. The creation of this integrated cognitive

knowledge structure is what we call it meaningful learning. Mayer (15) and Small (16) state that concept maps have been shown to enhance long-term information retention, reduce verbatim retention of information, and improve transfer of knowledge in future problem solving activities. Cutrer et al. reported the successful use of an expert concept map as an advanced organizer to improve the understanding of respiratory failure. In this study 46 pediatric residents were randomized into control and experimental groups based on the month of service to receive either a control lecture or a session using an expert concept map as an advanced organizer. Three concept maps were completed and scored using a standardized structural scoring method. Findings indicated that the experimental group improved significantly more than controls. Authors concluded that using an expert concept map an as advanced organizer improves knowledge organization and integration as well as enhancing deeper understanding of medical knowledge (17). To corroborate the use of concept maps as a strategy for meaningful learning, it should be mentioned that they can be utilized in the development of group and collaborative learning as well. In a qualitative study by Kinchin and Hay, they identified 3 patterns as they analyzed students' concept maps. These major patterns or structures (spoke, chain, and net) were seen as a sign of different developmental understanding. By furthering the research, they put students in groups of three and asked them to create a consensus concept map. They found that students with different knowledge structures showed greater learning improvements when working in triads in comparison to students with more similar knowledge structures (18, 19). Concept maps help meaningful learning in several other ways. When students are involved in creating concept maps, they have the opportunity of organizing, summarizing, analyzing, and evaluating different concepts or ideas. In this regard, critical thinking skills as a foundation for other meaningful learning activities can be promoted and developed. Pinto and Zeitz express that misconceptions, incongruities and weaknesses in the knowledge structure of students would be revealed because creating concept maps externalizes the concepts in the student's existing knowledge structure. Thus, by correcting these errors, greater understanding and the meaningful learning is achieved (5). In summary, using concept maps is an important strategy for meaningful learning. Students can review and align existing knowledge, organize new knowledge, recognize a new component of a concept or idea, and relate former and new information. In this run, long-term retention of the information in an integrated approach which is very crucial in the career development of medical students can be fostered .

3. How can concept maps be made?

The first step in constructing a concept map is finding a domain of knowledge which the student or the map maker should be familiar with (it is much better if a limited domain of knowledge is selected). The student or the map maker should define a context in which the map will be constructed. Thus, a focus question that specifies a particular problem or a question should be considered. This will show the context and the hierarchical structure of the concept map (the better the focus question, the richer the concept map). The next step will be the identification of key concepts that apply to the domain. The most general, most inclusive concepts, based on the problem or situation, should be identified. By the same token, the most specific, least general concepts are placed either. In this regard, the most general concepts or superordinate concepts (high-order concepts) must be placed at the top of the map. Beneath the general concepts, more specific relevant concepts or subordinate concepts (lower-order concepts) should be placed. This is what Ausubel labels as

subsumption (5). This relationship between superordinate and subordinate concepts will change based on the learner's conceptual frame of reference. In addition, lower order concepts must be broken down into finer components and be tied to higher-order concepts by using linking words or linking phrases. This step is called progressive differentiation. Finally, cross linkages occur by reconciling and linking concepts from one side of the map to concepts on the other side. Ausubel labels this step as integrative reconciliation (20, 21). Cross-links help us see how a concept in one domain of knowledge represented on the map is related to a concept in another domain shown on the map .

In summary, concept maps are considered as a way of learning by both students and faculty staff. Once students begin to create concept maps, they are building very high levels of cognitive performance. By adopting concept maps in teaching and learning, critical thinking and clinical reasoning of medical students will be flourished (4). This is what Bloom (1956) identified as high levels of cognitive performance, namely evaluation and synthesis of knowledge (22). Thus, concept mapping can be a very powerful tool to foster higher level of thinking. This is more evident as medical students are needed to learn active teaching strategies in order to become lifelong learners and learn meaningfully. Taken this into account, concept mapping help medical students to become competent practitioners with the ability to think critically and solve problems in a variety of clinical practice settings to meet the needs of the society. It is highly important to assist students by showing them the ropes during the initial stages of creating concept maps as it can be a daunting task without guidance. If students are totally aware of the fact that constructing maps can facilitate their learning in a meaningful way and help them in scoring well on tests, they would eagerly and enthusiastically apply this learning strategy in their learning. As mentioned earlier, the great impact of concept maps is definitely evident. Literature shows that as students' learning grow; the maps they create will change over time (4). This is analogous to the process that happens in the development of an expertise. As medical students develop their level of expertise (from a novice to an expert), their understanding of particular topics grows and deepens. On the premise of the findings, we can express that concept mapping helps students to develop their knowledge in a cumulative process and fosters the required skills and competencies that a medical student needs. In addition, concept maps promote meaningful learning by providing an additional resource for learning.

References:

1. Ausubel DP. Educational psychology: A cognitive view. New York: Holt McDougal; 1968.
2. Novak JD. Concept maps and Vee diagrams: Two metacognitive tools to facilitate meaningful learning. Instructional science. 1990; 19 (1):29-52.
3. Novak JD, Gowin DB. Learning how to learn. New York: Cambridge University Press; 1984.
4. Daley BJ, Torre DM. Concept maps in medical education: an analytical literature review. Med Educ. 2010; 44 (5): 440-8.
5. Pintoi AJ, Zeitz HJ. Concept mapping: a strategy for promoting meaningful learning in medical education. Med Teach. 1997; 19 (2): 114-21.
6. Brauer DG, Ferguson KJ. The integrated curriculum in medical education: AMEE Guide No. 96. Med Teach. 2015; 37(4):312-22.
7. Watson GR. What is concept mapping? Med Teach. 1989; 11 (3-4): 265-9.
8. Carnot MJ, Feltovich P, Hoffman RR, Feltovich J, Hoffman RR, Feltovich J, et al. A summary of literature pertaining to the use of concept mapping techniques and technologies for education and performance support. [Cited 2003 Jul 8]. Available from: https://carmenwiki.osu.edu/download/attachments/15599855/IHMC+Literature+Review+on+Concept+Mapping.pdf.
9. Irvine LM. Can concept mapping be used to promote meaningful learning in nurse education? J Adv Nurs. 1995; 21(6):1175–9.

10. Novak JD, Canas AJ. The Theory Underlying Concept Maps and How to Construct Them. Technical Report IHMC Camp Tools 2006-01. Pensacola, FL: Institute for Human and Machine Cognition; 2006.
11. Abel W, Freeze M. Evaluation of concept mapping in an associate degree nursing programme. J Nurs Educ. 2006; 45 (9):356–64.
12. Ertmer PA, Nour AY. Teaching basic medical sciences at a distance: strategies for effective teaching and learning in Internet-based courses. J Vet Med Educ. 2007; 34 (3):316–24.
13. Kinchin IM, Cabot LB, Hay DB. Using concept mapping to locate the tacit dimension of clinical expertise: towards a theoretical framework to support critical reflection on teaching. Learn Health Soc Care. 2008; 7(2):93–104.
14. Mayer RE. Models for understanding. Review of educational research. 1989; 59(1):43-64.
15. Small PA Jr. Consequences for medical education of problem-solving in science and medicine. J Med Educ. 1988; 63(11):848-53.
16. Cutrer WB, Castro D, Roy KM, Turner TL.. Use of an expert concept map as an advance organizer to improve understanding of respiratory failure. Med Teach. 2011; 33(12):1018-26.
17. Kinchin IM, Hay DB. How a qualitative approach to concept map analysis can be used to aid learning by illustrating patterns of conceptual development. Educ Res. 2000; 42 (1):43–57.
18. Kinchin I, Hay D. Using concept maps to optimize the composition of collaborative student groups: a pilot study. J Adv Nurs. 2005; 51 (2):183–7.
19. West DC, Park JK, Pomeroy JR, Sandoval J. Concept mapping assessment in medical education: a comparison of two scoring systems. Med Educ. 2002; 36(9):820–6.
20. Boxtel CV, Linden JV, Roelofs E, Erkens G. Collaborative concept mapping: provoking and supporting meaningful discourse. Theory into practice. 2002; 41 (1):40–6.
21. Bloom, B. S. Taxonomy of educational objectives; the classification of educational goals. 1st ed. New York: Longmans Green; 1956.