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ADVANCING TEACHING AND LEARNING IN MEDICAL EDUCATION THROUGH THE USE OF CONCEPT MAPS

Barbara Daley, University of Wisconsin - Milwaukee, Dario Torre, Medical College of Wisconsin, Tracy Stark-Schweitzer, University of Wisconsin - Milwaukee, Singh Siddartha, Medical College of Wisconsin, Monica Ziebert, Medical College of Wisconsin, Jenny Petkova, Medical College of Wisconsin
Email: bdaley@uwm.edu

Abstract. The purpose of this study was to investigate the ways in which the use of concept maps influenced the learning processes of third year internal medicine students in the context of medical education. Sixty-three students were taught to use concept mapping as a learning strategy at the beginning of their internal medicine rotation. The first and final concept maps created by these students were collected and scored. Results indicate that there was a significant difference in the concept map scores of students during their clerkship rotation. Implications for teaching and learning in medical education are drawn.

1 Introduction

According to Shulman (2005), "the *signature pedagogies of the professions* are not eternal and unchanging. Even though they seem remarkably stable at any one point in time, they are always subject to change as conditions in the practice of the profession itself and in the institutions that provide professional service or care undergo larger societal change" (p. 5). As such the practices of medical education are changing, creating multiple questions in the field. Is medical education preparing future practitioners for the changes in care delivery? Are medical students learning in ways that will facilitate their future clinical practice? Are there educational strategies that can be increasingly effective in the development of medical practitioners? Due to the rapid changes in the science of medicine and the need for future practitioners to remain competent in such an evolving medical environment, today's medical students should be encouraged to learn in a meaningful way and become lifelong learners. Meaningful learning, the ability to understand and relate relevant medical concepts by linking them to prior knowledge is of great formative value for junior medical students. Furthermore critical thinking and clinical problem solving are of significant importance in the education of future physicians. Despite attempts to foster new ways of learning, mainly seen in graduate medical education (West, Pomeroy, Park, Gerstenberger, & Sandoval, 2000), the development of new teaching tools has been limited due to difficulty in developing, delivering and assessing such strategies in undergraduate medical curricula. Nevertheless, the Association of American Medical Colleges (AAMC) has been concerned enough about this issue, that they have launched a project specifically to investigate the clinical education of medical students. AAMC (2001) states, "the Association has embarked on a number of programmatic activities designed to assist medical schools in their efforts to reform their curricula, and to improve the pedagogical approaches being used to promote student learning" (p. 1).

The purpose of this paper is to describe a study that investigated concept maps as a pedagogical approach used to promote learning with third year internal medicine students. In this study, concept maps were used as both a learning tool and an assessment approach. The intent of this investigation is to expand the understanding of educational strategies that can assist medical educators as they prepare future practitioners.

2 Literature Review

As the medical profession continues to change, so do the educational methods by which medical students are taught. West et al. (2000) acknowledge the need for alternative teaching and learning strategies that will enable medical students to retain vast amounts of information, integrate critical thinking skills and be able to solve a range of complex clinical problems.

Many literature sources support the utilization of concept mapping as a beneficial learning method (Novak, 1990; Pinto & Zeitz, 1997). Irvine (1995) recognizes concept mapping as a means to promote meaningful learning and as a metacognitive strategy. Concept maps demonstrate a student's mastery of a topic's attributes, relationships and for a greater development of holistic understanding (Marchand, D'Ivernois, Assal & Hivon 2002; Plotnick, 2001).

Concept mapping has been successfully used in education for a number of years (Novak, 1990). Several other health related fields have also used concept mapping as a successful learning tool. In nursing, concept maps have been used as an illustrative teaching/learning strategy, which allows the students to visualize the nursing process (Schuster, 2000). Beitz (1998) acknowledges that concept mapping can improve problem solving, clinical instruction and can be used to promote optimal learning of nursing theory and practice. At the Cornell University College of Veterinary Medicine concept maps have been used as teaching tools in order to facilitate the understanding of concepts more clearly and as a reflection of the students' learning (Edmondson & Smith, 1998).

Therefore, concept mapping has the potential to provide medical students with an additional educational tool in order to understand complex and vast amounts of required reading, and would allow for the student to demonstrate interrelationships of particular topics and show a holistic knowledge of this understanding. Since errors in practice are costly, meaningful learning strategies and tools are necessary for the development of accurate (diagnostic) reasoning processes.

2.1 Lifelong Learning

Meaningful learning, as defined by Ausubel (1968), links new knowledge with previous knowledge ultimately creating life-long learning. Life-long learning is promoted through concept mapping by the student's ability to not only create meaningful learning, but to transfer knowledge gained to future problems as well. Concept mapping facilitates the student's ability to organize information, assess existing knowledge gains, develop insights into new and existing knowledge and transfer knowledge to new experiences. To be competent professionals, medical students must become life-long learners (Pinto, 1997). According to Weiss and Levison (2000) in order to assist medical students to keep abreast with vast amounts of new information and become competent physicians, medical educators must teach the students life-long learning skills.

In many disciplines, particularly in the sciences, concept maps have been used successfully to promote meaningful learning and effective teaching. As a metacognitive tool, one advantage of concept maps is that concept maps can be used in most any discipline or with a variety of teaching methods (Edmondson & Smith, 1998). In medicine, meaningful learning is now recognized as a major goal amongst medical educators (Pinto & Zeitz, 1997). Therefore, concept maps have the potential to facilitate meaningful learning within medical education. However, although meaningful learning through concept mapping can be significant and stimulating, it is often difficult for teachers to move away from rote learning to meaningful learning (Harpaz, Balik, & Ehrenfeld, 2004; Novak, 1990).

2.2 Meaningful Learning Outcomes

As previously stated, the goal of concept mapping is to foster learning in a meaningful way (Novak & Gowin, 1984). Often the outcomes of this type of learning are varied and unpredictable. However, the literature cites three main concept mapping outcomes; to provide an additional resource for learning, to enable feedback and to conduct learning evaluation and assessments (Roberts, 1999).

2.2.1 Resources for Learning

As a resource for learning, concept maps allow the student to demonstrate their mastery of the concepts associated within a particular body of knowledge (Marchand et al., 2002). Concept mapping is a creative activity that fosters reflection into one's own understanding (Coffey, Carnot, Feltovich, Hoffman, & Cañas, 2003). According to Pinto and Zeitz (1997) concept maps can facilitate students' understanding of the organization and integration of important concepts. By connecting old and new knowledge, this type of learning clarifies knowledge, improves critical thinking and assists in completing missing knowledge (Harpaz et al., 2004).

From a student's perspective, concept mapping encourages them to think independently, produces more self-confidence and provides an increased awareness of making connections across different areas of knowledge. Teachers reported that concept mapping assisted students to become active learners and organize theoretical knowledge in an integrative manner or conceptual framework (Boxtel, Linden, Roelofs, & Erkens, 2002; Harpaz et al., 2004).

Laight (2004) designed a study to explore students' attitudes towards concept maps as an additional learning resource. Pre-prepared concept maps were integrated into traditional instructional methods. Developed questionnaires asked whether the concept maps were useful and also allowed for comments. A significant majority of the students reported that pre-prepared concept maps were useful to their learning. Even though no significant statistical association between the self-reported usefulness of the concept maps and a preferred learning style was shown, students did report an encouragement to think more deeply and noted an increased understanding of conceptual interrelationships. Therefore, according to Laight (2004) pre-prepared concept maps may offer alternative and innovative learning/teaching opportunities and methods in large classes and may promote teaching to multiple learning styles.

"Students and teachers constructing concept maps often remark that they recognize new relationships and enhance new meanings or, at least, meanings they did not consciously hold before making the map" (Novak & Gowin, 1984, p. 17). Concept mapping also allows for the students to reflect on their own (mis)understandings and take ownership of their learning.

Collaborative learning was explored in a study done by Kinchin and Hay (2000). Following the identification and themes of three major patterns of knowledge development (by analyzing individual student concept maps), the students of different knowledge patterns collaborated together. This study found that when the students of these separate knowledge structures collaborated together, more progress took place. Students who produced "low end" concept mapping structures benefited from students with "higher end" concept mapping structures, thus producing greater conceptual change.

Furthermore, in a qualitative study using concept maps performed by Boxtel et al. (2002) when students collaborated on a particular task, it was discovered that they communicated more effectively, leading to the co-construction of reason and meaning. Furthermore, the concept maps encouraged verbalization of questions, answers and assumptions allowing peers to communicate incorrect connections or links, creating a co-construction of meaningful learning.

2.2.2 Feedback

In relationship to feedback, concept mapping can assist the student in clarifying a topic and teachers can use maps to provide feedback and identify student misunderstandings (Roberts, 1999). According to Kinchin and Hay (2000) concept maps are seen as a communication tool between student and teacher which reveals the students' constructions of connections.

Edmondson and Smith (1998) performed a qualitative study that analyzed students' responses to the integration of concept maps as a teaching/learning tool. The majority of the students claimed that concept maps greatly facilitated their understanding. Almost one-half agreed that creating a concept map was an effective learning device. As a teaching method, the concept map provided the teacher with the students' errors or misconnects, thereby allowing the teacher to provide feedback and clarify content.

2.2.3 Evaluation Methods

Concept maps can be used as evaluation tools for identifying both valid and invalid learner thoughts and links. Concept maps can be used in formative assessments (where the teacher can assess the student's learning at a particular point) or summative assessments (to determine the student's understanding of a complete section or for a grade) (Coffey et al., 2003). Williams (2000) notes that concept maps can be used as an assessment for learning rather than an end process of learning. Concept maps are a useful tool for, "making the process of knowledge explicit" (p. 37). However, according to Roberts "because maps can vary greatly in style, a scoring method which suits the particular type of map must be chosen" (1999, p. 716).

Concept mapping was used as assessment tool in a case study completed by Williams (2004). In this case study, the student analyzed the role of a walk-in center nurse. The role was analyzed with evidence, a literature review, and a reflection of other walk-in centers. Throughout the study, the student followed specific criteria and guidelines. Feedback was provided consistently, according to how the mapping progressed. At the completion of the case study, the student had successfully demonstrated an understanding of evidenced-based practice. Therefore, when using

concept mapping as an assessment tool, the assessments should be meaningful to the students and reflect real situations in order to create meaningful and life long learning skills (Williams, 2004).

Concept mapping was also used in a pretest/posttest study done by West et al. (2000). Although concept mapping assessment scores did improve after course instruction, concept mapping assessment (CMA) scores did not correlate with final course or standardized test scores. According to West et al. (2000) "the absence of a positive correlation suggests that CMA measures a different knowledge characteristic than do multiple choice examinations" (p.1109) and therefore, concept mapping assessment has the potential to evaluate how students or residents organize and use knowledge in a way that traditional tests cannot. This type of assessment may also provide insight into why some residents score well on objective written examinations but have difficulty with clinical application.

As previously stated, concept mapping has the possibility to measure a student's evolving knowledge framework. According to Kinchin and Hay (2000) concept maps can reveal what each student knows and also can illustrate how the student understands and arranges knowledge in their individual minds. Finally, concept maps can provide teachers with insights into misunderstanding, misconceptions or common errors (Boxtel et al., 2002; Edmondson & Smith, 1998). In medical education, concept maps could provide a valuable tool to medical educators that reveal students' misunderstanding of concepts. These misunderstanding could lead to an identification of potential (patient) errors (West, 2002).

2.3 Concept Mapping and Medical Education

Currently, most medical students are enrolled in traditional curriculums that use rote learning strategies in their basic science courses (Pinto & Zeitz, 1997). However, with this methodology, educational deficits are being noted in clinical errors, including judgment and poor integration of theory and practice (Eitel & Steiner, 1999). It is imperative that medical education be astute in the development of problem-solving skills, particularly in the context of diagnostic reasoning. Finally, changes must also encompass how to approach and integrate the demand for vast and emerging information into the medical education curriculums. Therefore, medical education must seek alternative educational tools and strategies in order to produce successful outcomes. Clinical errors can be detrimental to all. Edmondson and Smith (1998) stress accurate diagnosis is critical to the practice of medicine.

Coles (1990; as cited in Edmondson and Smith, 1998) states that, "students need to be encouraged to recognize that merely understating what they are learning (deep-processing) is not in itself sufficient. They need to elaborate their knowledge; to build up more and more complex networks; to structure their knowledge" (p. 21).

Concept mapping can facilitate meaningful learning in medical students, residents and physicians. When used as a supplemental learning tool, concept maps can potentially promote deep learning in medical and biomedical science education (Laight, 2004). Concept mapping in the medical field allows the student to conceptualize a body of knowledge by identifying numerous cross-links between the concepts, thus serving as a useful tool for selecting and developing learning objectives regarding the topic (Weiss & Levison, 2000). Finally, concept maps can help form a bridge from medical school to residency training by integrating new knowledge from the residency program with the knowledge acquired during medical school (Pinto & Zeitz, 1997). Therefore, concept mapping could facilitate the process of medical students learning to learn and integrating new concepts into long-term memory.

Additionally, since evidenced-based innovative educational ideas have surfaced and concept mapping is a well-known learning aid and evaluation tool, many authors have called for a change in medical education. However, the attempt to change traditional curriculum has experienced strong resistance due to the paucity of concept mapping literature in the medical field and the limited literature regarding validity and reliability (Eitel & Steiner, 1999; Laight, 2004; Weiss & Levison, 2000; West et al., 2002). According to West et al. (2002) in order to evaluate developing knowledge, the structural features of the maps need to be incorporated into the thinking frameworks of resident doctors. Therefore, if medical education is to use concept mapping as an educational tool, then valid and reliable methods of concept mapping assessment measures are needed.

Although well-known as a successful learning aid and evaluation tool, medical educators rarely use concept mapping as a teaching/learning method. As such, the purpose of this study was to conduct more research on concept mapping in medical education and to promote awareness of this technique with empirical evidence.

3 Research Questions

From this literature review it is evident that concept maps can promote learning and changes in students' thinking in a variety of ways. Also concept maps have been used effectively in science education, math education, veterinary education, nursing education and engineering education. However, there has been limited application in medical education. As such, the following research questions are advanced to guide this inquiry:

1. How do concept maps impact the learning of third year medical students?
2. How do concept map scores of third year medical students change during their clerkship?

4 Methodology

This study used a mixed-methods design that investigated student learning through concept map change scores. Additionally, students completed a qualitative evaluation of their experiences learning with concept maps (reported elsewhere).

From July 2005 – October 2005, each group of third year medical students rotating through the internal medicine clerkship were taught to use concept maps. This involved the clerkship director spending approximately 1.5 hours teaching students about the underlying premise of learning with maps, steps in map construction, using CMAP tools to create the maps, and discussing the maps with students during their clinical rotation. In all, 63 students were included in the clerkship and this study.

Each student created three maps during the course of their clerkship. The maps were created around clinical problems, such as renal failure, congestive heart failure, etc. For the purposes of this study, the first and last maps were collected from each student. Points were awarded according to the scoring formula developed by Novak & Gowin (1984). Points were awarded for the subsumption of lower order concepts under higher order concepts, progressive differentiation of concepts, and the integrative reconciliation of concepts. Based on the scoring formula the students received points for creating propositional linkages and for the analysis and synthesis of concepts on their maps.

Reliability was established by obtaining two independent scores on each concept map. All researchers scoring maps were academic physicians specializing in internal medicine and trained to score concept maps. The correlation between the two independent scores was .73. Mean scores for the first map were then compared to mean scores of the third map for all students participating in the study. A dependent t-test was used for these comparisons.

5 Results

Study results indicate that concept maps were an effective learning strategy for medical students in their third year clerkship rotation. Figure 1 depicts the concept map of one student at the beginning of their internal medicine rotation and Figure 2 depicts the final map of the same student. What these figures demonstrate is the growth in concept differentiation and the development of a more sophisticated system of cross links.

Data analysis (Table 1) demonstrates a group mean of 71.711 on the first concept map and 94.09 on the final concept map of the clerkship rotation, for a difference of 22.38. The t-value comparing the first to final map was –4.1773 (p=.0001). The data indicate a statistically significant difference between the first and final map scores of the internal medicine clerkship rotation.

Variable	No. of Cases	Mean	Difference
First Student Map	63	71.71*	22.38
Final Student Map	63	94.09*	

P value * = .0001

Table 1. Changes in Concept Map Scores over Third Year Clerkship

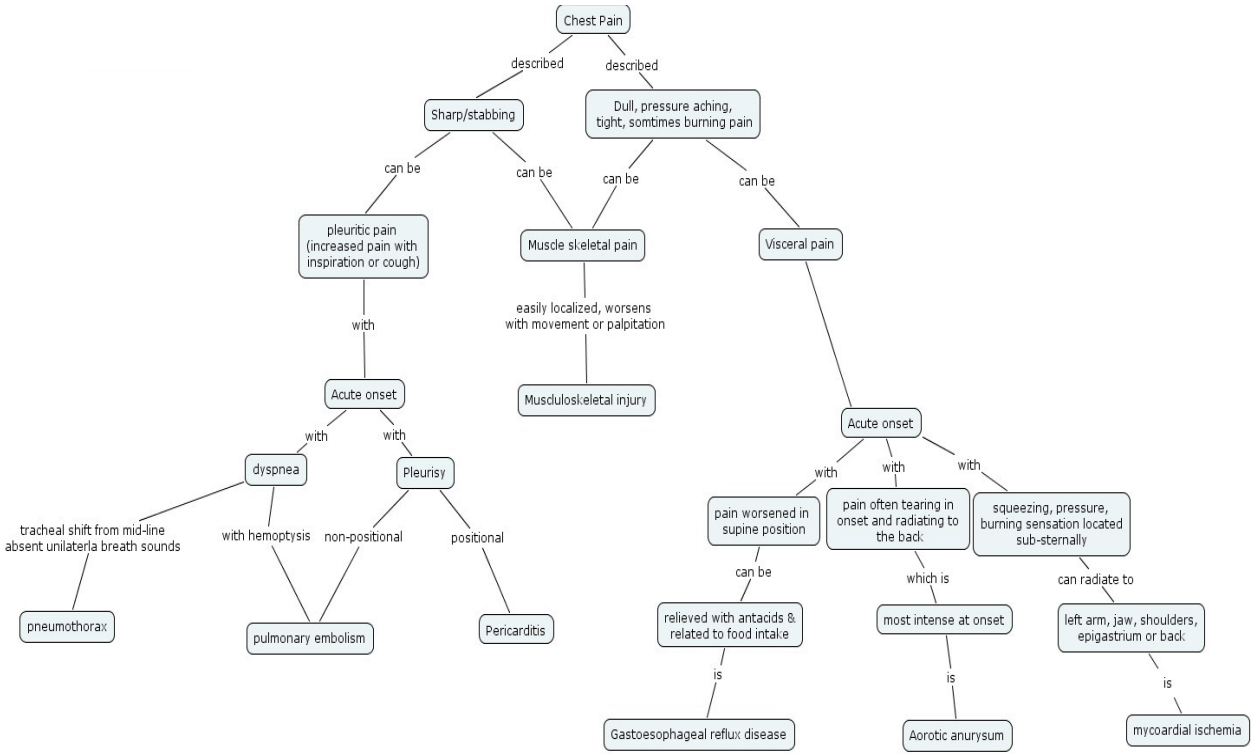

Figure 1: First Map of Internal Medicine Rotation

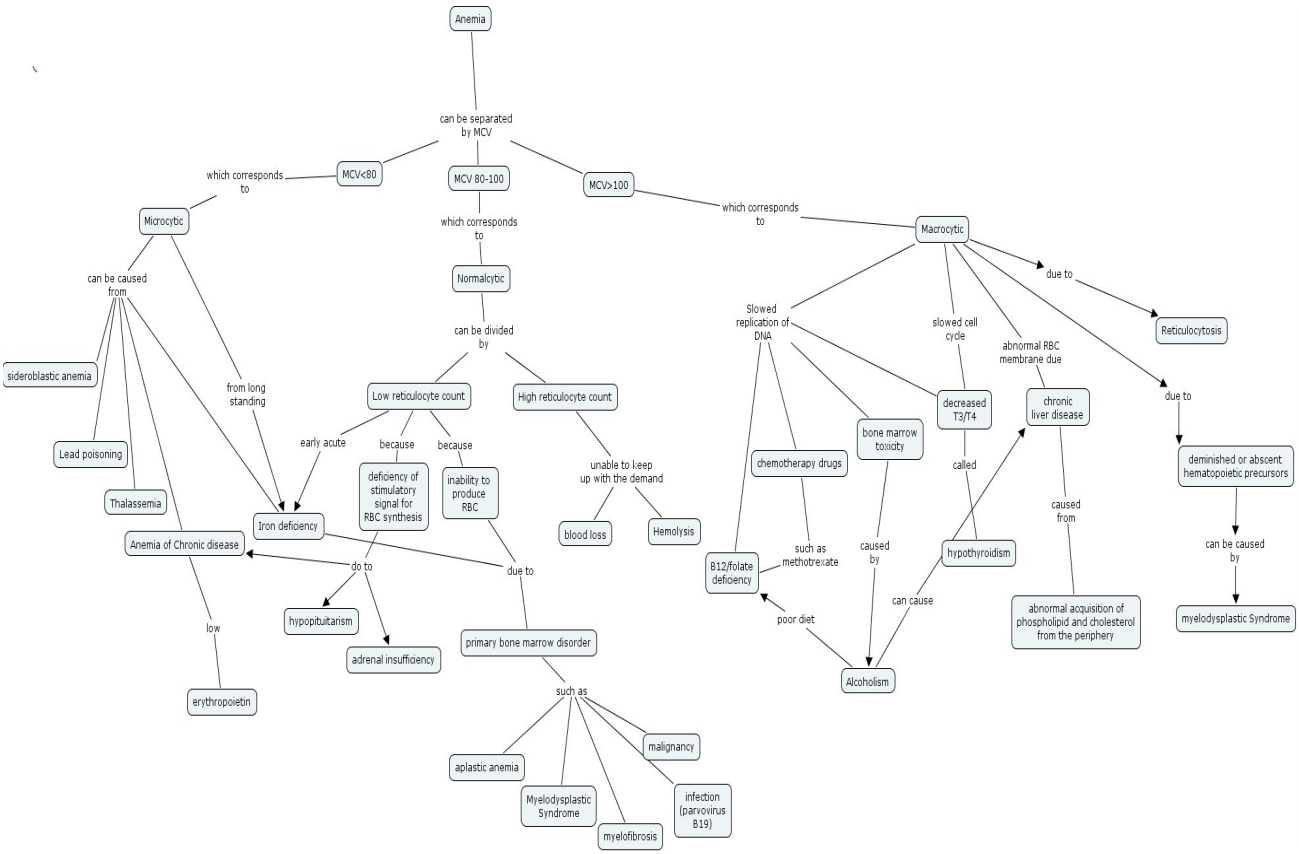

Figure 2: Final Map of Internal Medicine Rotation

6 Discussion

Results of this study indicate that using concept maps with medical students facilitated learning during the clerkship rotation. The findings from this research support previous work on concept mapping (Novak, 1998; Novak & Gowin, 1984). What is unique to this study is the application of concept maps as a tool to foster meaningful learning among third year medical students. Their ability to advance their learning, understanding, and thinking through the use of concept maps over a two-month clerkship rotation is an important step in teaching medical students new pathways to learning. It also demonstrates an increasing ability to think critically and to relate relevant medical concepts using a completely new method, which is an extremely important proficiency for junior medical students.

Additionally, in teaching the students how to do concept maps, it became clear that not only did these students not understand their own learning processes, but they were resistant to change learning strategies that had worked for them in the past. Once these students understood that the maps had the potential to support their learning in the clerkship by linking their theoretical knowledge to their clinical practice, they tended to be more interested in the mapping process. They began to see the maps as a way to understand their patients and the patients' disease process.

7 Implications for Medical Education

This study has numerous implications for medical education. First, study results indicate that medical students were able to use concept maps to understand content in new ways and to create maps that linked theoretical material to clinical practice. The implication here is that concept maps, as a tool, may assist medical students in advancing their skills in critical thinking, diagnostic reasoning and patient assessment. The ability to apply theoretical knowledge in a clinical setting is an advanced thinking skill that needs to be specifically developed in medical students. The change in concept map scores in this study indicates that this process took place, but additional research is needed on exactly how the maps facilitated the process of applying theoretical knowledge in the clinical context. In addition, more research is needed on how concept maps facilitate critical thinking, diagnostic reasoning and patient assessment.

Second, this study implies that faculty in medical education could benefit from learning about concept mapping as a teaching/learning strategy. One of the biggest challenges for faculty in medical education is changing teaching approaches to incorporate what we know about student learning. Using concept maps necessitates that faculty have a good understanding of various learning theories and approaches and the ways in which maps represent students' thinking. To use this strategy effectively faculty need to be able to create their own concept maps that demonstrate subsumption, progressive differentiation and integrative reconciliation (Novak & Gowin, 1984). This involves learning how to construct concept maps, and learning how to use them in teaching. To use this approach faculty development programs may provide the needed assistance.

Finally, to use mapping faculty need to be willing to foster an approach to learning as meaning construction. This means that the focus of clerkships shifts from teaching and presenting information to learning and creating meaning. This is much more than a change in how we talk about teaching and learning. It is a fundamental shift in teaching approach, faculty role, student responsibility and assessment of learning. As such, the role of the faculty member shifts from content expert to facilitator of learning. Often this is a demanding change that requires a new way of thinking about teaching and learning.

In summary, this study demonstrated that concept maps were an effective learning strategy for residents in their third year clerkship. Concept maps scores significantly improved over the course of the two-month rotation, leading to more effective learning outcomes. More research is needed on how the maps link to other aspects of medical education and faculty development.

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