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**Mapping as a learning strategy in health professions education: a critical analysis**

Pudelko, ,B., Young, M., Vincent-Lamarre, P, Charlin, B.

**Abstract**

Context: Mapping is a means of representing knowledge in a visual network that is becoming more commonly used as a learning strategy in medical education. The driving hypothesis behind the development and use of concept mapping is the assumption that it supports and furthers meaningful learning.

Purpose: The goal of this paper is to examine the effectiveness of concept mapping as a learning strategy in health professions education.

Methods: The authors conducted a critical analysis of recent literature regarding the use of concept mapping as a learning strategy in the area of health professions education.

Results: Among the 65 articles identified, 63% were classified as empirical work, with the majority (75.6%) of these being pre-experimental designs. Only 24.3% of empirical articles assessed the impact of mapping on meaningful learning. Results of the analysis do not support the hypothesis that mapping per se furthers and supports meaningful learning, memorization, or factual recall. When documented improvements in learning were found, it was often when mapping was used in concert with other strategies, such as collaborative learning or instructor modeling, scaffolding and feedback.

Conclusion: Current empirical research on mapping as a learning strategy presents methodological shortcomings that limit its internal and external validity. The results of our analysis indicate that mapping strategies that make use of feedback and scaffolding have beneficial effects on learning. Accordingly, we see a need to expand the reflection process on the characteristics of the representational guidance of mapping techniques and tools based on field of knowledge, instructional objectives, and characteristics of learners in health professions education.

**Key words: concept mapping, mind mapping, learning strategy, knowledge representation**

1. Context

Concept mapping is a technique used to graphically represent conceptual knowledge through the use of labeled nodes and connecting links between nodes. It was developed primarily by Joseph Novak1-3 as a way to represent meaningful relationships between concepts. Mind mapping refers to another graphical knowledge representation technique, developed by Tony Buzan4-6 to meet the requirements of the multimodal representation of knowledge. Both techniques represent knowledge as propositions in which the map “nodes” (terminology used in concept mapping) or “branches” (terminology used in mind mapping) help identify key ideas. These key ideas are connected by links that refer to relationships that may or may not be verbally described. Concept maps are organized in a hierarchical manner, often top-down, with the more inclusive concept at the top (tree-like map), while mind maps “should start from the center or main idea and branch out as dictated by the individual ideas and general form of the central theme” (spider or radial maps) (Buzan,7 p. 91).

Both techniques were primarily designed as self-study and thought-organization learning strategies intended to help students organize and develop conceptual knowledge in the context of text-based learning. The driving hypothesis behind the two techniques is constructivist in nature: when learners actively identify main ideas and create links between them, they interpret, relate, and incorporate new information into their previous knowledge to elaborate complex semantic networks. This so-called meaningful or deep learning—as opposed to rote or surface learning (memorizing non- or poorly-related facts)—purports to allow for flexibility in solving problems and critical thinking. Over the last few decades, we have seen increasing interest in a variety of forms of mapping in science education at most educational levels, paired with the development of associated technological support (i.e. mapping software).8 This has also been the case in health sciences education. Recently, Daley and Torre9 identified 350 articles reporting the uses of concept mapping in health professions education between 1989 and 2009. The authors examined a sample of 35 studies and concluded that “there is a growing body of evidence on the effectiveness of mapping as method to promote meaningful learning” and specifically “demonstrates that concept maps can assist in medical student learning” (p. 44). However, the analysis carried out by Daley and Torre9 focused on a variety of uses of concept mapping: as a learning strategy, but also as an assessment tool, an instructional design tool, a course evaluation method, and even a technique to elicit expert knowledge. Several studies in fields other than health professions education were also included in their analysis. Lastly, the authors emphasized the existence of methodological limitations without examining them in depth. The analysis conducted in this paper aims to clearly and specifically assess the effectiveness of mapping as a learning strategy in health professions education.

1. Objectives

We propose to review existing literature examining the possible benefits of mapping specifically for learning in health professions education. As a complement to the critical analysis conducted by Daley and Torre,9 we propose to examine research regarding the use of mapping solely as a teaching and learning strategy. In other words, we will examine available evidence supporting the use of mapping as a means to encourage meaningful learning by students in health professions education. We will also analyze some methodological aspects seen in this research area. Finally, we will discuss some implications of this analysis and of the theoretical framework of educational practice and research on mapping in a medical or health professions education context.

1. Methods

We carried out a literature search in MEDLINE, for the years 2000–2011, using the key words *concept map\** and *mind map\*.* The references of all retrieved articles were scanned to identify additional papers that were in line with mapping as learning-teaching strategy. Additional searches were performed using EBSCOHost and ACADEMIC SEARCH combining the keywords: *medical-* , *nursing-* , or *health- education*, *teach\** or *learn\**. As a result, 220 articles related to the use of concept or mind mapping in health professions education or professional activities were retrieved.

Retrieved articles were then analyzed to identify those that dealt specifically with mapping as a learning-teaching strategy, i.e. when students actively put together or used a map in the context of learning. Consequently, we excluded many papers that dealt mainly with mapping as an evaluation of learning or assessment method. Following review, 65 English-language papers meeting these criteria were selected. The content of these papers was then analyzed in four main phases, by two independent coders. The few discrepancies were discussed until a consensus was reached.

We began by examining all papers according to a set of predetermined categories: type of paper (e.g. theoretical, empirical), health professions education field (e.g. nursing), and theoretical background (for example Novak’s theory).

Next, we examined and categorized all empirical articles according to the following categories: instructional or learning goal (e.g. improving critical thinking) and instructional or learning strategy or method that incorporated mapping technique. At this stage, we also examined the methodological aspects of the research work by classifying the empirical articles by methodology used.10 Three main empirical research categories were used:

* Pre-experimental studies: e.g. ”one shot" case design (known also as “after only design”), one group pre-post design (or single case study);
* Quasi-experimental studies: pre-post design, non random assignment;
* Experimental studies: pre-post design or post-test only design, random assignment.
* Insert Figure 1 approximately here

We then categorized and described the measures of learning effects reported in the empirical research according to Kirkpatrick’s four-level training evaluation model.11 The four levels are:

* 1- Reaction of students – what students thought and felt about the training;
* 2- Evaluation of Learning – the measurement of the increase in knowledge or intellectual capability, before and after the learning experience;
* 3- Evaluation of Behavior – the extent to which trainees applied the learning and how it changed their behavior;
* 4- Evaluation of Results – the effect on the business or environment resulting from the improved performance of trainees.

Lastly, we critically analyzed the overall results of the empirical and methodological aspects by situating these results and the theoretical background of mapping in a broader educational psychology and cognitive psychology perspective.

1. Results

## Overall analysis

### Type of paper

Of the 65 papers analyzed, 24 (37%) were theoretical in nature: they described the theoretical framework, the technique, the benefits, and means of incorporating mapping as a learning-teaching strategy in health professions education.9, 12-34 Those remaining were considered to be empirical papers (n=41, or 63%).35-75

### Health professions education field

Publications in nursing education were the most common, accounting for 40 (62%) of published papers. A total of 14 papers (21.5%) discussed the use of mapping as a learning strategy in medical education. The remaining papers reported the use of mapping in other health sciences education fields such as dentistry,21, 25, 39, 59, 65  veterinary medicine,45, 47 pharmacology,62, 63 chiropractic medicine,43 and nutrition.64

### Theoretical background

Most papers (n=46, or 71%) discussed the mapping approach as theorized by Novak. Buzan’s mapping approach was included in 22 papers (34%). Lastly, 26 papers, all in nursing education, used mapping as an alternate representation for care plans as suggested by Schuster.29, 30 Bear in mind that in this last approach, the terms *concept map* and *mind map* are often used interchangeably, and this approach is sometimes linked to that of Novak or Buzan.

## Analysis of empirical research

### Instructional/learning goal

The use of mapping to facilitate learning can be motivated by a variety of pedagogical objectives. In order to examine the breadth of reasons why mapping has been applied, we documented the various learning objectives described in the empirical work we reviewed. Note that a study can have several objectives simultaneously. Figure 2 portrays the distribution of the three main objectives mentioned in different fields of health professions education.

Insert Figure 2 approximately here

Our analysis revealed that “meaningful learning” was the main objective for using mapping as learning strategy (n=24, or 57.5% of empirical papers) in most fields, except in nursing education and nutrition. In these two fields, the objective mentioned most often is to promote critical thinking, mainly when using mapping as a representation of care plans. Another objective proposed only in medical education is to foster memorization and recall (n=4).

### Instructional strategies/methods

Mapping was initially proposed as a self-study strategy to encourage text-based learning (for example44, 48, 71, 74). However, in most cases the use of mapping is incorporated into various instructional methods, primarily collaborative learning (n=10, or 24.3% of empirical papers) and in concert with feedback and scaffolding-centered methods provided by instructors (n=10, or 24.3%), sometimes using instructor-made maps (n=4, or 9.7%).

The preparation of care plans through the use of maps that is described in 16 studies (39% of empirical papers), often incorporates collaboration, feedback, and guidance. Other instructional methods used with mapping include problem-based learning (n=4, or 9.7%), a mix of assessing and learning strategies (n=5, or 12%) and online or blended learning (n=3, or 7.3%).

### Methodological aspects

In analyzing the methodologies used in the empirical papers, we found that 31, or 75.6%, of empirical papers describe the pre-experimental research work.

Of the latter, 26 papers (or 63.4% of empirical papers) were considered to be one shot case studies36, 39-43, 47, 50, 52, 53, 55, 57, 59, 60, 62, 63, 65-67, 69-72 and 5 (or 12.2%) studies were pre-post one-group design*.*35, 46, 54, 64, 75

The other 10 empirical articles (24.4%) are split between quasi-experimental research37, 58, 61, 73 and experimental research.44, 48, 49, 51, 56, 74

Insert Figure 3 approximately here

Our analyses indicated that in all empirical research work, only the first two levels of Kirkpatrick’s four-level training evaluation model (2006) were assessed, i.e. level 1 – reaction of students, and level 2 – evaluation of learning. In one shot case studies*,* only one group is exposed to the intervention, i.e. mapping activity and only a post test is given to measure the effect of the intervention, most often reaction of students (Kirkpatrick’s level 1). In this style of study there is no control group. When these studies do investigate student learning (Kirkpatrick’s level 2), they typically score maps generated by students, but often only a subset of generated maps.

In the pre-post one group design studies, learning was assessed through maps (pre- and post-maps) in 4 out of 5 studies.35, 54, 64, 75 In these studies, researchers evaluated the difference between the score (means of which varies across studies) assigned to the first map produced on a topic (or a pre-map) and the score of a later map produced (post- map). Only one pre-post one group designresearch46 used measures other than pre- and post-maps, which included questionnaires evaluating critical thinking.

Learning in quasi-experimental and experimental research was evaluated using MCQ tests, pre-validated questionnaires, problem-solving exams, or map scores. Two studies examined the relationship between the scores on graded maps and performance on the final exam, and both showed low correlation.47, 60

The reaction measures (Kirkpatrick’s level 1) in the empirical papers varied from student informal reports (sometimes anecdotal data) to surveys whose results may also address various aspects of the instructional method that incorporated mapping. The surveys usually used 5-point Likert scales, and less frequently included open-ended questions. The number of students questioned in the surveys varied widely, from 5 to 168.

Below we have included a summary of the results for both the reaction of students and evaluations of learning reported in the empirical papers. With respect to learning, we excluded from our analysis studies using one shot case study designs, due to their poor internal validity. In the “learning” category (Kirkpatrick’s level 2) we have also included the evaluation of learning that involves complex cognitive or metacognitive skills such as critical thinking and students’ approach to learning.

### Evaluation of student appreciation

With respect to the student responses to the use of mapping, informal reports suggest a very positive general appreciation of mapping by students.39-42, 50, 52, 69, 70 Eight additional articles using surveys only report on qualitative data, and find that most students appreciated mapping.35, 51, 54, 64, 66, 71, 72 In papers describing quantitative results of surveys regarding student response to mapping, the frequency of positive views range between 42% and 81%.43, 45, 47, 57, 60-63, 74, 75 A single paper reported a very high rate (97%) of positive student responses, specifically regarding the future use of mind mapping as a self-study technique.74 However, several other studies indicated that there are many students who do not believe they would use mapping in the future as it was “too difficult, too time consuming to make”.38 Students also reported feeling that they were “frustrated and apprehensive”72 with building maps and express “negative feelings”.60 The results of Divakar’s study45 showed that 73% of students surveyed “do not like mapping”, even if 51% found it “useful in learning”. Similar results are reported by Ertmer47 where the “majority indicated that they did not like creating maps” and by Moni65 who found that “an unexpected finding was that the concept mapping task was not generally favored by the cohort”. On the whole, the majority of the studies reviewed that employed student response questionnaires report that at the very least, some students do not appreciate mapping. One negative aspect that stands out most often is the “time consuming” aspect of mapping.35, 38, 47, 51, 54, 60, 66, 68, 71, 74, 75

### Evaluation of learning

In the 15 studies (or 36.5% of all empirical papers)that evaluated the influence of mapping on learning, three main clusters of research emerged.

The first cluster includes research evaluating the effects of mapping on memorization and factual recall from written information.44, 48, 74 All studies in this cluster were experimental or quasi-experimental, and were all carried out using medical student participants. The results of these three studies did not show any significant difference between the intervention and control groups for the immediate recall test. A study conducted by Ghanbari49 that used maps prepared by the instructor can also be placed in this cluster. The results show a significant difference only in women who performed better in the mapping group than in the control group. No interpretation was provided for this finding.

The second cluster includes studies evaluating the effects of mapping on “meaningful learning”. Studies in this cluster were experimental, quasi-experimental or pre-post single case studies assessing understanding, problem solving,51, 54, 56, 61 and critical thinking.35, 44, 46, 64, 73, 75 These studies were carried out with nursing, medical, and nutrition students as participants.

In studies conducted by Kumar,61 Gonzalez,51 and Hsu,56 mapping was used in conjunction with other teaching techniques intended to facilitate guided learning and informative feedback. These three studies did find significant improvements in understanding and problem solving for students who used mapping rather than a traditional teaching method. However in Gonzalez’ work,51 the significant improvement was found only in students with lower academic performance. In the work by Hsu,56 learning was evaluated through a post-test using maps on the concepts studied in the course. Given that students in the control group had been using maps for the first time for this test, while students in the treatment group used them 6 times during the 16-week semester, we can suggest that the score difference in the two groups may not indicate learning differences, and may perhaps reflect the difference in familiarity with the mapping technique.

 Four studies noted a significant improvement in scores between the pre- and post-maps, used as a means to “comprehend multifaceted care” or to improve critical thinking.35, 54, 64, 75

Two studiesuse questionnaires developed to specifically evaluate critical thinking: CCTST (California Critical Thinking Skills Test)73 and HSRT (Health Sciences Reasoning Test).44 They did not show any difference between groups on the overall score in the posttest.

In a study conducted by Ellerman,46 a significant improvement of critical thinking was noted. Yet in this study the evaluation is carried out retrospectively by students as they rated at the end of the program what they believed their level of critical thinking was when they began.

In summary, of six studies evaluating meaningful learning using measurements other than maps, two studies found no significant difference along the above-mentioned dimensions. Two others presented methodological problems that challenge the positive impact, and two found learning improvement.

The third cluster of studies evaluated the effects of mapping on students’ approach to learning. This cluster includes a single case study in nursing.37 The research was designed to examine if the construction of maps has an effect on (i) the approach to learning (surface vs. deep) as measured by the Study Process Questionnaire76 and (ii) the self-regulation of learning (adaptative, inflexible, irresolute control beliefs) as measured by the Strategic Flexibility Questionnaire77. No significant pretest-posttest differences were found in the mapping group with respect to the approach to learning. The only significant difference deals with the “adaptative control” aspect for which the mapping group showed an improved score.

1. Discussion

Our analysis sheds light on the existence of many methodological limitations of empirical studies, of which 75.6% were pre-experimental in nature. Nearly 84% of these pre-experimental studies were one shot case studies which certainly provide interesting information on the views and reactions of students to the use of mapping, but their poor internal validity did not enable us to draw reliable conclusions as to the effect of mapping on learning. Then, in the 80% pre-post one group studies, the mapping effect on learning was evaluated through comparison of map scores. The pre-post one group designs can provide convincing data if systematic replication of the effect within and across different contexts or studies is found (Kratochwill78). However, in order to summarize multiple findings for the purposes of building evidence, the measurement of the outcome variable must occur *after* the manipulation of interest, since “this sequencing ensures the presumed cause precedes the presumed effect” (Kratochwill,78 p. 8). Assessing the effects of mapping on learning solely through the evaluation of differences in the maps makes it difficult to disentangle cause from effect. In addition, the validity and reliability of map evaluation methods is controversial.79-82 In summary, only 9 of 15 articles evaluated the effects of mapping on learning by using measures other than maps themselves.37, 44, 46, 48, 49, 51, 61, 73, 74 Only two studies among them clearly indicated positive effects on aspects of meaningful learning. But since in these studies the mapping activity is carried out in conjunction with other instructional strategies, like collaborative learning, providing feedback, and scaffolding, it is still difficult to isolate an improvement that can be attributed to mapping from those of other strategies, especially considering that the positive effects of these strategies are well documented in educational psychology research.83

Moreover, the observations and opinions collected in the empirical research reviewed here suggest that the student responses to concept mapping are rather mixed. When taking into account the various possible biases related to expectancy (subject-expectancy or observer/teacher expectancy effect) and the fact that papers published more often report the positive than the negative effects of an intervention, the negative comments generated and expressed by students in regards to concept mapping should not be disregarded.

Given these findings, in contrast to Daley and Torre,9 it is quite difficult to conclude that there is growing evidence that mapping itself encourages meaningful learning, which is the primary objective of its use in health professions education. Furthermore, experimental studies comparing mapping and other self-study strategies typically do not show any significant difference in knowledge memorization and recall. These results corroborate the results of the latest meta-analysis on the effects of concept mapping on learning (Nesbit and Adesope84), which suggest that when concept mapping strategies are compared to learning activities requiring similar levels of cognitive engagement, such as generating summaries or outlines, the reported effect size favoring concept mapping is often small. As a result, these researchers have expressed doubts regarding the stability of the effect and its pedagogical significance.84

One criticism of the studies that rely on recall tests is that they may not have evaluated the “right element” of using mapping as learning strategy, since the recall tests are not appropriate for evaluating learning in a constructivist perspective,85 which is the basis of mapping in education. Remember, however, that in Novak’s constructivist approach (the most elaborated and cited as a theoretical framework), concept mapping is designed to promote meaningful learning through effective encoding in long-term semantic memory; that is, “getting knowledge in memory”. We suggest that this assumption can be challenged from a theoretical standpoint, which in turn can lead to various implications in terms of the design of instructional strategies that include mapping in health professions education.

Firstly, we can emphasize, as Karpicke and Blunt8[6](#_ENREF_87) did recently, the contribution of retrieval activity to the process of learning. These researchers challenged the driving assumption behind concept mapping; specifically that elaborative activity favors the encoding of semantic knowledge in long-term memory stores, and, in this manner, improves learning. They compared the effectiveness of retrieval practice and elaborative studying with concept mapping for encouraging the meaningful learning of science materials. The results demonstrated that students in the retrieval practice condition performed significantly better (50% improvement) than students in elaborative studying with concept mapping condition, which itself was not significantly better than spending additional time reading. These results support those found in our current analysis, and that of the meta-analysis of Nesbit.8[4](#_ENREF_85) Karpicke et al. put forward that “research in cognitive psychology has challenged the assumption that retrieval is neutral and uninfluential in learning. Not only does retrieval produce learning, but a retrieval event may actually represent a more powerful learning activity than an encoding event” (p. 772). With this in mind, the learning strategies that encourage retrieval developed spontaneously by students, or instructional strategies like test-enhanced learning87, 88 could effectively be more beneficial to learning than elaborative strategies like concept mapping.

This is one possible explanation for student reticence with regard to mapping as a learning strategy. We can put forward that students in health sciences, especially medical students, may have already developed effective study strategies, perhaps based mainly on knowledge retrieval. These strategies are viewed as more effective because they are congruous to the context and the methods of institutional assessment. Replacing usual and proven strategies with other strategies may be cognitively costly and suboptimal from students’ point of view.

Secondly, Novak’s approach postulated that concept mapping promotes learning because the concept map reflects the form in which semantic knowledge is encoded in long-term memory, specifically by means of a propositional language-like network. This hypothesis, in a way that resembles the assumptions behind general problem-solving skills,[89](#_ENREF_90) explains why concept mapping is usually considered as a domain-free cognitive strategy. In other words, structuring knowledge in propositional form can improve teaching and learning in any field of knowledge, regardless of its nature. By contrast, cognitive psychology research suggests that external representations can make the properties of conceptual structure of the knowledge area more salient,90-92 and thus enhance problem representation,[93](#_ENREF_94) or stimulate different cognitive processes. For educational practice, this can be expressed by representational techniques that provide explicit guidance on the deep structures of knowledge. That said, we have observed that the use of mapping in nursing education is more focused on the representation of care plans, hence on “schemata”-type goal-oriented knowledge structures that could be intensified through script theory.94 By contrast, in medical education, researchers and instructors are primarily interested in the representation and learning of cause and effect relationships (causal or functional structures) underlying biomedical knowledge. We think that future studies should focus more on the representational guidance provided by various mapping techniques based on the field of knowledge in question.

Thirdly, many studies indicate that upon construction of maps, the greatest difficulty which is also the most conducive to learning is verbally specifying the type of relationship between the concepts.95 Note that mind mapping and concept mapping techniques differ with respect to the verbal representation of relationships between concepts: it is inexistent in mind mapping, and it is optional in concept mapping. However, none of the analyzed research explicitly takes these differences into consideration in mapping representational properties. In fact, researchers often consider the two techniques to be similar, which led us to not distinguish them in our analysis.

From an instructional point of view, this tends to a proposal that representational guidance of mapping techniques should also focus on verbalizing knowledge about relationships, which can be achieved through discussion, asking questions, informative feedback, or self-explanation. Here again the role of teacher guidance seems important to direct learner attention to more relevant aspects of a field of knowledge and optimize its conceptualization. But, from this standpoint, the use of mapping is moving significantly away from Novak’s or Buzan’s initial vision, according to which learning is encouraged when learners develop their own idiosyncratic maps without any structuring other than the propositional and vaguely hierarchical format suggested by mapping techniques, and with little guidance from experts. Representational strategies that comprise more guidance, informational feedback, and instructor scaffolding may be more directly relevant to the education of health professionals.

1. Conclusion

The use of mapping in health sciences education over the last ten years has been carried out mainly in the context of Novak’s theoretical framework, developed primarily for the purpose of meaningful science learning among students at the elementary and secondary levels.96,97 During the development of concept mapping, it represented a genuine educational solution97 based on the identification of what constitutes a problem—the need to develop metalinguistic awareness and metacognitive knowledge in children—and on the cognitive educational theory current at the time.99, 100 The mind mapping technique and tool developed by Buzan were also based on the identification of an actual problem, which was the need for students to have access to active reading strategies. But the proposed solution was largely justified by a misconception, or “neuromyth” disseminated by pop-psych hemispheric dominance theory (learning or cognitive styles of the left and right brain).101

We propose that the later acceptance of concept or mind mapping in health professions education, while showing the creativity of educators, mainly came about as a direct transfer of an educational solution from one context to another, often without undertaking an in-depth analysis of the nature of the learning problem. This phenomenon can partially be explained by the increasing adoption of a learner-centered paradigm favoring the active construction of knowledge by students, and partially by the availability of software that makes map creation much easier, like CMap Tools and MindManager. The former was especially designed to implement Novak’s concept mapping technique and the latter, Buzan’s mind mapping. One might therefore wonder to what extent these tools are adapted to elaborate other types of external representations and if adopting it “as is” might immediately limit reflection on other types of representational guidance that might prove to be more appropriate for health professions education. This is why the current challenge of educational research in this field is to suggest a refined problem setting and more in-depth theorization of mechanisms underlying learning with graphical representations of knowledge (of which mapping is one example). This is certainly a long-term challenge that deserves the development of a collaborative research approach102 drawing from current health professions education and cognitive psychology research, and so set sights on more Research that is Conceptual and Thoughtful103 in this field.

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Figures

**Figure 1**. Flow diagram of methods applied for the critical analysis of literature



**Figure 2.** Number of articles discussing various instructional goals by health professions education field

**Figure 3.** Various types of empirical papers, and the percent frequency of each (Note: OSSC=’one shot’ case studies; PPOG=pre-post one group; QE=quasi-experimental; E=experimental)

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