Knowledge Maps Improve Comprehension in Therapeutics[1]

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The purpose of this study was to examine knowledge mapping as an educational tool to improve comprehension in two modules of a therapeutics course. Two groups of students attended either the gastrointestinal or cardiovascular modules taught with traditional outlines. After testing, they crossed over to the opposite module which was taught with knowledge maps. This module was followed by an examination testing identical concepts as the previous groups. Students also completed a Likert-scale questionnaire to assess their attitude toward knowledge mapping. The mean score on the gastrointestinal exam increased from 80.2 to 84.7 ($P<0.05$). Likewise, mean score on the cardiovascular exam increased from 78.3 to 88.2 ($P<0.001$). Questionnaires indicated that students found knowledge maps easier to study than traditional outlines. The students also stated that knowledge maps were useful in logically grouping information and in depicting interrelationships between concepts.

BACKGROUND

Pharmacy education often differs from many of the undergraduate courses upon which it builds. It demands that the student absorb an overwhelming amount of complex information. The student is required to master this detail and to integrate it simultaneously into developing knowledge structures. The problem is compounded by the disparity of disciplines in pharmaceutical education. Not only does the student have courses in traditional basic sciences (anatomy, physiology, biochemistry), but also intense courses in specialized disciplines (*e.g.,* pharmaceutics, pharmacokinetics, therapeutics). All of this happens rapidly and in an atmosphere of intense pressure. Unfortunately, most pharmacy students rely on previously developed learning strategies (*i.e.,* rote memorization) that satisfied course expectations in the prepharmacy curriculum. Subsequently, many students become frustrated when their previously tried and successful strategies fail.

Knowledge maps are information processing tools that represent information in two-dimensional, node-link-node displays (Figure 1)(1). These maps provide a mechanism to transform standard printed material into a visual/spatial perspective. The nodes contain the key concepts or main ideas, while the links represent relationships among concepts. Links are illustrated in Table I. A thorough description of knowledge mapping has been reported by Evans and Dansereau(2) and by Lambiotte, Dansereau, Cross and Reynolds(l). The present research project emphasized the use of knowledge maps as a method to present information in an organizational structure that also guides the student in its interpretation and integration. The knowledge map structure which was employed was the Texas Christian University Knowledge Mapping System(1).

Knowledge maps serve two purposes. First, as communication devices they can help to span the gap between instructors and learners. Common problems for novice learners are: (*i*) difficulties in discriminating those facts that are important and central to a particular domain, and (*ii*) a tendency to learn isolated facts without perceiving interrelationships. Because knowledge maps can display information spatially (using size, shape, color, and distance), learners can determine the relative importance of various facts and can see how they are linked to one another. Improving a learner's conceptual framework improves retention of facts and helps in the subsequent application of information to answer questions or solve problems(3,4). The instructor can use these maps in the form of slides or overheads to enhance the learning process. In printed form, students can use them to facilitate information processing both individually and in group study. A second purpose of knowledge mapping is as a means to extract conceptual interrelationships from experts who may possess complex knowledge of a domain, but paradoxically may be unable to express this

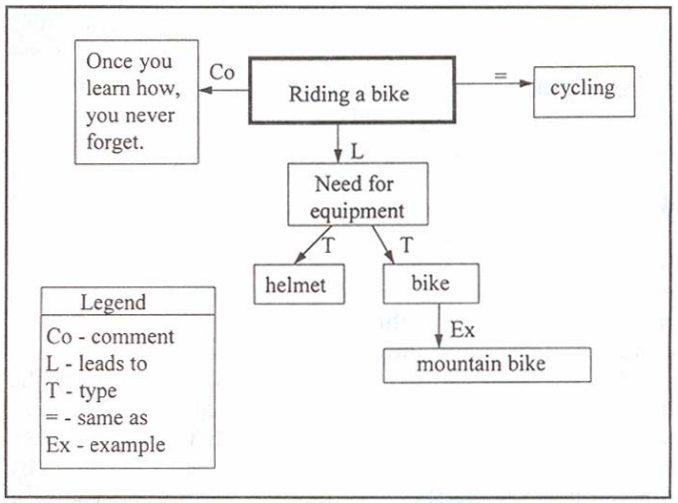

Fig. 1. Example of a knowledge, map (whole map configuration) used to illustrate the link connectors and nodes.

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Table I. Link types for knowledge mapping[a]

Name	Symbol	Example			Interpretation
Dynamic:					
Leads to	L →	Intense	L →	Good grades	"intense studying leads studying to good grades"
Next	N →	Brush your teeeth	N →	Comb your hair	"first brush your teeth and next comb your hair"
Influences	I →	Anxiety	I →	Test performance	"test performance"
Descriptive:					
Type	T →	Dog	T →	Poodle	"one type of dog is a poodle"
Part	P →	Dog	P →	Tail	"one part of a dog is its tail"
Characteristic	C →	Most dogs	C →	Bark	"a characteristic of most dogs is that they bark"
Function	F →	Dog	F →	Man's best friend	"one function of dogs is as man's best friend"
Elaborative:					
Example	EX →	Poker hand	EX →	Three aces, a 3, and a 4	"an example of a poker hand is three aces, a 3 and a 4"
Analogy	A →	Hangover	A →	Being stuck in a dryer	"an analogy to a hang-over is being stuck in a dryer"
Comment	Co →	More tests	Co →	No way!	one comment about the idea of having more test is "NO WAY"
Same as	= →	Cell body	= →	Soma	"the cell body is the same as the soma" or "another name for the cell body is the soma"

[a]Links adapted from the TCU Mapping System (1).

knowledge in a simple or straightforward manner(5.6).

Knowledge maps differ from other mapping techniques which have been described. Unlike concept maps, knowledge maps are not always hierarchical(7). This non-hierarchical approach allows more flexibility for the cartographer (*i.e.,* instructor) when designing a map. One map may describe a linear process, while another may compare and contrast information relating to the choice of one process over another. Further, link connectors are from a standard set of labels, rather than idiosyncratic.

Two types of knowledge map configurations include whole maps and stacked maps. Whole maps are all contained or presented on one page, overhead, or slide. While whole maps may present an overall view of information, there may be problems associated with the amount or complexity of the information. Stacked maps divide the information into more manageable portions. However, one problem with the stacked map design is that they may be confusing since they arc interlocked to several other knowledge maps(8).

The first purpose of this study was to test the hypothesis that students who receive supplemental knowledge maps of therapeutics material will develop a higher level of competence in recall and application of the material. Second, we assessed the utility of knowledge mapping as a vehicle for extracting and organizing knowledge in pharmaceutical education.

METHODOLOGY

Knowledge maps were created through collaboration between the mapping expert (education specialist) and the content experts (therapeutics instructors). The knowledge maps used were primarily whole maps. Major concepts were identified in each lecture and an initial set of knowledge maps was outlined. The maps were all constructed using Microsoft PowerPoint® software. Subsequent modifications were made by the content experts. Learning objectives preceded the set of knowledge maps used for each lecture. Students were randomized into two groups: (*i*) cardiovascular lectures with traditional handouts and gastrointestinal lectures with knowledge maps, or (*ii*) gastrointestinal lectures with traditional handouts and cardiovascular lectures with knowledge maps. The cardiovascular and gastrointestinal modules of therapeutics were taught in the Fall of 1993. The cardiovascular module consisted of 15 lectures covering hypertension, hyperlipidemias, angina, myocardial

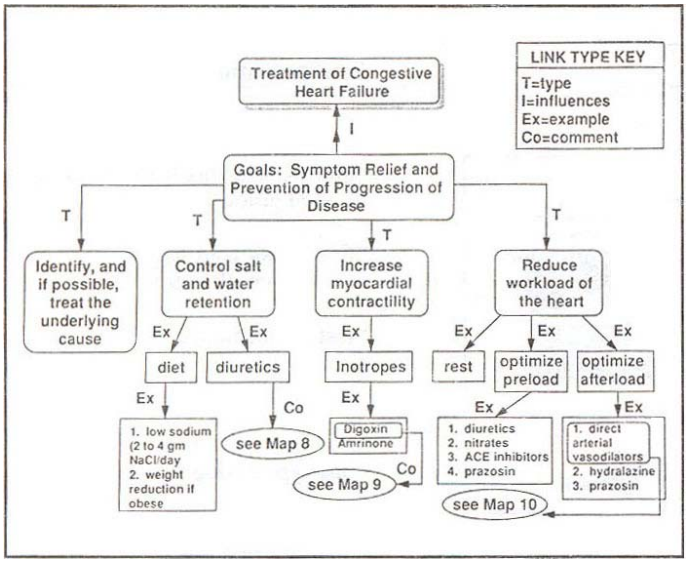

Fig. 2. *Knowledge map (stacked map configuration) depicting some of the goals of treatment of congestive heart failure and the main types of therapy employed.*

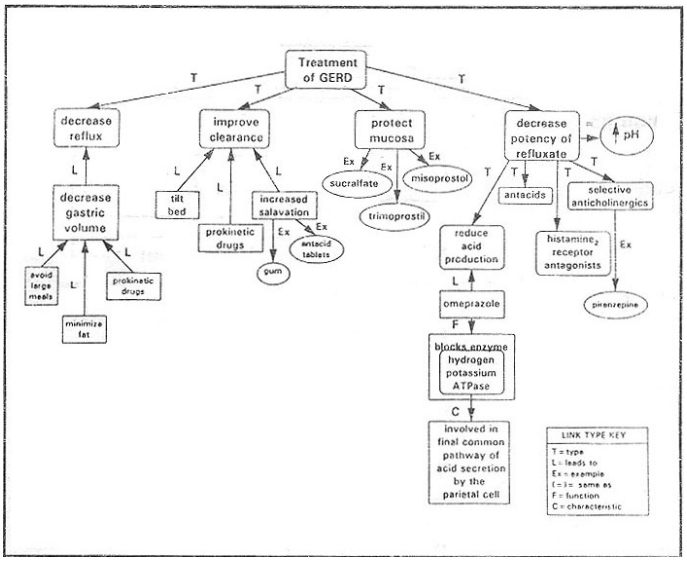

Fig. 3. Knowledge map (whole map configuration) depicting the treatment of gastroesophageal reflux disease.

Table II. Likert scale questionnaire[a] responses to specific questions: All groups combined

#	Question	Mean	SD
1.	Knowledge maps were easier to study than traditional outlines.	2.17	0.77
2.	Knowledge maps increased my comprehension of this topic in Therapeutics.	2.37	0.71
3.	The use of knowledge maps increased my test score on this exam.	2.35	0.85
4.	The introduction and incidence portion of the lecture presented with knowledge maps was effective.	2.26	0.95
5	The pathogenesis portion of the lecture presented with knowledge maps was effective.	1.98	0.65
6.	The nonpharmacologic approach to treatment section of the lecture with knowledge maps was effective.	2.09	0.81
7.	The pharmacotherapeutic approach to treatment presented with knowledge maps was effective.	1.83	0.68
8.	The drug section describing mechanism of action, adverse effects, and place in therapy presented with knowledge maps was effective.	2.22	0.99
9.	All Therapeutics lectures should be presented with knowledge maps exclusively.	3.8	1.17
10.	Only some Therapeutics lectures should incorporate a mixture of traditional outlines and knowledge maps.	2.41	1.0
11.	Therapeutics class should incorporate a mixture of traditional outlines and knowledge maps in all lectures.	2.33	1.19
12.	Therapeutics class should incorporate a mixture of traditional outlines and knowledge maps in only some lectures.	2.91	1.23
13.	Knowledge maps should not be used at all in Therapeutics.	4.52	0.69
14.	Some therapeutic topics can be better explained and understood using knowledge maps than other topics.	1.74	0.74
15.	Knowledge maps helped me to logically group information.	2.04	1.01

[a]l-strongly agree. 2-agree, 3=neutral, 4~disagrec. 5=strongly disagree.

infarction, congestive heart failure, and arrhythmias. The gastrointestinal module was simultaneously taught by another instructor and included lectures on peptic ulcer disease, gastritis and inflammatory bowel disease. The groups were analyzed to assure that both groups were comparable with regard to previous academic standing. A workshop for students was conducted to provide techniques for map construction and the use of this tool for study and review. In addition, mapping workshops were provided for the two faculty members who generated the expert knowledge maps. Topics included using knowledge maps as information extraction tools, supplements to lectures, and as review instruments. After the mapping workshop, one group of students attended the cardiovascular module while the other group of students attended the gastrointestinal module. Both lecture series were taught with traditional outline material to supplement in-class lectures. At the end of the lecture series, each group of students took a midterm examination on the material. The groups crossed over to the opposite module, both of which were taught with knowledge maps as the sole source to supplement in-class lectures. At the end of the second 15-lecture module, students received midterm examinations testing identical concepts as the initial groups to ascertain if significant differences in cognitive knowledge existed. The instructors attempted to keep all conditions, except for the presence or absence of supplemental knowledge maps, the same for each group. Scores were compared between each group to determine if knowledge maps were better supplemental material than traditional outlines.

A primary endpoint in this study was the determination of student performance on midterm examinations with and without supplemental knowledge maps. Results on the gastrointestinal and cardiovascular examinations were compared between the student groups using traditional outlines and those using knowledge maps. This was done by independent *t*-tests with a confidence interval of 95 percent. After the students completed both modules, a five-point Likert scale questionnaire was given asking the students to compare the two methods.

RESULTS

The two groups of students were similar with regard to gender and overall grade point average. A total of 70 students participated, with 35 students in each group. In Group I (cardiovascular section with knowledge maps), there were 12 males (34 percent), as compared to 9 males (26 percent) in Group II (gastrointestinal section with knowledge maps). The overall grade point average in Group I was 2.92 as compared to 2.97 in Group II, a difference which was not statistically significant.

Mean scores for the cardiovascular and gastrointestinal sections without maps were 78.3 and 80.2, respectively. With the addition of knowledge maps, mean scores significantly improved for the cardiovascular section with a mean score of 88.2 ($F<0.0001$) and for the gastrointestinal section with a mean score of 84.7 ($F<0.05$).

Results from the Likert scale questionnaires are summarized in Table II. Item analysis was performed on each, with mean and standard deviation reported for all items. Based on this analysis, students were supportive of the incorporation of knowledge maps into the therapeutics curriculum. Concerning specific items from the questionnaire, students felt that knowledge maps were easier to study than traditional outlines and that the knowledge maps helped them logically group information. The students did not feel that knowledge maps should be used exclusively. but rather should be incorporated with traditional outlines. Students also felt that some topics can be better explained using knowledge maps than others. Based on the questionnaires. Figures 2 and 3 represent the students' concept of the most useful knowledge maps generated from each section.

DISCUSSION

Instruction with alternative study strategies is expected to better prepare students for entry into clinical practice, where the ability to integrate material from various frameworks is vital for effective decision-making. The introduction of more sophisticated approaches to teaching and learning is essential if our goal is to transform students from an *ad hoc* process of memorizing to an active learning process that can be sustained throughout a professional career.

Knowledge maps were considered most useful for information which was not purely descriptive, but rather teaches an order or relationship. For example, although it was simple to construct a map explaining the characteristics of quinidine, this map added little to a simple outline. On the other hand, a map comparing and contrasting two types of reentry arrhythmias may have "painted" a picture in the students' minds and more clearly illustrated the information.

The most common complaint from the students was that the knowledge maps did not convey the information in a detailed manner. Therefore the students added details as notes in the margin. These cluttered maps were used as study guides. Several students remarked that the knowledge maps were good for summarizing and organizing information, but should not be used alone. Consequently, our handouts in subsequent semesters have included a combination of outlines and knowledge maps.

Of particular interest was that a few students in the lower quartile of the class showed improvement in test scores when using knowledge maps. These students commented that the benefit of the maps for them was the emphasis on the most important information. They stated that many times their grades suffered because of an inability to differentiate between major concepts and minor details. An area for future study is to determine if differences in student learning styles predict who learns better when knowledge maps are utilized.

In this study, results showed an improvement in scores after mapping techniques were employed, as compared to scores when traditional handouts were used. In addition to an improvement in overall scores, student questionnaires indicated that some students were particularly helped with the mapping technique and were using this technique in other coursework to improve their studying. A potential weakness of the study was that both sections with knowledge maps occurred after the sections with outlines. Although students were asked to study from the knowledge maps only, scores could have been higher secondary to students receiving traditional outlines from other students.

The Commission to Implement Change. Background Paper II of 1991 states: "Students come to the health professional schools adept at memorizing facts, and the teaching methods in most professional schools readily focus on this ability. In practice, the practitioner must rely on his or her ability to interpret data in order to reach conclusions and solve problems."(9) Despite the limitations of lecture formats, we believe that supplemental material which teaches relationships between facts is more beneficial to students than outlines which simply list concepts associated with various disease states or medications. Analogous to this. maps allow students to visualize a logical sequencing of outcomes associated with a disease state. This format is easily followed and has been used by some students, after only minimal experience with maps, in other areas of their curriculum. Knowledge maps appeared to improve the understanding of complex concepts in this study.

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