PEER-LED TEAM LEARNING
LEADER TRAINING

CONCEPT MAPPING AS A KNOWLEDGE-BASED STRATEGY FOR ENHANCING STUDENT UNDERSTANDING

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As represented by the Peer-Led Team Learning Project, improving the understanding of undergraduates in chemistry, biology, and physics is a major National Science Foundation (NSF) priority. In pursuit of this goal, exploration of research-based perspectives in science education and related disciplines (e.g., instructional science, cognitive science) that purportedly focus on the learning of science is a fundamental starting point for science faculty whose goal is to improve the effectiveness of their courses. However, when doing so, many faculty teaching science courses quickly discover that the literature contains a wide variety of perspectives, each of which emphasizes different keys to effective science instruction in the form of strategies faculty could implement to improve science instruction.

Activity-based approaches in which students are involved can be (and often are) implemented in a fragmented fashion that has no explicit linkage to the core concepts (e.g., underlying principles, theories, big ideas) of the discipline and, therefore, no potential to build the cumulative understanding of core concepts and principles necessary for mastery of a discipline. As the recent Third International Math and Science Study (Schmidt, *et al.*, 1997) findings have reaffirmed, successful science teaching is associated with the explicit teaching of a coherent conceptual framework rather than simply involving students in activities and hoping that meaningful learning results. In essence, the function of a knowledge-based approach to science instruction is to insure that *all* of the instructional activities in a science course are maximally relevant to students gaining an understanding of the core concepts in a discipline.

It is important to note the link between the idea of knowledge-based instruction and that of expertise in a discipline. It is well accepted in cognitive science that experts organize their knowledge differently than novices and that the organizing framework for expert knowledge is in the form of core concepts and relationships. As a result, compared to novices, experts in a discipline are able to observe and interpret phenomena in more meaningful ways by drawing upon and applying their prior knowledge and understanding of underlying core concept relationships. In considering science faculty as knowledgeable experts, the broad goal of the science courses they teach is for students to gain cumulative, meaningful understanding of the discipline in the same form as their teachers, that is in terms of core concepts, organizing principles, and relationships. This article illustrates the use of concept mapping as a tool through which science faculty can develop a knowledge-based approach

to instruction in which lecture, student laboratory activities, and other assignments are coordinated to focus on understanding the core concepts inherent in the discipline.

Figure 1 illustrates a concept map of core concepts in chemistry that were used to organize and coordinate instruction in a one-semester general chemistry course. This was part of an NSF-funded CHEM-BOND project at Florida Atlantic University. Figure 1 was developed in answer to the general questions: "*What is chemistry about?*"*"What core concepts in chemistry are relevant to all aspects of the content in a general chemistry course?*"and "*What cumulative conceptual knowledge about chemistry should students gain from the course that will provide a conceptual foundation for future learning?*"As used in the course, the core concepts represented on the concept map were elaborated in greater detail to incorporate and connect all major course topics. Because of the initial core concept analysis and subsequent conceptual elaboration conducted by faculty, instruction in the course maintained a common organizing focus for all lectures, laboratory activities, and student discussion sessions led by peer leaders. As a result, student understanding of chemistry concepts was significantly improved, students reported greater confidence in their understanding, and student drop-outs and failures were reduced.

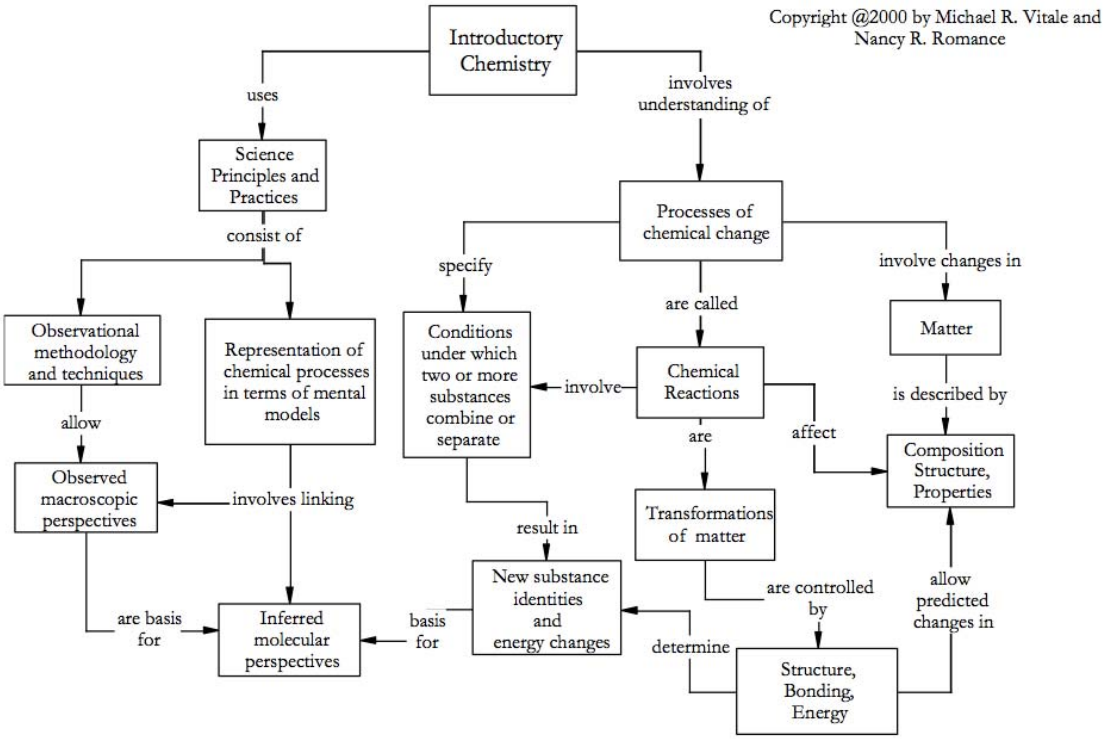

Figure 1 Concept map showing conceptual framework for relating major topics in introductory chemistry (e.g., measurement, atomic structure, chemical bonding, reactions, thermochemistry). Additional concept maps (sub-maps) are used to elaborate major topics and how they are taught through lecture, laboratory activities, and discussion sessions.

Somewhat analogous to instructional models that emphasize the use of activities without linking the activities to underlying core concepts, there are a wide variety of concept maps (or graphic organizers) presently popular in education. However, in our work, we use a specific form of concept mapping called *propositional concept maps*. As Figure 2 shows, *propositional concept maps* are visual representations of knowledge that meet three criteria to insure they are useful tools in designing knowledge-based instruction. The first criterion is that concepts, generally in the form of nouns, are always linked to other concepts by labeled relationships, generally in the form of verbs or verb phrases. The second criterion is that the relationships between pairs of concepts are chosen so that the concept pair and the linking relationship always form a complete thought, e.g., sentence or proposition. And, the third criterion is that the concept map is organized *hierarchically* with the broadest core concepts (big ideas) at the top, subordinate concepts below, and illustrative examples, if any, at the bottom. In fact, both Figure 1 and Figure 2 are illustrations of *propositional concept maps*.

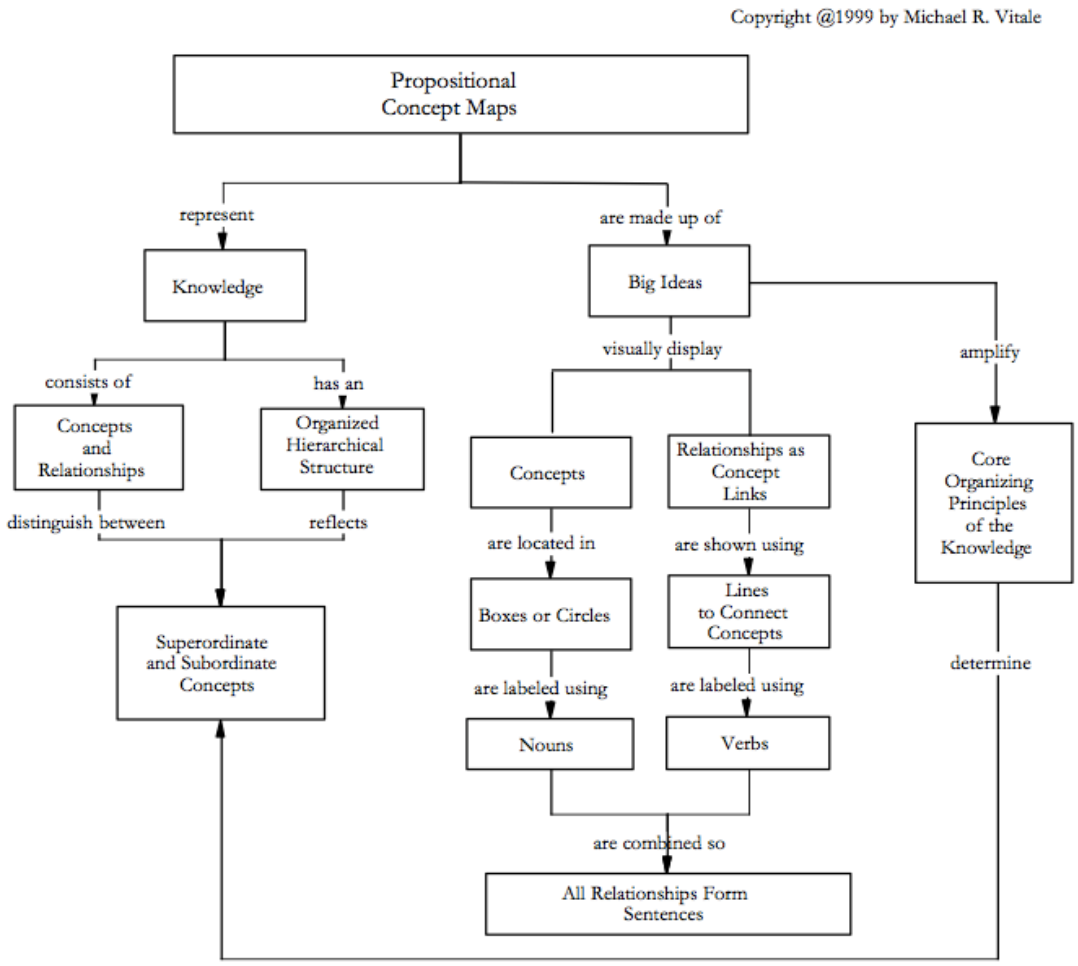

Figure 2. Concept map of propositional concept mapping. Emphasis in concept mapping is on identification of core concepts in the curriculum and use of core concepts to organize knowledge.

Keeping the three criteria in mind, *propositional concept maps* should be considered to represent a visual perspective of core organizing concepts or principles within a discipline. In elaborating the maps with greater detail, it is important to realize that a variety of perspectives representing hierarchical knowledge within a discipline could be constructed and that additional sub-maps are ordinarily required to represent knowledge in greater detail.

Considering *propositional concept mapping* as a tool in knowledge-based instruction, Figure 3 overviews a number of possible uses by faculty and students. As discussed above, concept mapping could be used by instructors to analyze and represent the organization of the core concepts of the discipline and serve as a guide for instructional planning. However, as Figure 3 also shows, faculty could present concept maps to students to support organization and learning of concepts presented in lectures or laboratory activities. Concept maps could provide faculty with the means for insuring that learning and assessment activities developed for the course focus on and are organized in accordance with the underlying structure of the core concepts in the discipline.

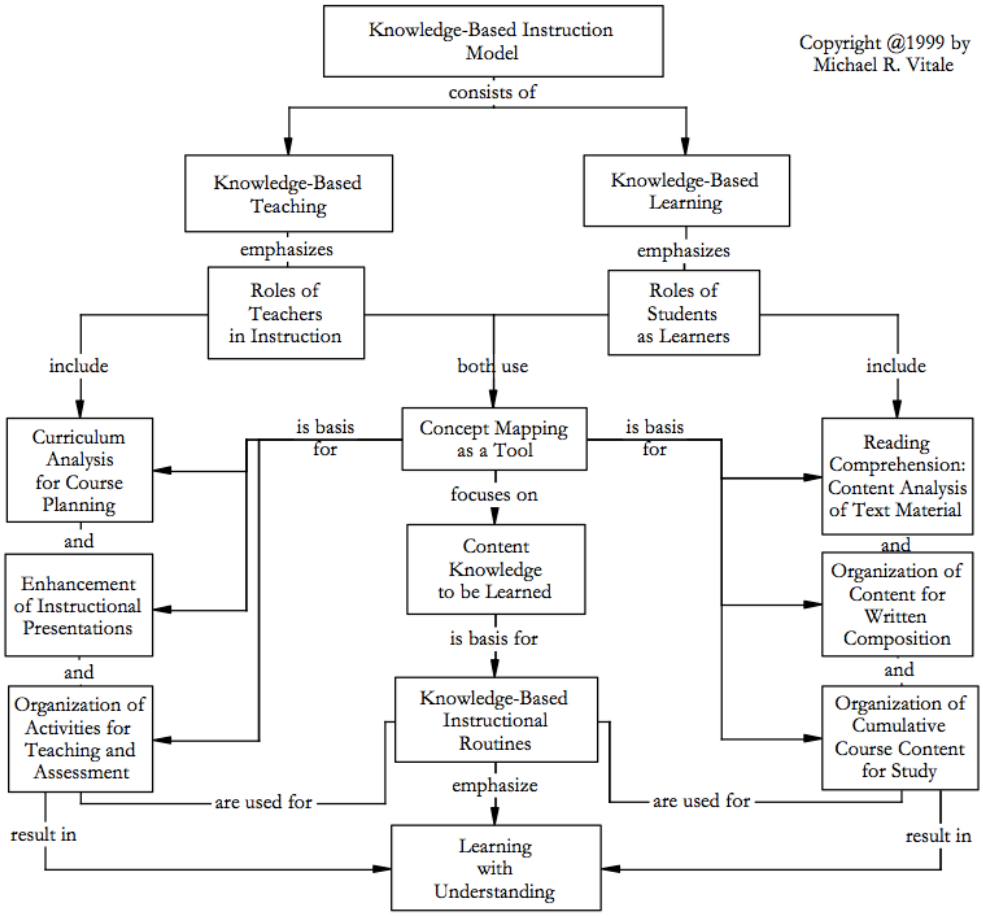

Figure 3. Overview of a Knowledge-Based Instruction Model. Enhancement of instructional presentations includes use of concept maps to visually support teaching. The idea of knowledge-based "routines" is that all teaching and learning activities used in instruction should be based on an overall curriculum framework that focuses on the logical structure of the discipline.

As Figure 3 also shows, *propositional concept mapping* is a powerful tool for students as well as instructors. First, students could construct concept maps to identify and organize the core concepts in textbooks and other materials they read. Second, students could construct and use concept maps as an organizational guide for writing assignments and other projects. Third, students could construct and use concept maps to organize the cumulative content of the course, e.g., lecture notes, laboratory activities, reading materials, in the form of a study guide.

At Florida Atlantic University, the Peer-Led Team Learning initiative which originally focused on introductory chemistry has been expanded to introductory biology. In both areas, applying the general knowledge-based instructional model and using *propositional concept mapping* have resulted in a strong linkage between lectures, laboratory activities, and peer-led discussion sessions that have focused on the core concepts in the discipline, resulting in significant improvements in student course understanding and attitudes. In this sense, the results of both initiatives are highly promising and represent an exciting form of "work in progress."

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Additional Information

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