CONCEPT MAPPING AND CALCULATORS, FACILITATING THE BIG IDEAS

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The University and its Academic Setting

Northwestern State University is a regional University located in Natchitoches, Louisiana seventy miles south of Shreveport, Louisiana. Natchitoches and Northwestern are located on the Red River with farming and timber as the basics for the economy of the area. The University is noted for Business, Nursing, and Education. The University set a record enrollment of 10,000 students for the Fall semester of 2002.

The Mathematics Department at Northwestern is primarily a service department. Most students are taking college algebra and either finite mathematics or applied calculus. If we wish to change our curriculum, we can do so without major complaints from the other departments that we serve. Prior to the decade of the nineties we were an imitation of other mathematics departments from small state universities, which we sought to emulate. Thus, we were not excellent, nor were we bad, we were mediocre.

The primary goal of the algebra course was manipulation of algebraic terms and the solving of linear and quadratic equations. We did not seem to have the time to locate those phenomena that exhibited linear and quadratic behavior. We were disappointed in the results of this algorithmic approach that did not give enough time and effort to meaningful problems. The beginning courses involved an inordinate amount of algebraic manipulation with few connections between previous material and future materials. There was very little time for modeling tasks from physical situations with the basic function-models of polynomials, exponentials, and rationals.

The Use of Technology

In 1992 we began to experiment with technology trying a computer program named DERIVE and graphing calculators. We continued the use of DERIVE until the Computer Algebra System (CAS) called the TI-92 was available. We preferred the hand-held technology that could be used in the classroom without moving to the computer lab to solve a problem. We were very pleased with this technology and we changed requirements as new technology was developed.

Currently, we require our students who are not in the calculus sequence to have available a TI-83 or TI-83+ for their work in mathematics. A major in mathematics or science or a student taking the precalculus or a course above precalculus must have the equivalent of the TI-92+ in their hands during the course. The faculty recently received the Voyage 200

from Texas Instrument, but we have not made that the standard for higher level courses. Students may use other technology, but the support for technology not normally used in the Department is much less than the support given for Texas Instrument calculators.

Our Goals Now

In the presence of technology, we have attempted to change the focus of our mathematics courses. The focus is on problem solving with the manipulation techniques replaced by the technology, hopefully, giving us more time to hone in on the critical issues in the problem solving process. Many physical situations can now be easily expressed in the four representations: graphical, symbolic, numerical, and verbal. The graphing technology easily represents a function in three of the four representations. It is this tool that gives the teacher several techniques for addressing a problem from a physical situation. When approaching a problem from various viewpoints, some students become confused and overwhelmed. Several teachers have searched for a better strategy to assist students in organizing the concepts in their mathematics course.

Two students were overheard in a conversation about calculus. The student who had taken the course was explaining to a friend who had obviously asked, 'what is calculus?' The response was not good. Even though the calculus student had the vocabulary from the course, he could not seem to describe the essence of the course. He had a collection of ideas, but he did not understand the big ideas from calculus. One goal of a course should be that a student could explain to a peer what the important ideas are in that course.

What is a Concept Map?

A concept map is a strategy for organizing information in a manner that permits a better understanding of the information. It is a pictorial view in which a word or words representing concepts are placed in circular or rectangular regions and connections between concepts are shown by lines between the concept regions. The main idea is usually created first and placed either at the top for a hierarchical structure or in the center for a circular structure.

Concept maps are useful at the beginning of some situation that we want to understand, and they are useful at a stage where we have several concepts that have been introduced and are related and we want to develop the connections among these ideas. Concept maps and the creation of concept maps help in making the connections between ideas that we want to keep, recall, and understand. In a college class concept maps can form a method of evaluation; students can be asked to write about an instructor-created concept map or they can be asked to create a concept map from a given general idea.

What do we want students to know?

We want our students to have a deep understanding of the most important concepts (the big ideas) in a mathematics course. We would like for them to be able to stand in front of peers and explains the essentials in a mathematics course they have completed. Moreover, we would like for them to know why it is meaningful for a college graduate to know these concepts. Professors have always had difficulty answering the question,

"Why do I need to know this, and when will I ever use it?" We want to create mathematics courses where that question is not dreaded, but welcomed. In fact, we seek a course that is so well taught and designed that the question is answered by the course, not by the instructor.

Students need to know that doing mathematics is not just about the mechanics of manipulating equations, but is about solving problems in the context of a real problem situation. They need to understand the power of modeling physical situations with basic functions. They need to see those models used to predict past and future outcomes. If we can show only a few meaningful situations that connect to the five or six basic function-models, we will instill in our students a new understanding of the power of mathematics.

Informal Geometry for Elementary School Teachers

Undergraduates preparing to become elementary school teachers must take four courses in mathematics, *College Algebra*, *Finite Mathematics*, *Mathematics for Elementary School Teachers*, and *Informal Geometry for Elementary School Teachers*. Students planning to teach mathematics in the middle school will soon be required to take additional courses for certification. It is often quoted that teachers teach as they were taught. The Informal Geometry course is a hands-on course designed with all of the elements that we want teachers to emulate when they enter their own classroom. Here we see three concept maps illustrating the big ideas in the course.

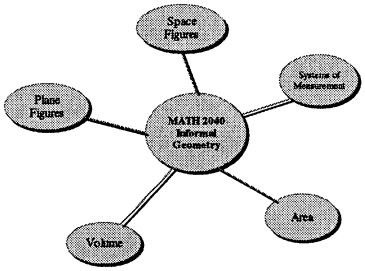

Figure 1

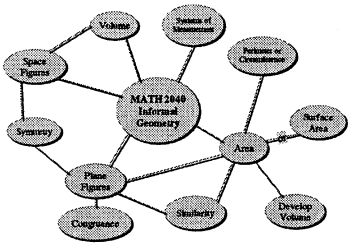

Figure 2

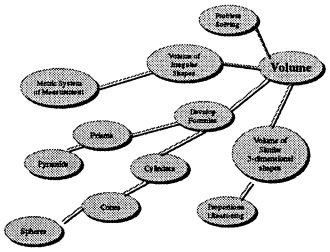

Figure 3

The concept map in figure 1 is a circular map with the most important ideas in the course radiating from the center. It could be used often in the course to bring the big ideas into focus. The concept map in figure 2 is an extension of the first giving a smooth transition from general concepts to more specific ideas. The concept map in figure 3 is even more specific as it gives the particular concepts related to volume. The desire is to give future teachers an understanding of the most critical elements in geometry for elementary and middle school, and we hope they develop methods of communicating the important ideas to their student when they become teachers.

College Algebra

Prior to the change to hand-held technology, we taught college algebra with many topics that appeared to be unrelated. The goal of a college algebra course appeared to be the teaching of paper and pencil techniques to solve linear and quadratic equations. Solving equations is a worthwhile endeavor, but the involved techniques used the available time

and prevented an overall understanding of the use of algebra. The variable "x" represented an unknown to be found and the algorithmic procedures to find x did not give the students any use for the course. The only purpose for the course seemed to be a hurdle for the students to vault.

We The use of hand-held technology in college algebra permitted a new course to be taught. The variable "*x*" represented change and the variable "*y*" also represented change. College algebra took on new meaning. It became a course that began to describe the changes happening about us. Quite often in a real world setting, two things are changing and the change of one is dependent on the change of the other. For example, there are multitudes of interesting phenomena that are changing dependent on the change in time. As time goes by everything from the paint on the wall to the population of the world is changing. Students recognize these are important ideas. We now describe the college algebra course as "Modeling the Patterns of Change." The idea of "two things changing and the change of one dependent on another" presents the function as the main idea in the algebra course.

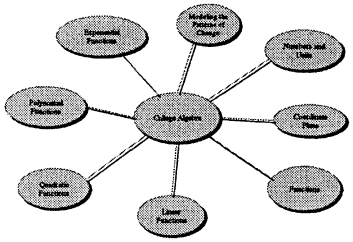

Figure 4

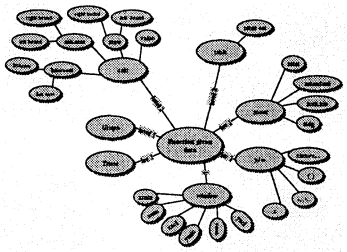

Figure 5

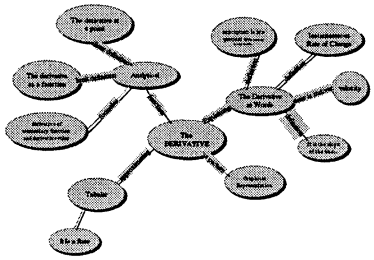

Figure 6

Calculus

In the first calculus course there are so many methods to think about the derivative. It is difficult for a student to separate the most important ideas. The concept map in figure 6 gives these important concepts and their connections. The ideas are listed here because of the size of the concept map.

- The derivative in words: It is the instantaneous rate of change…It is the quotient dy/dx where dy approximates delta y when dx is small.
- The derivative at a point, limit definition
- The derivative of a function, limit definition
- The derivative of elementary functions with derivative rules
- The derivative represented graphically, numerically, symbolically, and verbally

Concept maps in Hierarchical Form

Many advocates of concept maps express a preference for concept maps created in top-down form. There are many reasons for placing the concept map in this form. It is easy for the reader to identify the main idea of the concept map, and it is easier to connect more than one concept to another in this top-down format. The quadratic function as presented in the college algebra course is illustrated with a concept map in Figure 7.

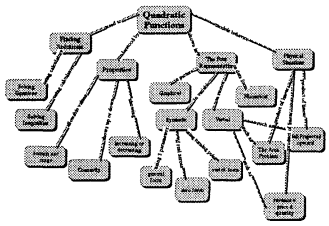

Figure 7

Concept Maps as Teaching Tools

Concept maps can assist in bringing a course from a collection of seemingly unrelated topics to a course that has a hierarchy. There can be a concept map for the entire course, a chapter, a section, and a topic. A concept map is an excellent tool to give to students before a test to have them focus on the important ideas to be tested. The concept map can illustrate the agenda for the class meeting in a manner that quickly gives the student a sense of what the teacher is doing during the class and how the topics connect to one another. An evaluation can be the writing about a concept map explaining each of the parts. Students can be given a concept map and placed in groups to change it and make it better. Students can be asked to create concept maps on the ideas of a section or chapter. We in mathematics are looking for ways to have students write about mathematics. Concept maps give the instructor an opportunity to do that.

What do we want you to know?

We want you to know that you can teach in the presence of technology if you are willing to make some changes in your teaching methods and, often, changes in the curriculum. We can teach in a new way that gives meaning to a course that before was lost in the mechanics. Concept maps can form an excellent evaluation instrument. Concept maps are not the only method of focusing on the most important ideas in a course, but they can form a great tool for teaching and learning

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