My Professional Lifetime Effort to Create A Science of Education

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My Dad was a big influence in my thinking.

Though he had only a 4th grade education in Dubova, Slovakia, he was wise.

My Dad, 1969

In 1945, Dad's 1940 Dodge needed a motor overhaul.
Dad asked me to do the overhaul, even though I had never worked on a car engine.
Dad said: "I know you can do it!"
I did it, and this was a big confidence builder!

Raised in the Russian Greek Catholic Orthodox church, I was awed by the grandeur of the Church.

God’s 10 commandments also made a lot of sense to me.

Whether it was the Church, Boy Scouts, or the teachings in our home, something made me want to accomplish something in my lifetime that could make life better for people.

Thomas Edison High School

I found elementary school and high school rather boring and spent most of my spare time reading or tinkering with things

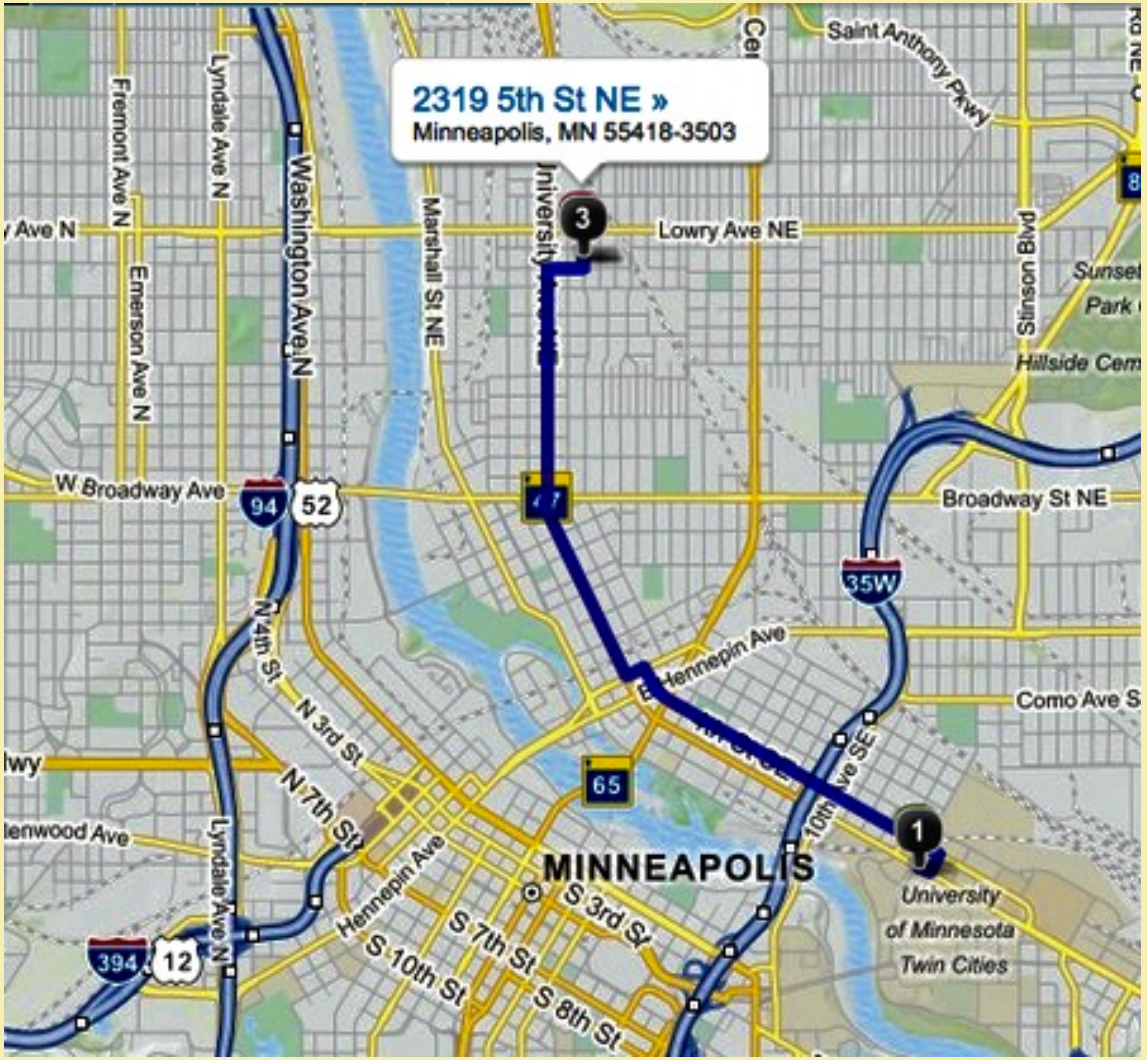
From 9th grade through college, I worked at Central Cleaners pressing cloths and waiting on customers

Hoffman Steam Press Machine

Even before high school, I questioned why so little emphasis was placed on understanding what we were studying, rather than just memorizing information?

Only Sam Drage, my physics teacher, and Ms. Fish, my English teacher, required understanding what we were studying. I loved those classes!

The University of Minnesota was just three miles from my home. I began working and saving for college at age 13.

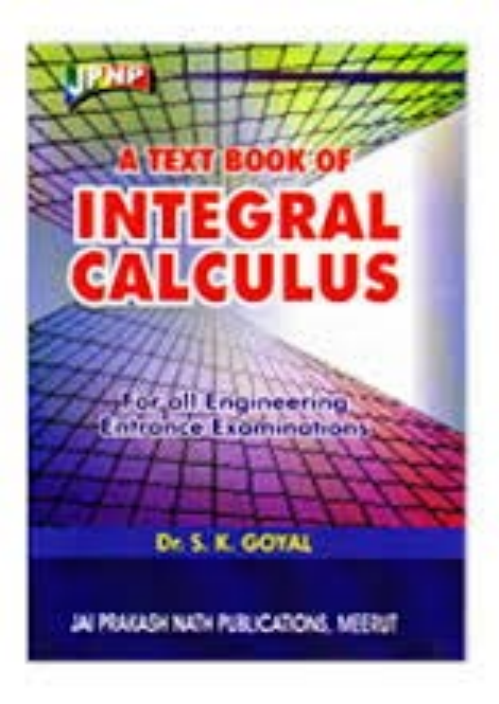


I graduated from high school at age 17 and began studies at the University of Minnesota in 1948.

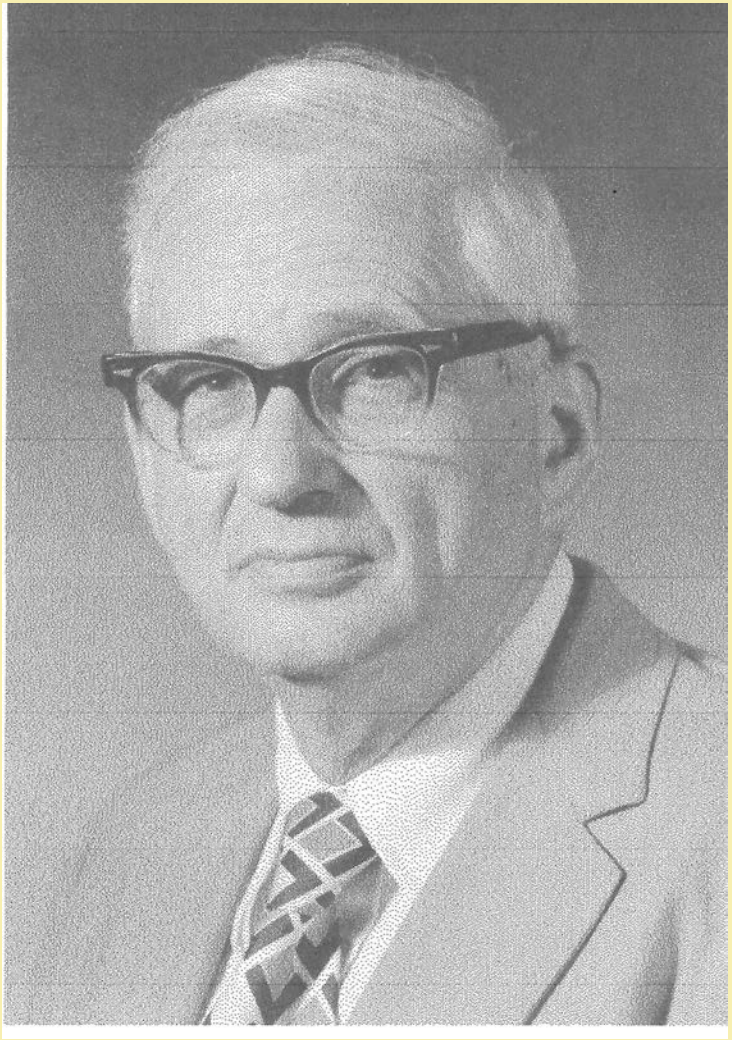
I began college with the intention to do a major in mathematics.
The Mathematics Department was located in Fowler Hall,
on University Avenue at the main entrance to the campus.

While studying for the final exam in Integral Calculus in my sophomore year, I came to the realization that for years I was learning only the procedures for doing mathematics, and I was not learning the concepts of mathematics!

I decided to switch my major to science education, where I had always focused on understanding the concepts of science.



In my senior year, I worked on a project in Albert Frankel's laboratory. This probably led to the invitation to join the Botany Department as a Teaching and Research Assistant in 1952.



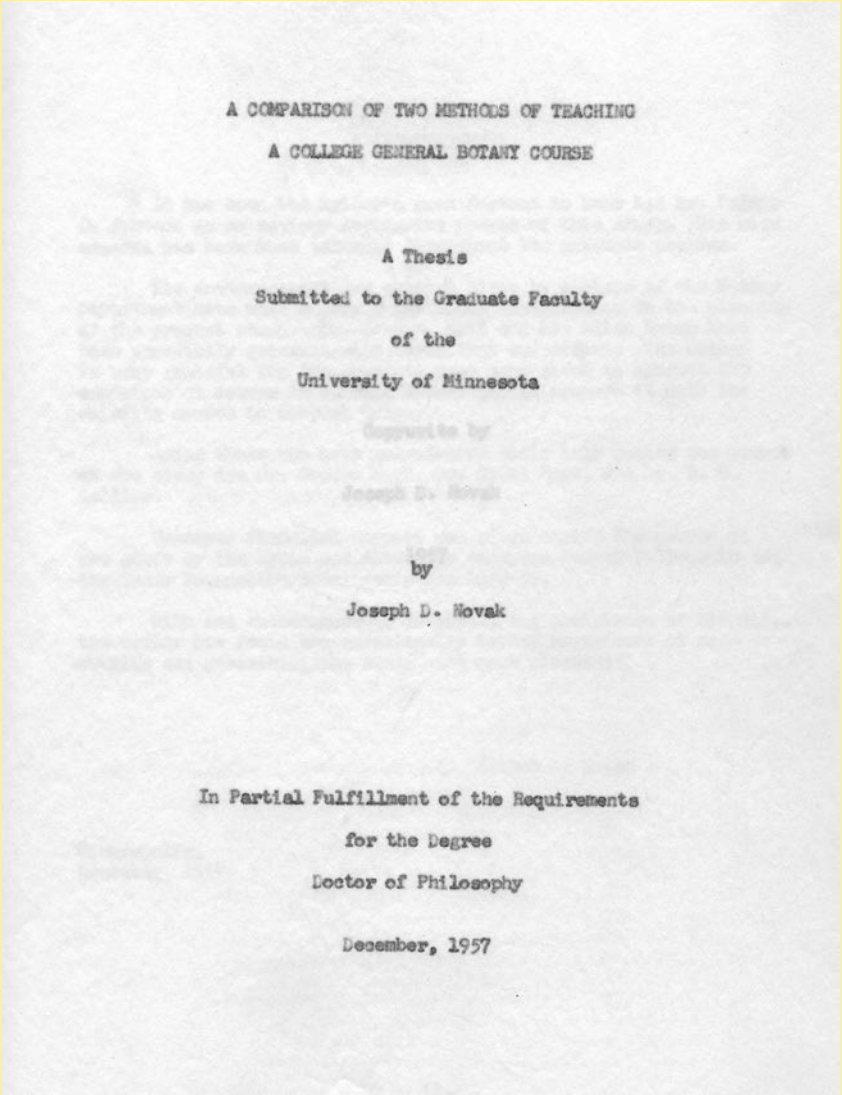
Albert Frankel, 1953

At Minnesota in the 1950's Psychology, Educational Psychology, and Theories of Learning courses presented only *behavioral psychology* ideas on learning.

BF Skinner and his experiments with Skinner boxes hugely influenced psychology and educational psychology at Minnesota and other schools.

Dad always said,
“If it doesn’t make sense, it is probably wrong”.

Rejecting the theories of learning I was taught, I searched for a better theoretical foundation for my PhD thesis research.



A COMPARISON OF TWO METHODS OF TEACHING
A COLLEGE GENERAL BOTANY COURSE

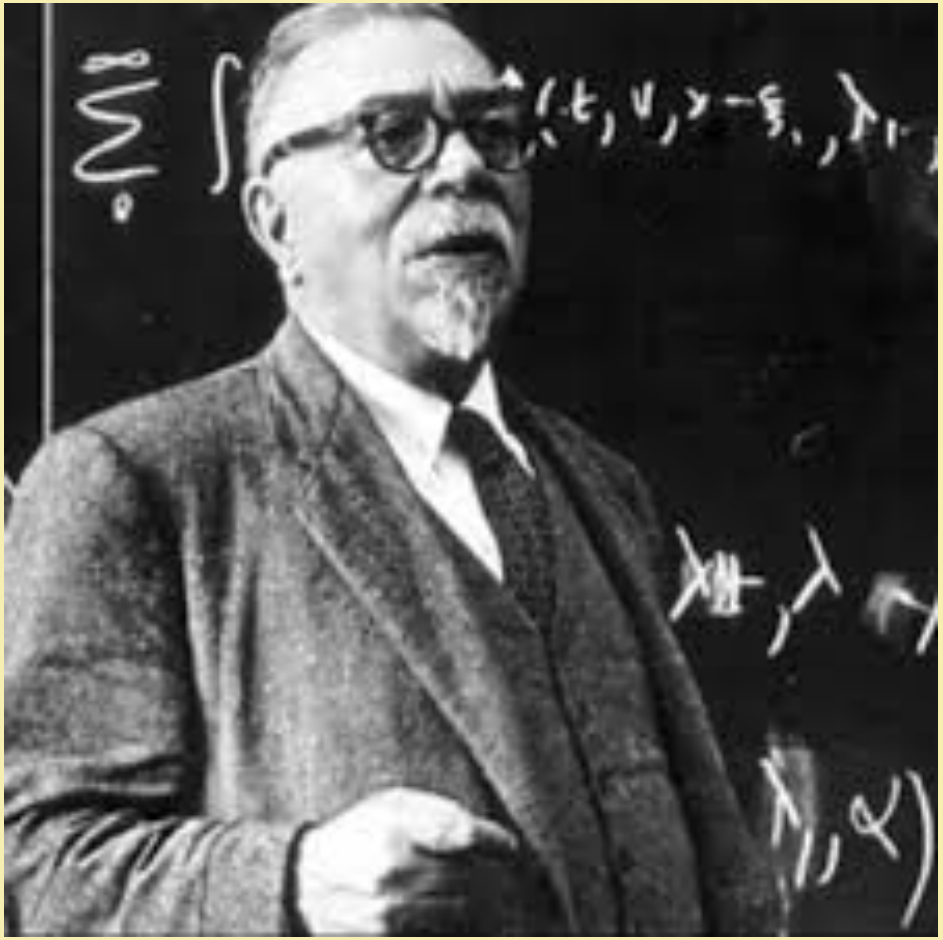
A Thesis
Submitted to the Graduate Faculty
of the
University of Minnesota

by
Joseph D. Novak

In Partial Fulfillment of the Requirements
for the Degree
Doctor of Philosophy

December, 1957

I based my PhD thesis research Norbert Wiener's Cybernetic Theory



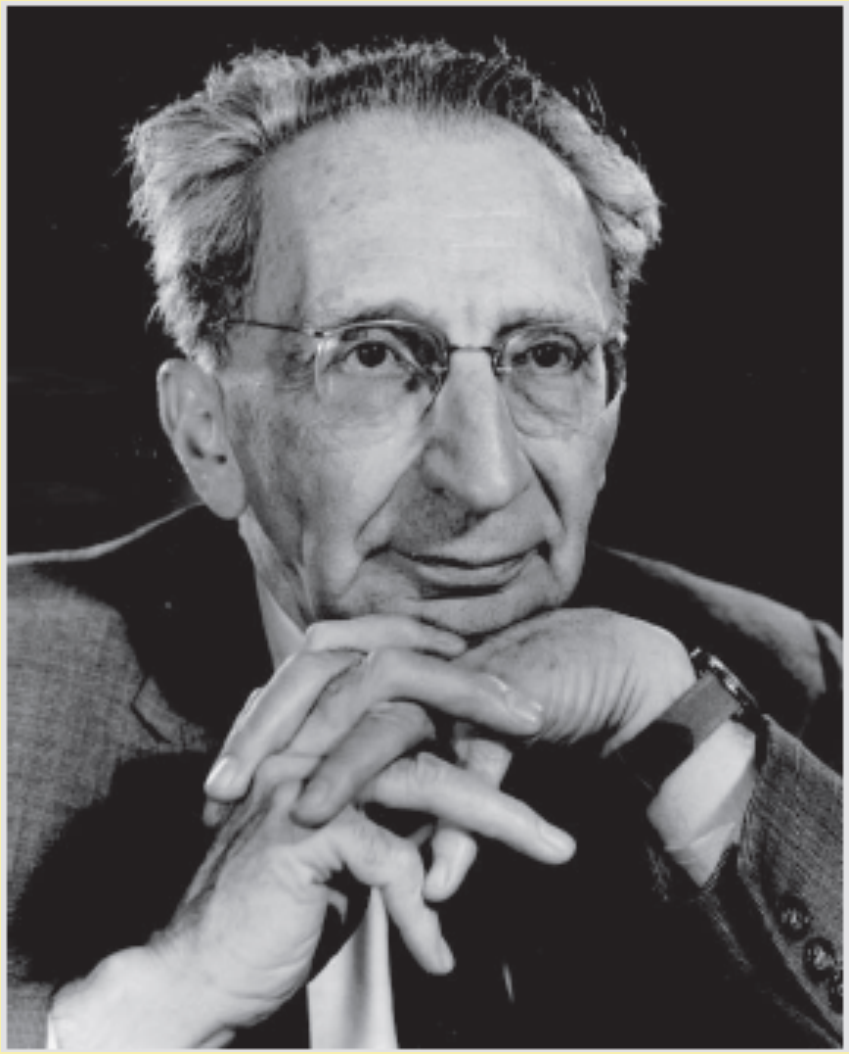
Norbert Wiener

Wiener's Cybernetic theory views the human brain as an information storing and process organ

How does the brain store and process information?

Herbert Feigl was my Professor for Philosophy in 1953. He was a leader in logical positivism. I did not think his ideas made sense, especially for botany.

I favored James Conant's 1948 view that knowledge is constantly evolving. Later this was called constructivism.

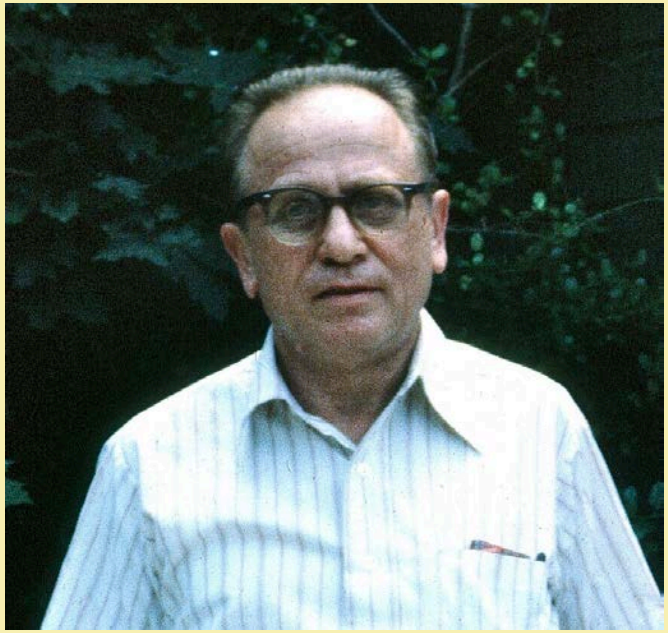


Herbert Feigl 1902-1988
University of MN 1940-1971

Once again, my Dad's teaching guided me:

"If it doesn't make sense, it is probably wrong"

Two books helped me see how people learn and how people create new knowledge



1963 David Ausubel,
Psychology of Meaningful Verbal Learning

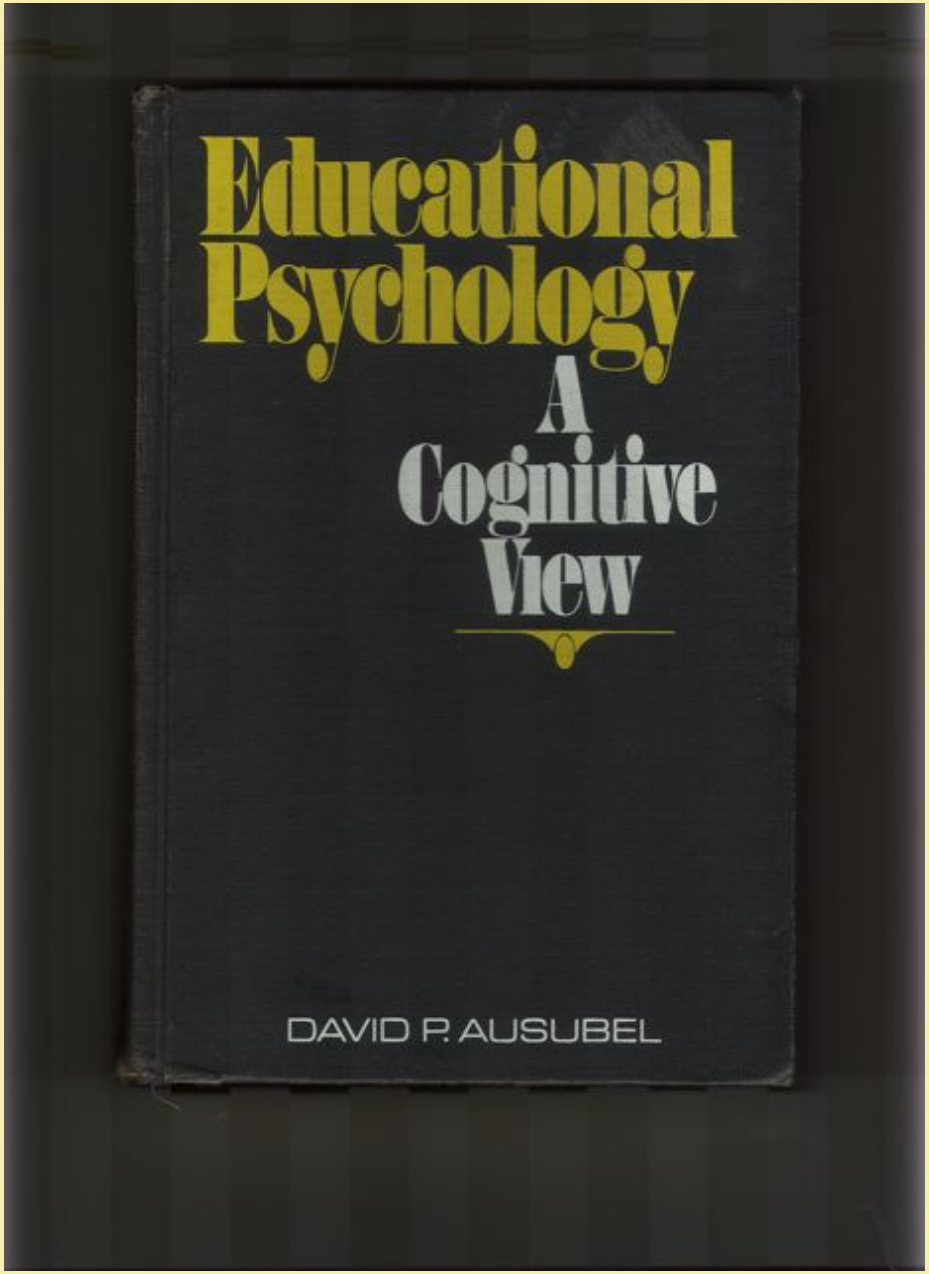
1962, Thomas Kuhn
The Structure of Scientific Revolutions

Stephen Toulmin's Book: *Human Understanding*: *Knowledge is a Human Creation* (1972)

This book really helped me understand the nature of, construction of, and evolution of concepts

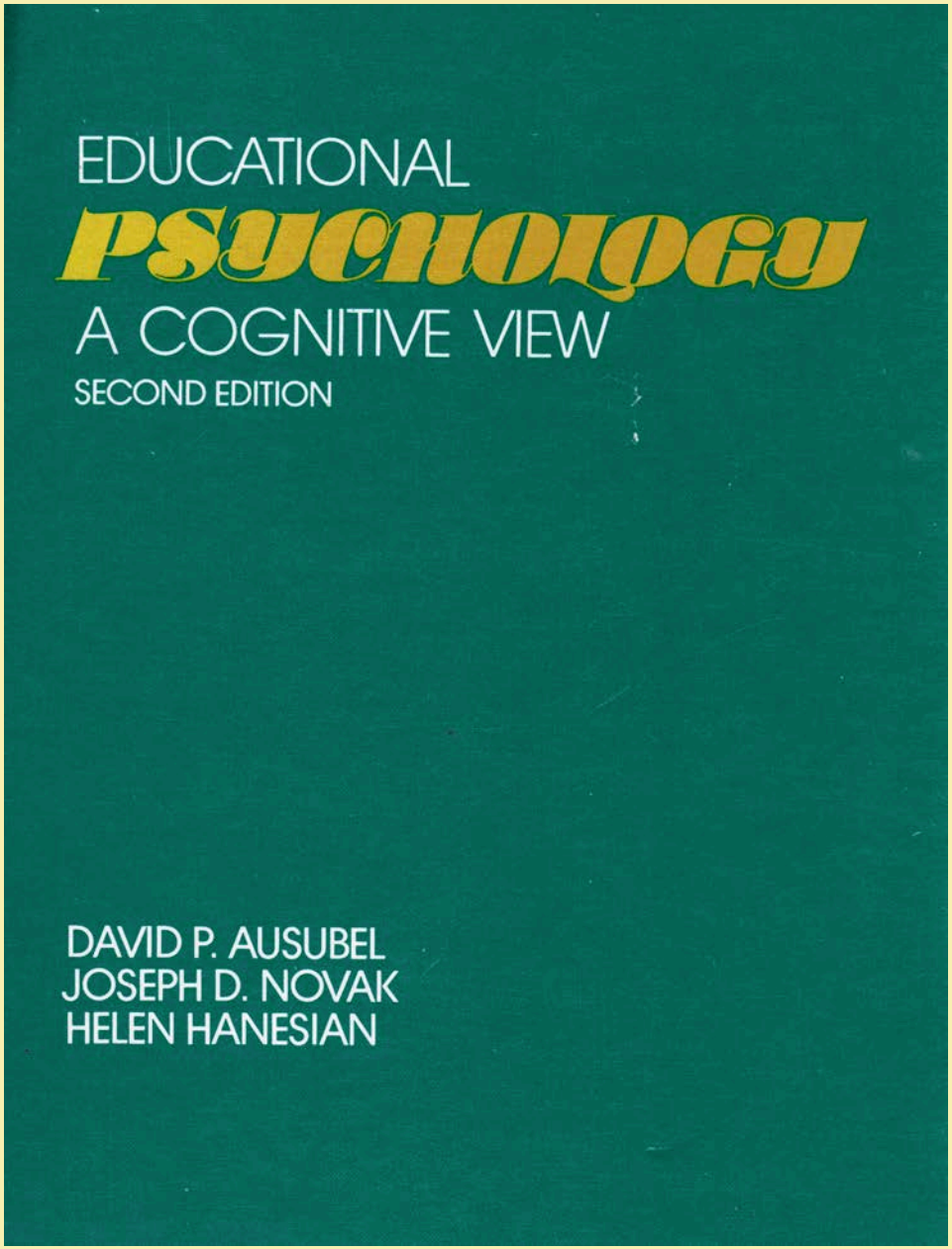
Ausubel, 1968
Epigraph:

The most important thing influencing learning is what the learner already knows. Ascertain this and teach him accordingly.

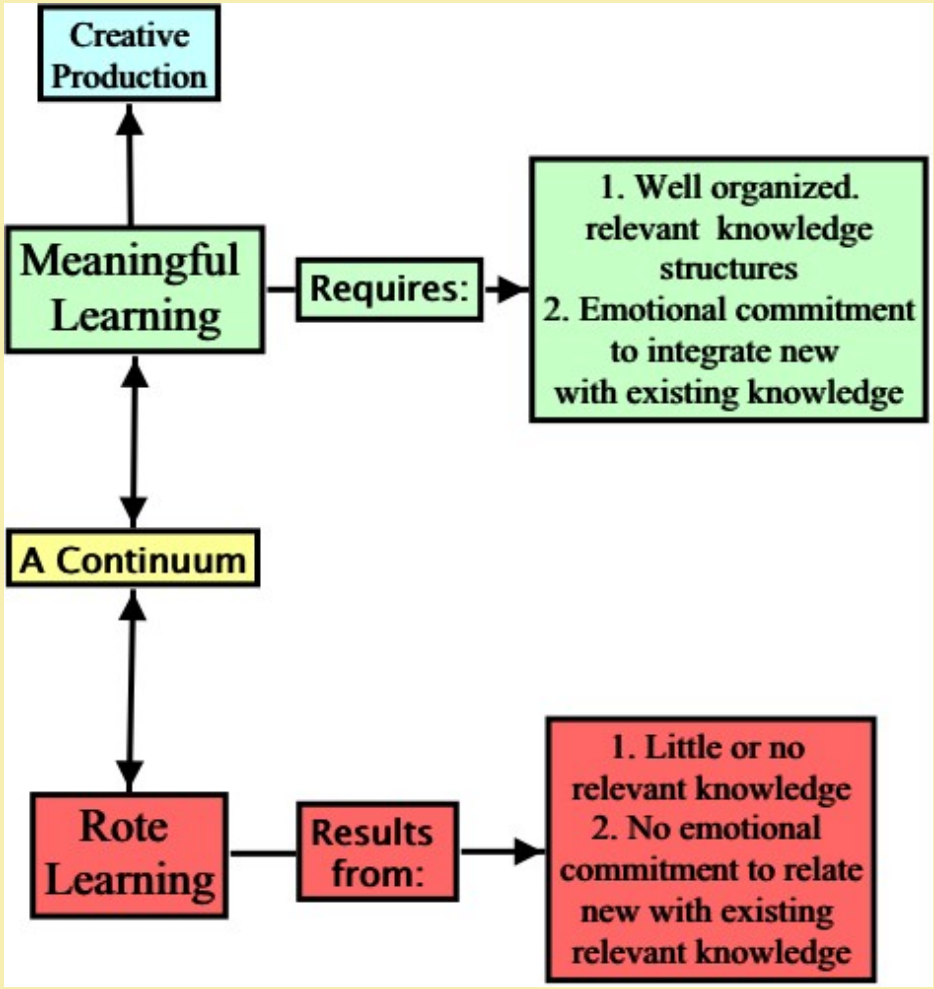


Ausubel invited me to revise the chapters on learning in his 1978 edition of *Educational Psychology: A cognitive view*.

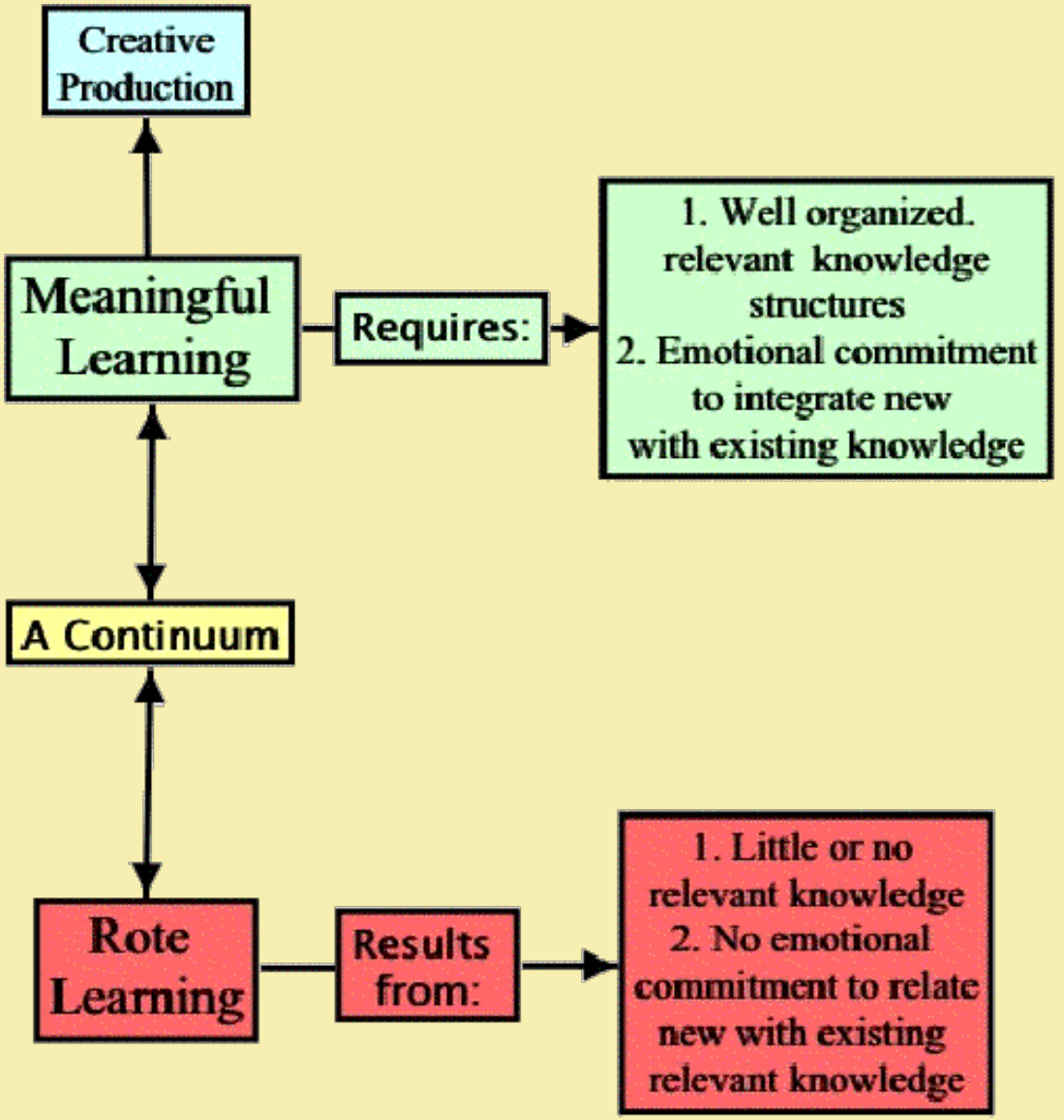
This collaboration deepened my understanding of Ausubel's learning theory.



Ausubel's theory carefully explains the difference *between rote learning and meaningful learning.*



While Ausubel accepted the idea that learning may vary from very rote to highly meaningful, he continued to view creativity as a distinct and rare quality of a few learners. He never used concept maps in his work.



The building blocks of Knowledge:

Concepts:

Perceived regularities or patterns in events or objects, or records of events or objects, designated by a symbol.

Propositions:

Two or more concepts linked together to form a meaningful statement.

How can we facilitate the learning of new concepts and propositions?

We raised three children and I learned much from them.

Jean Piaget's work, widely popular in the 1960' and 70's, claimed children could not learn abstract concepts, such as the nature of matter and energy, until age 14 or older.

I thought this was nonsense.

Jean Piaget 1898-1980

Once again, Dad's teaching came into play:

"If it doesn't make sense, it is probably wrong".

While age plays a role in capacity for learning, far more important factor is the acquisition of powerful concepts and propositions!

I learned from my children that they were capable of learning abstract concepts.

Education should be based on a valid:

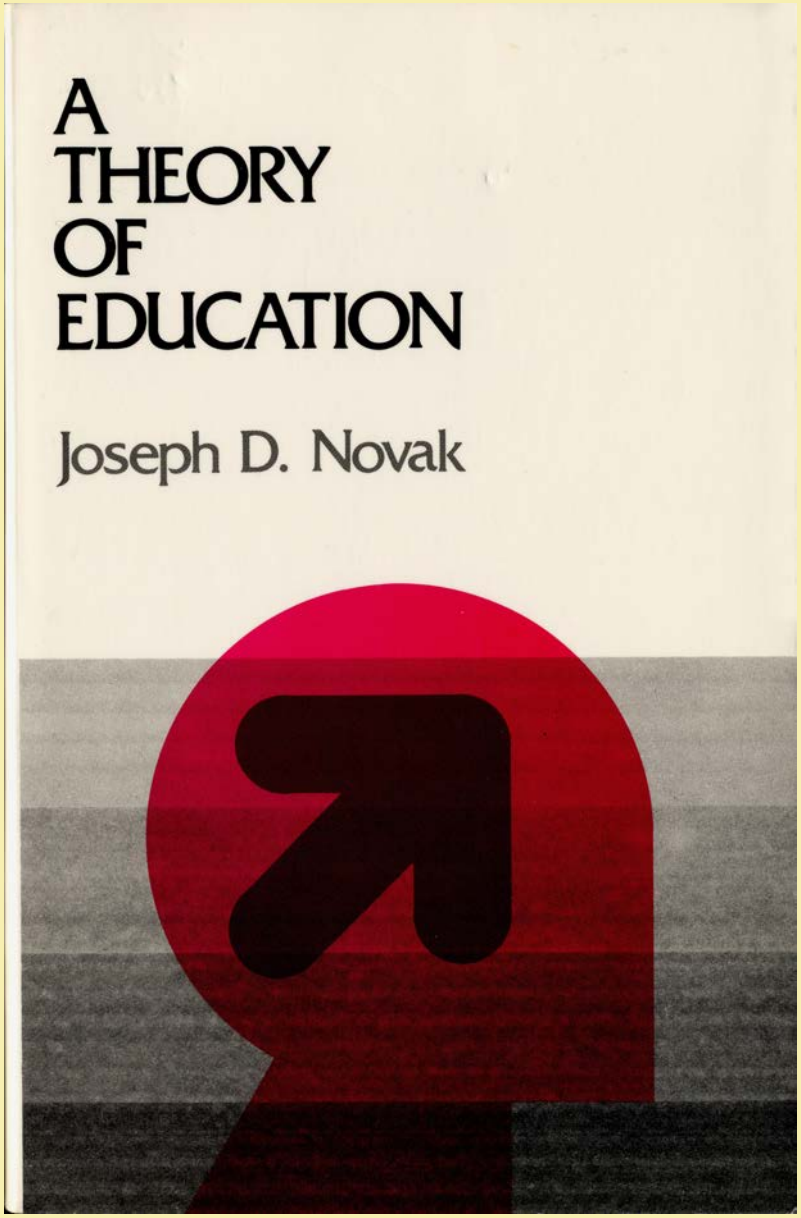
Theory of Knowledge
Theory of Learning
Theory of Education

Joe Novak
1974

By 1977, we had the Necessary:

Theory of Knowledge
Theory of Learning
Theory of Instruction

To create a viable
Theory of Education

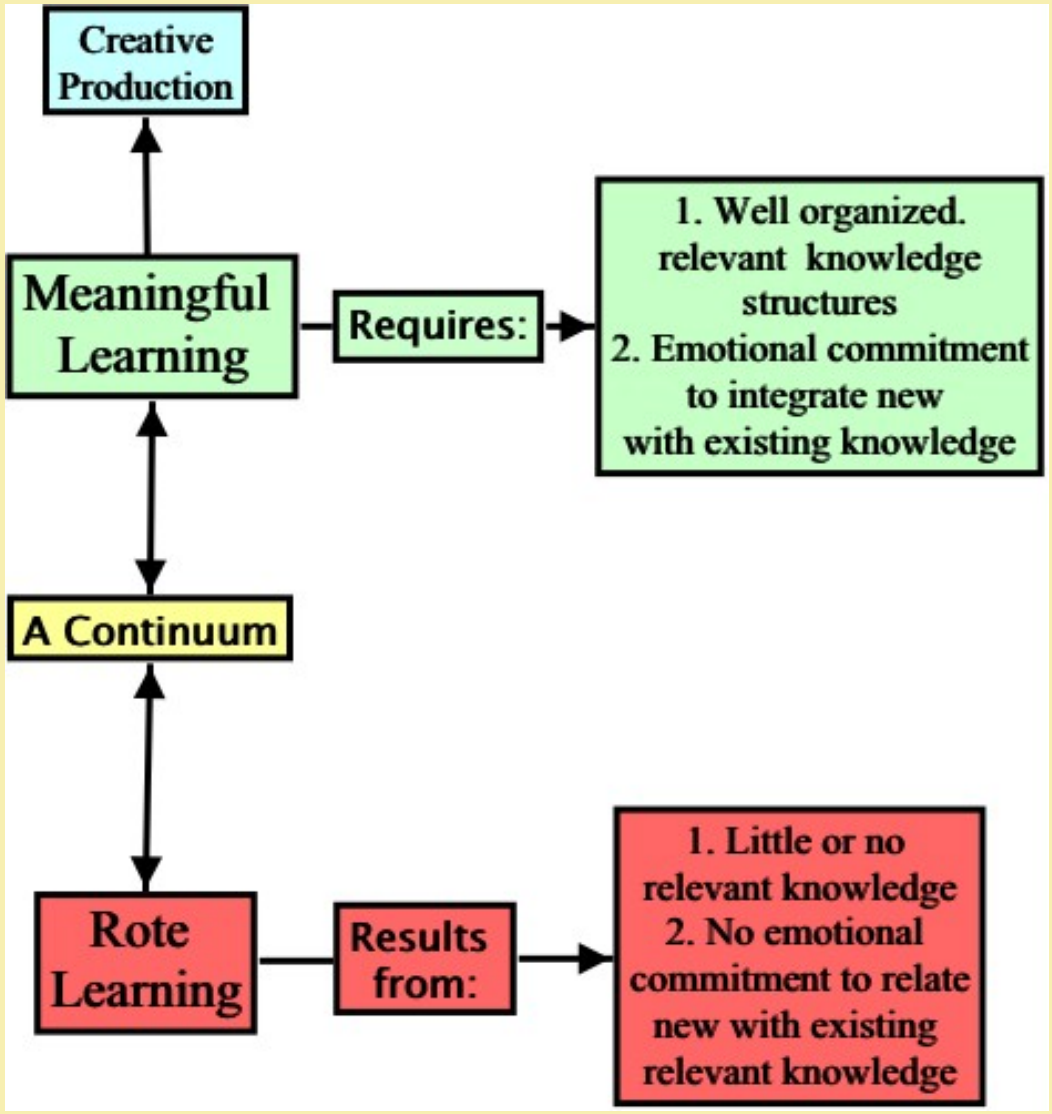


1977, Cornell University Press

I saw the fundamental problem of Education as:

Too little:

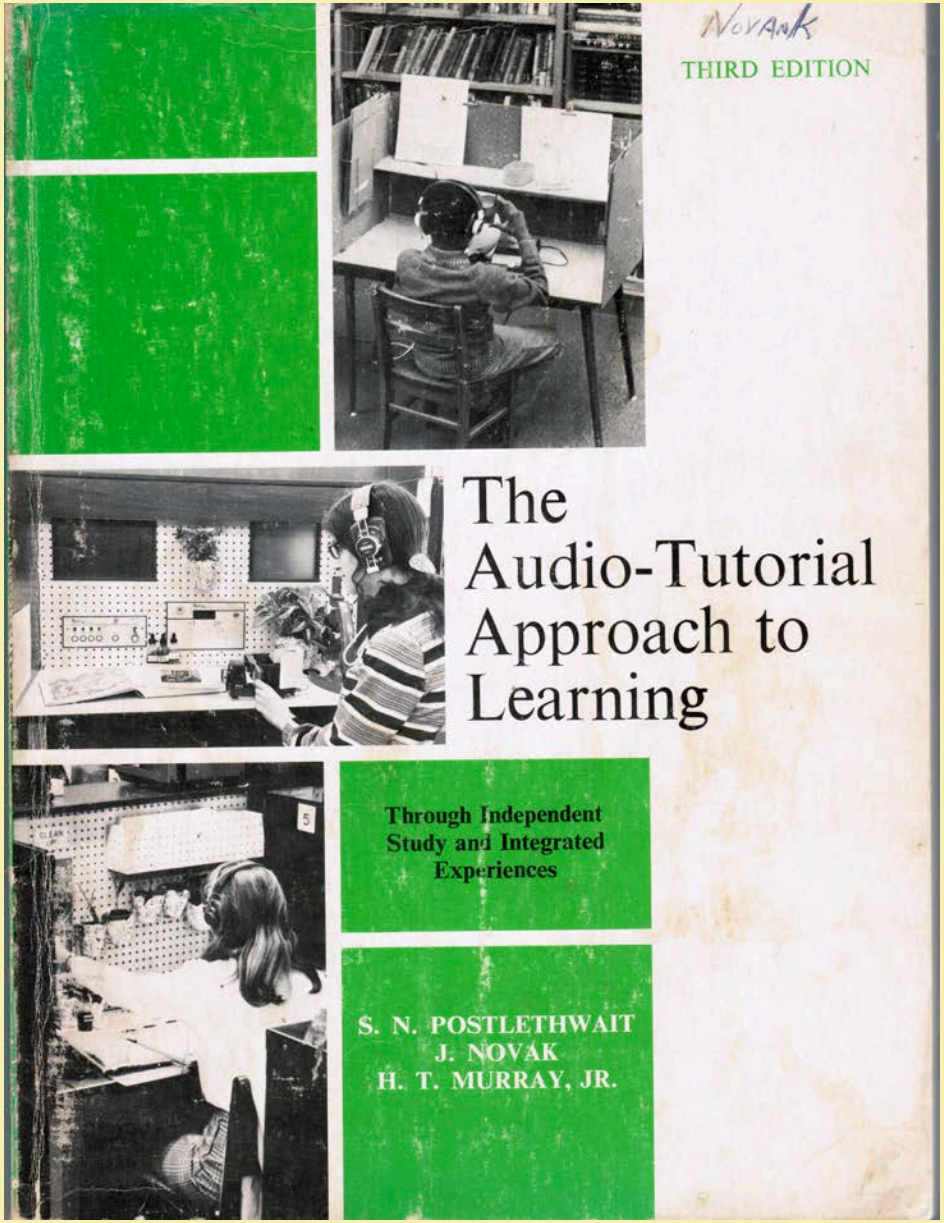
Too much:



Created in 1950, the National Science Foundation was the major funding agency for science and math education.

Only research projects based on Piaget's theory were funded by the National Science Foundation.
Repeatedly, my proposals were not funded by NSF.

In the early 1960's, Sam Postlethwait, Hal Murray and I developed the Audio-tutorial approach for learning at Purdue University



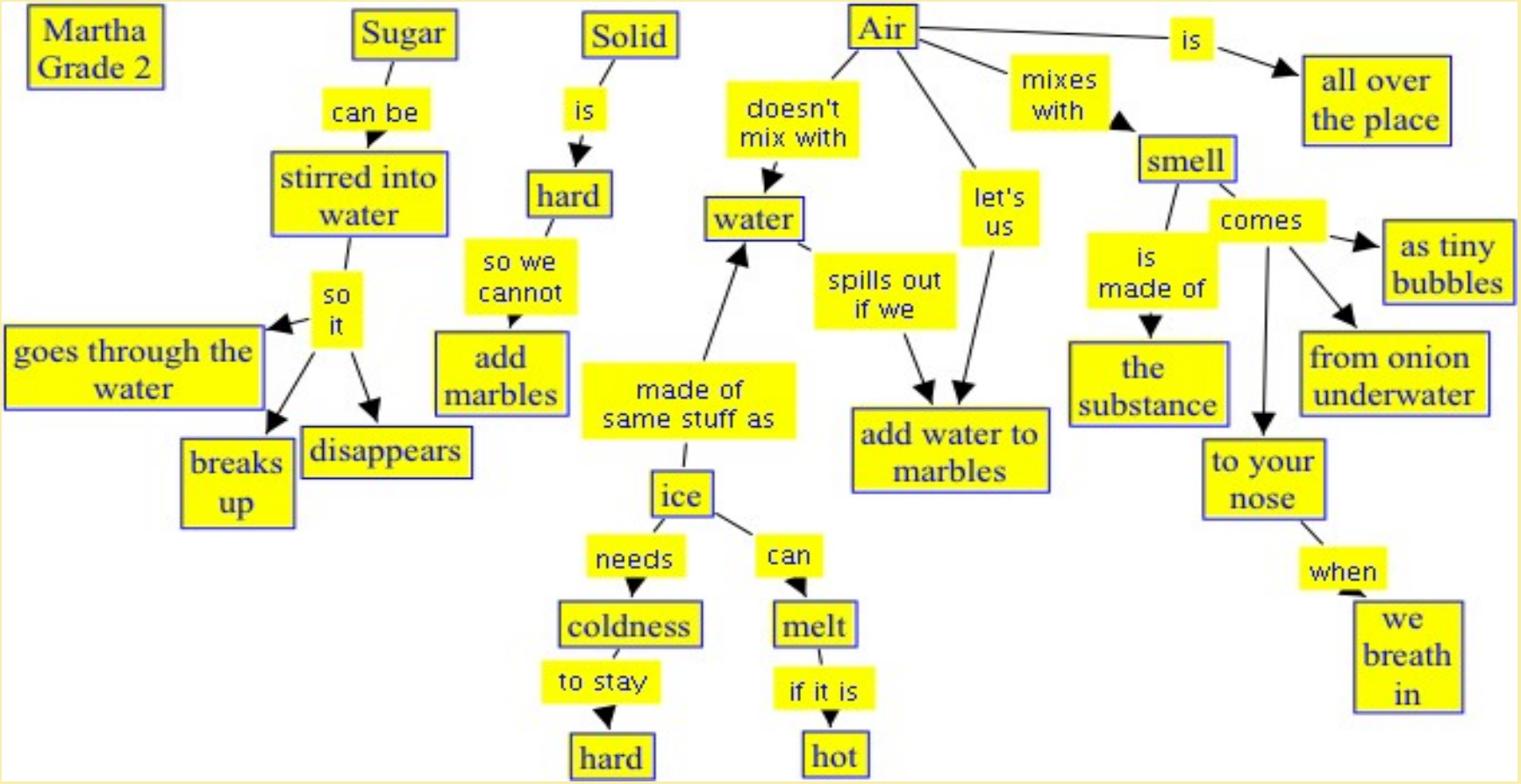
In 1965-66, while on sabbatical leave at Harvard University, I adapted the Audio-tutorial approach for teaching six and seven year old students.

6 year old studying seed growth

6 year old studying the particulate nature of matter

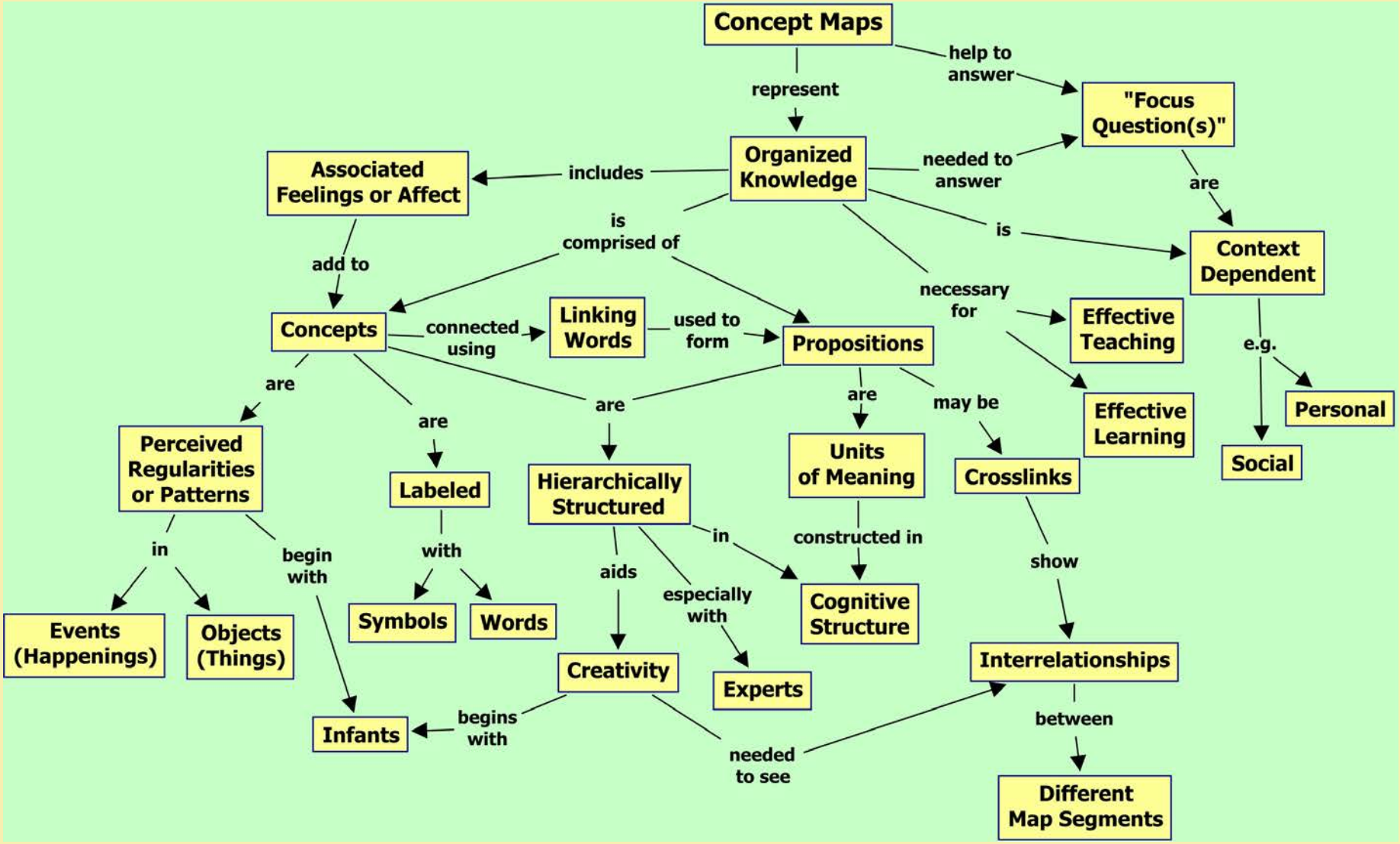
Novak's research group used modified Piagetian clinical interviews to assess learning

We needed a better way to represent children's evolving conceptual understanding



Concept mapping was invented and refined, 1972-75

This concept map showing the key features of our concept maps



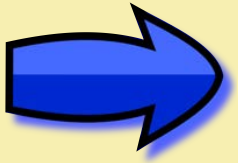
Our concept maps are based upon

A Theory of Knowledge
A Theory of Learning
A Theory of Education

We soon found that using concept maps during instruction and for assessment encouraged meaningful learning!

Students learning mostly by rote learning

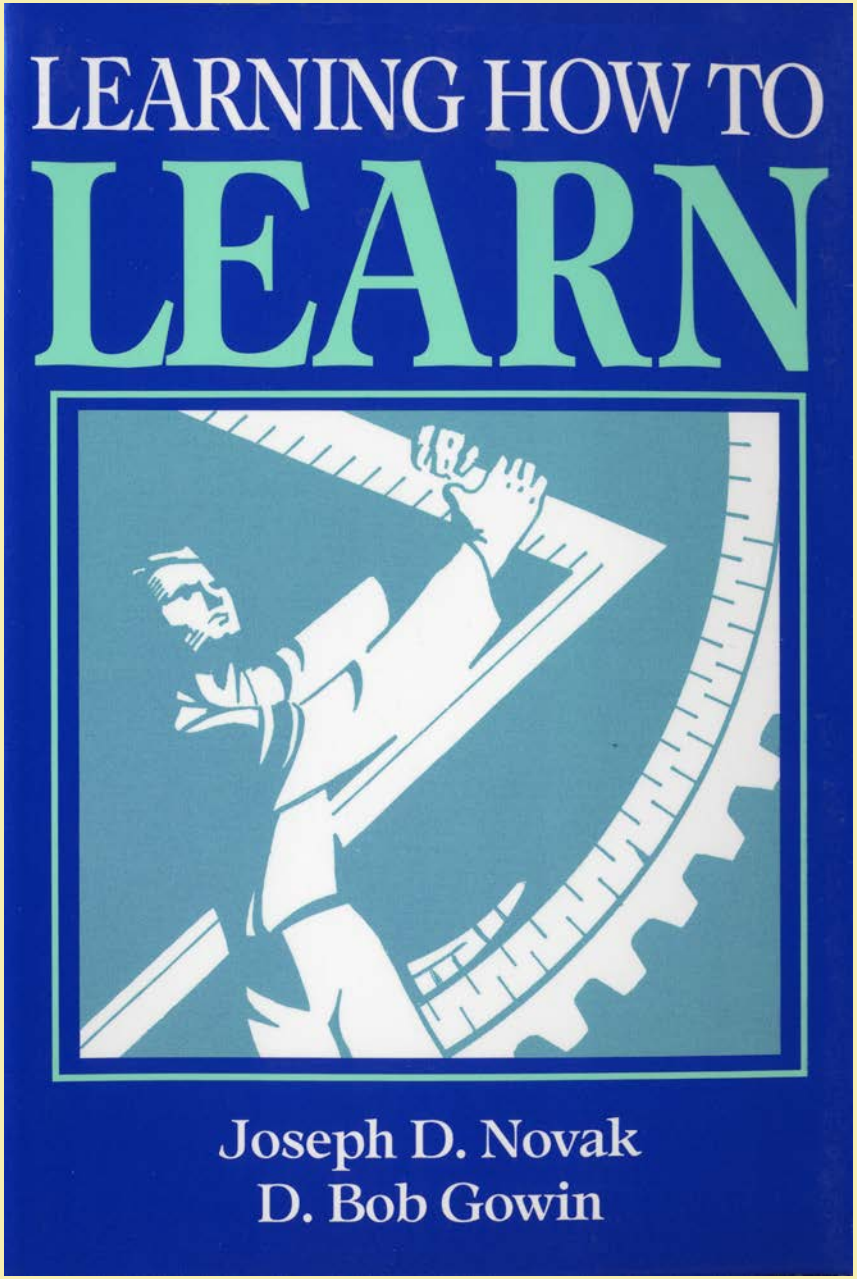
using



concept maps

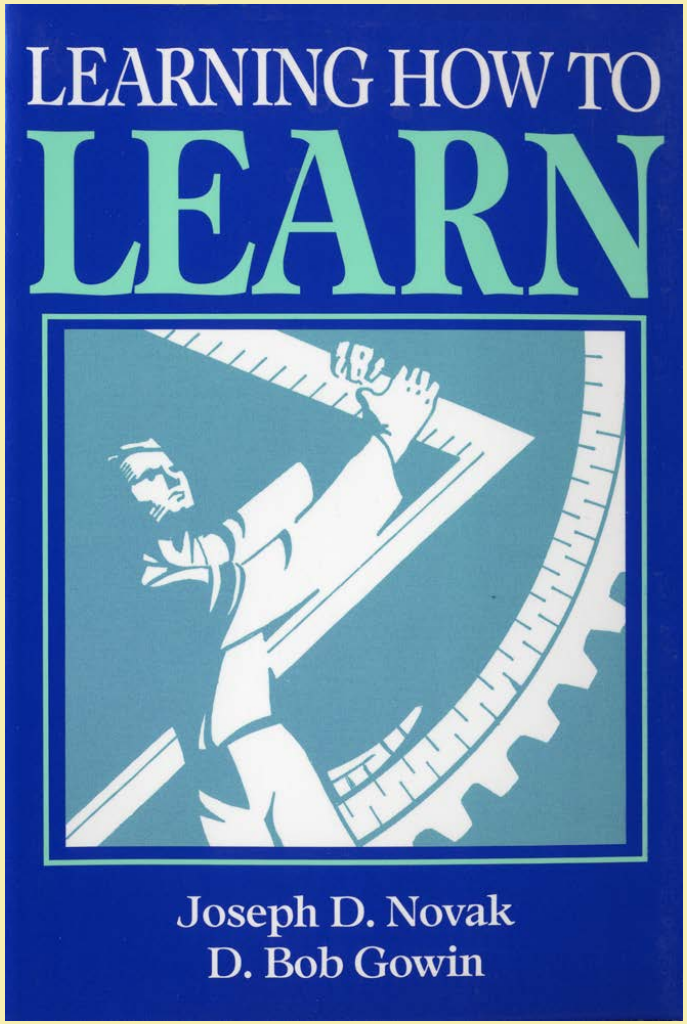
Student's learning moves to mostly meaningful learning

By 1984, we found that any learner can be helped to become a more efficient meaningful learner by using concept mapping and other learning tools and ideas

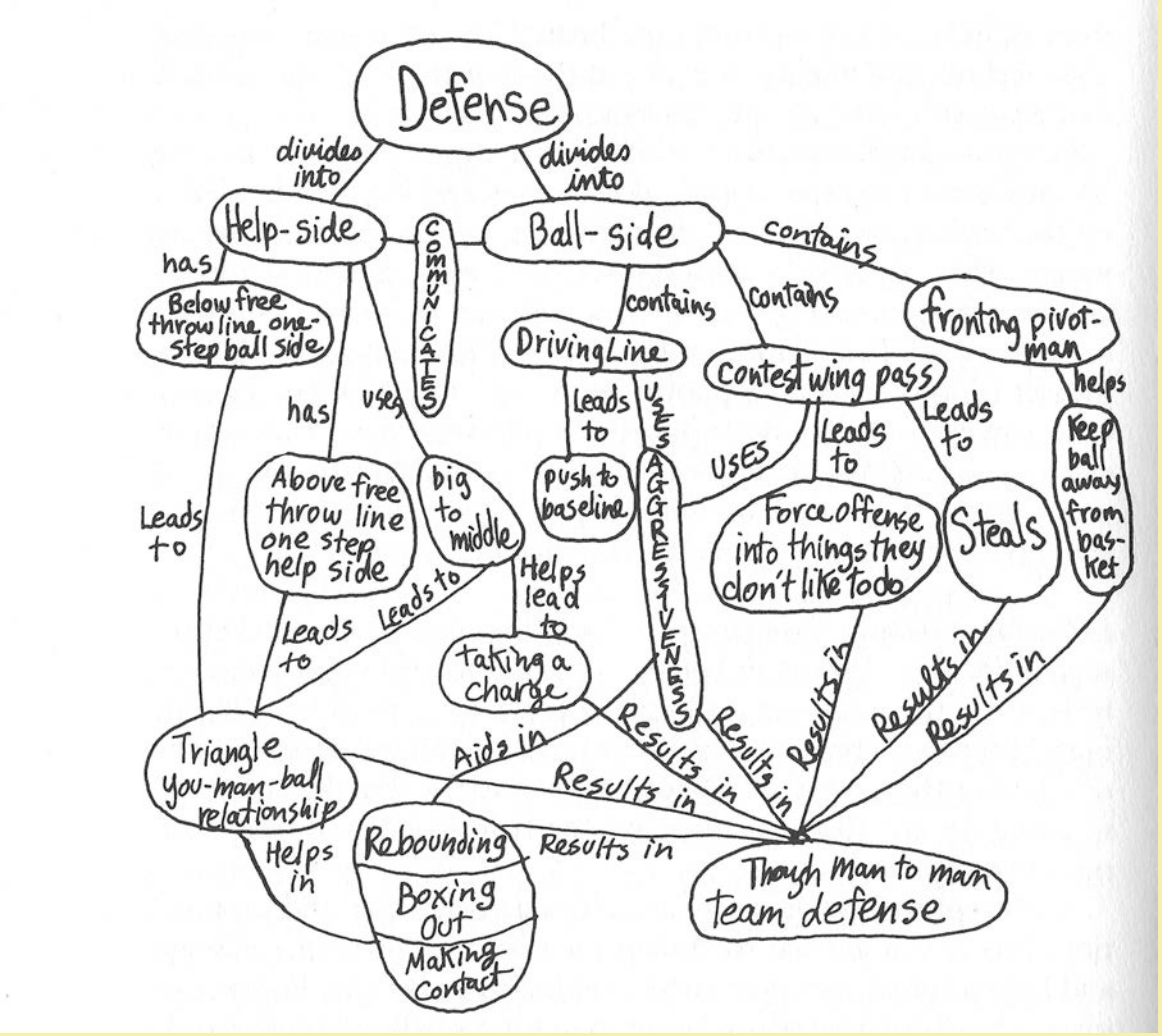


We found that the learning tools and associated ideas aided meaningful learning in many fields:

All areas of science and social sciences
Mathematics
Music
Languages
Nursing
Veterinary Medicine
Theater
etc, etc.



Drawing concept maps by hand can be tedious, especially since most people need to make three or four revisions of their concept maps as they gain new insights

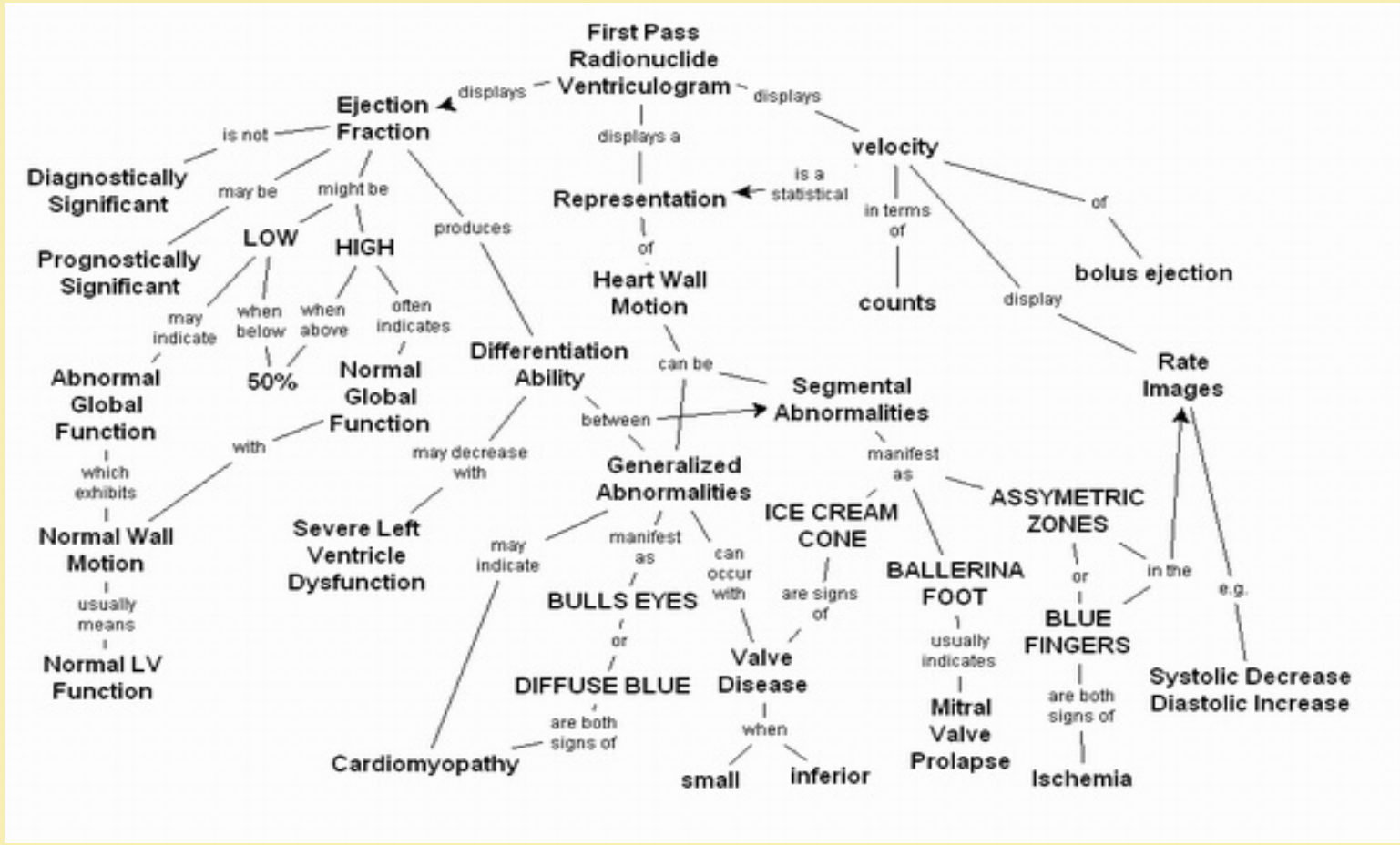


By 1985, desktop computers began to be more common.

Commodore's 1985 Amiga 1000 sold for $1295 dollars (without monitor) and had audio and video capabilities beyond those found in most other personal computers. It developed a very loyal following and add-on components allowed it to be upgraded easily.

Beginning in 1990, Alberto Cañas has led the group that created CmapTools at the Institute for Human and Machine Cognition (IHMC)

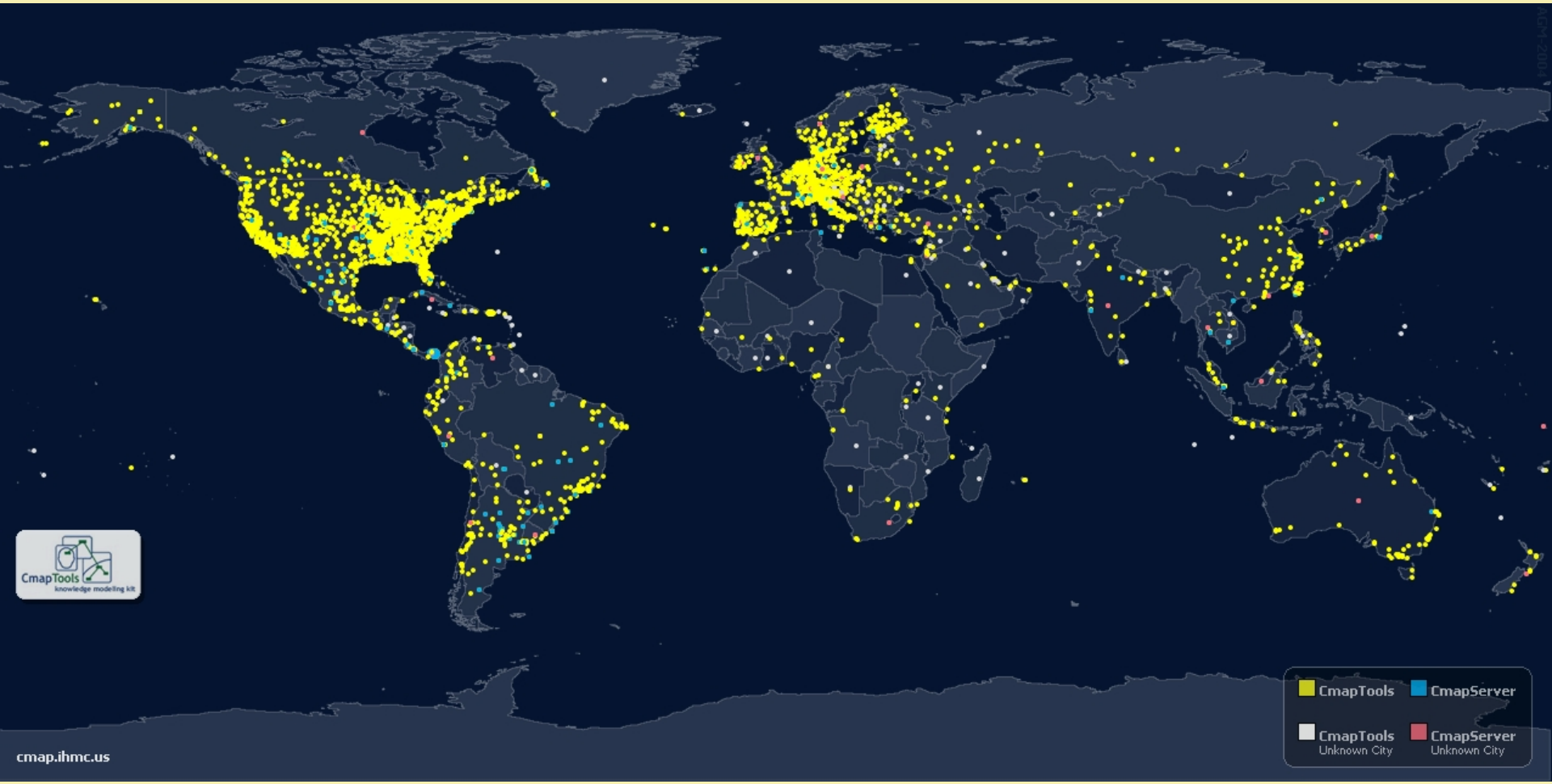
One of the first uses of concept maps was to represent expert knowledge concisely. This was often the limiting factor in creating expert systems. This concept map was created from interviews with Dr. Andrews, a cardiologist in Pensacola, Florida.



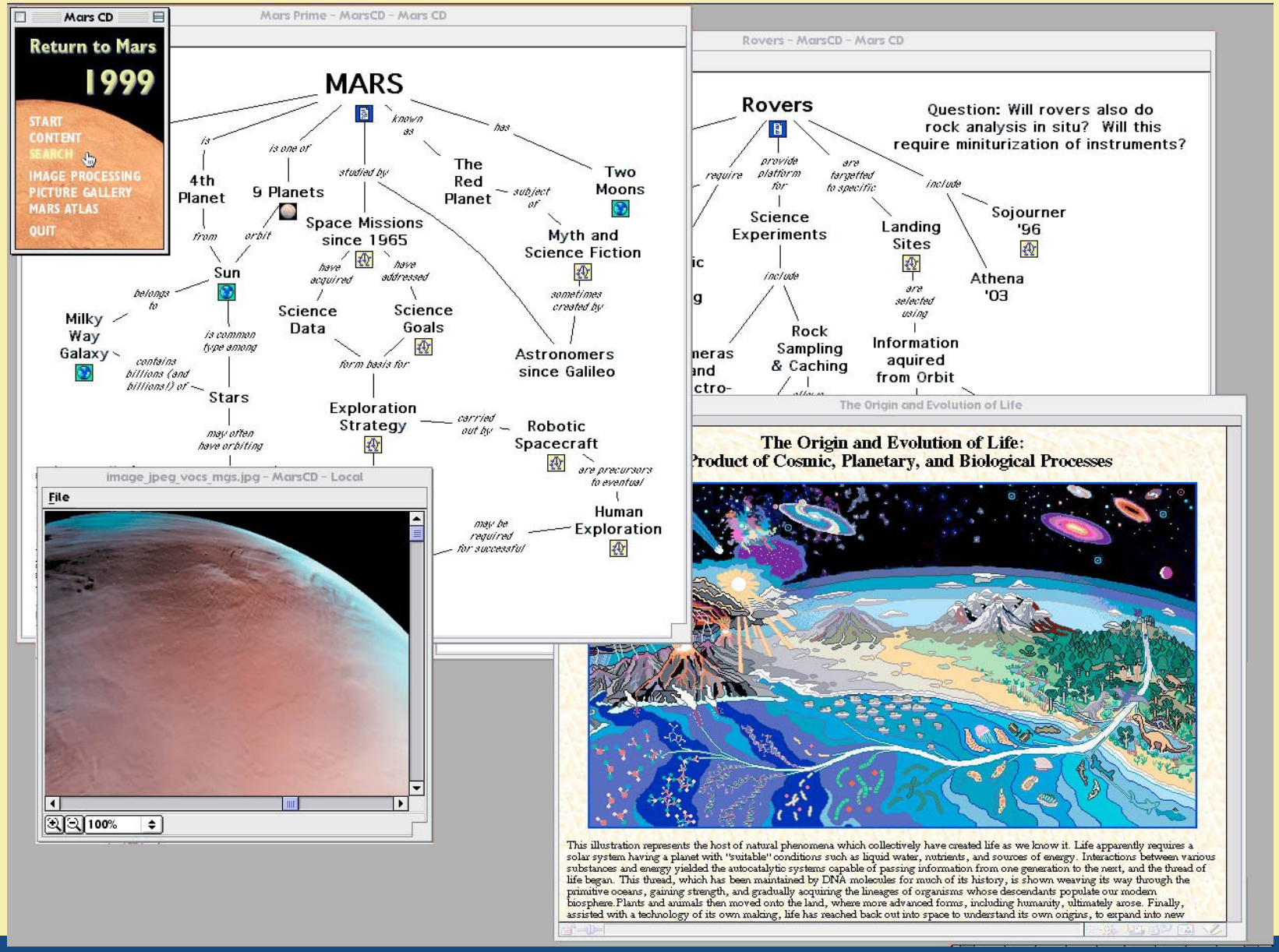
1990 to today

With funding from the Department of Navy, NASA, and National Security Administration, Alberto Cañas led the group that created greatly improved CmapTools at IHMC

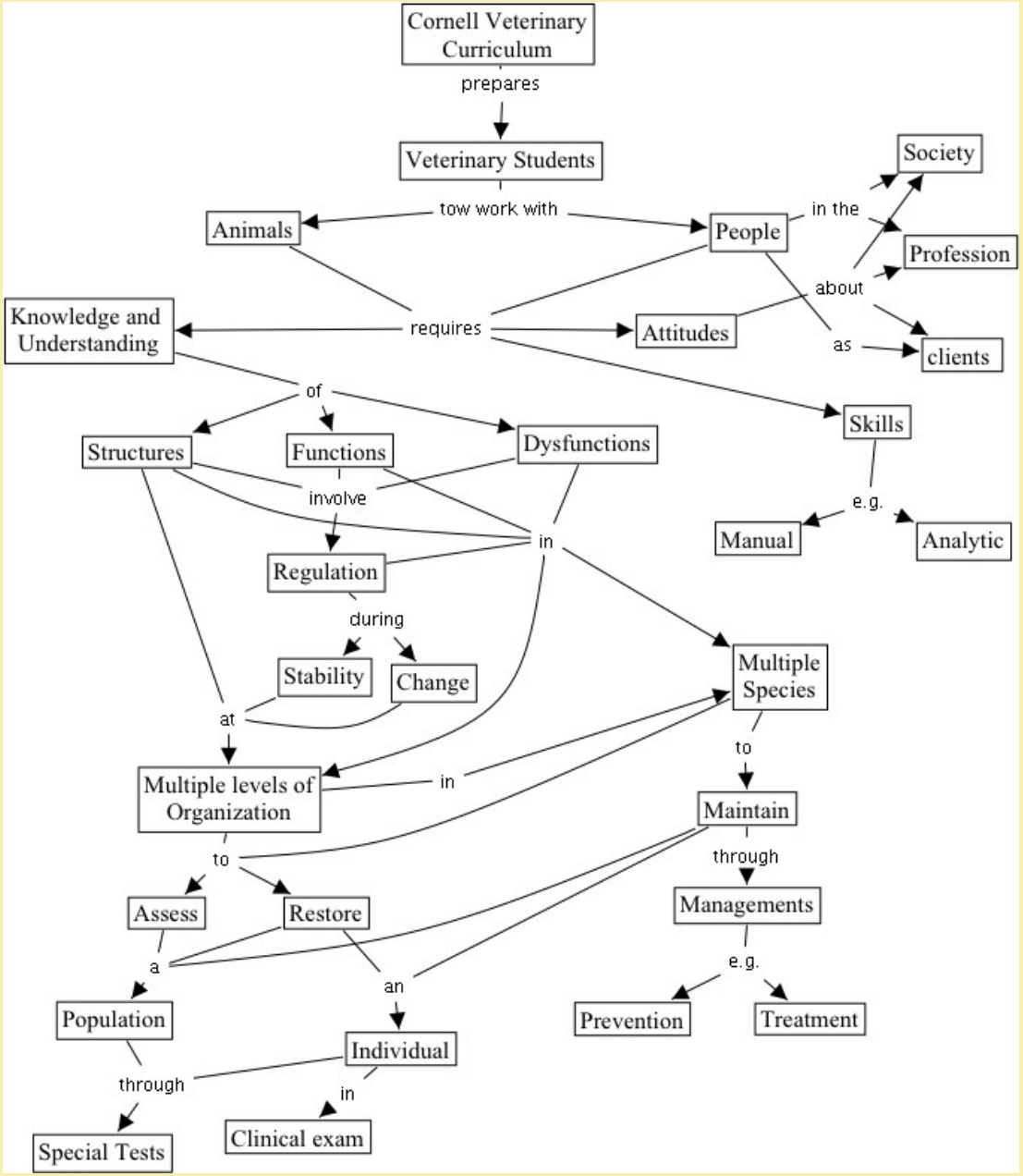
CmapTools software is free and is being downloaded all over the world



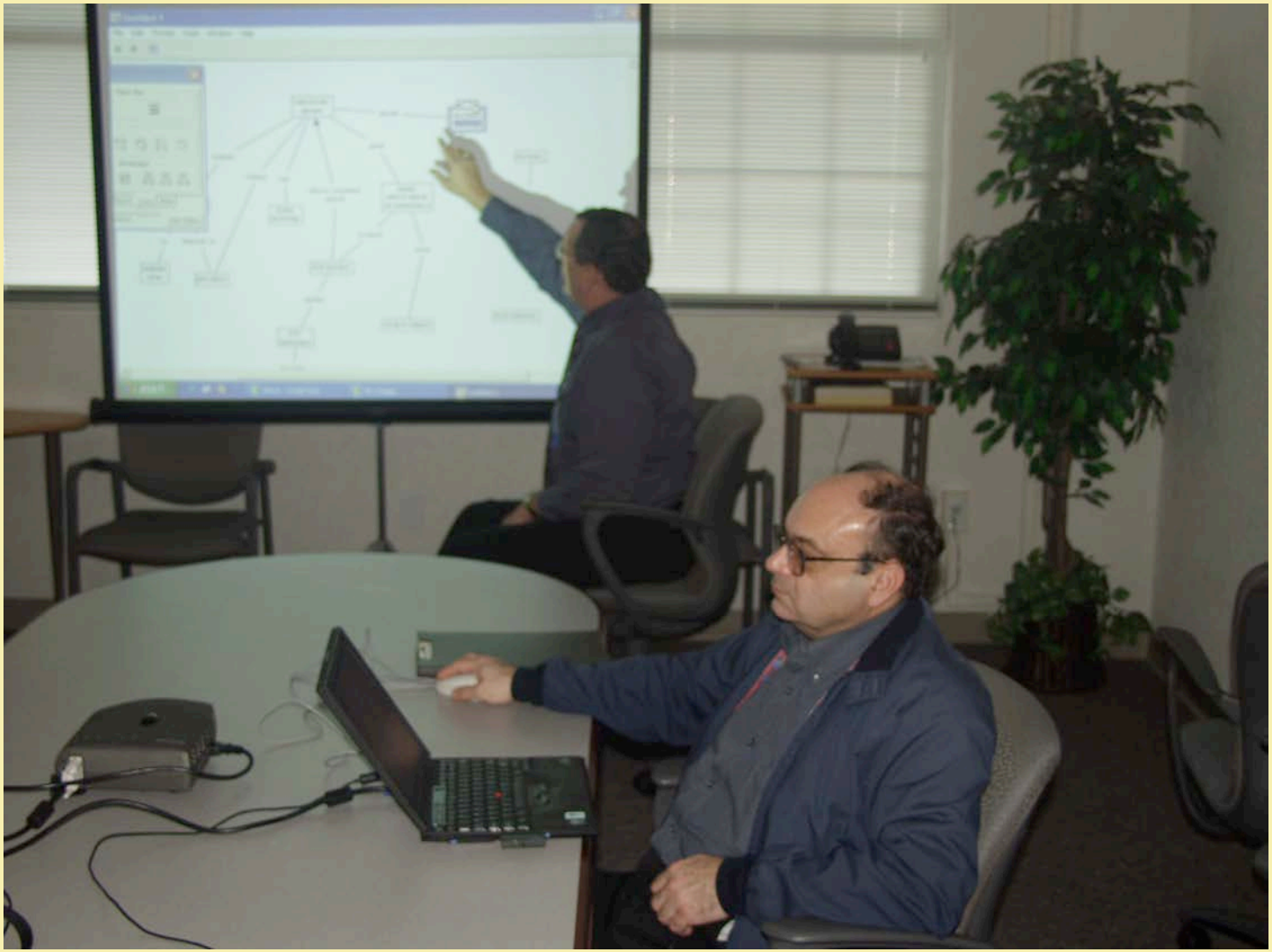
CmapTools allows for adding any digital resource to concepts. The resource pops open when its icon on a concept is clicked



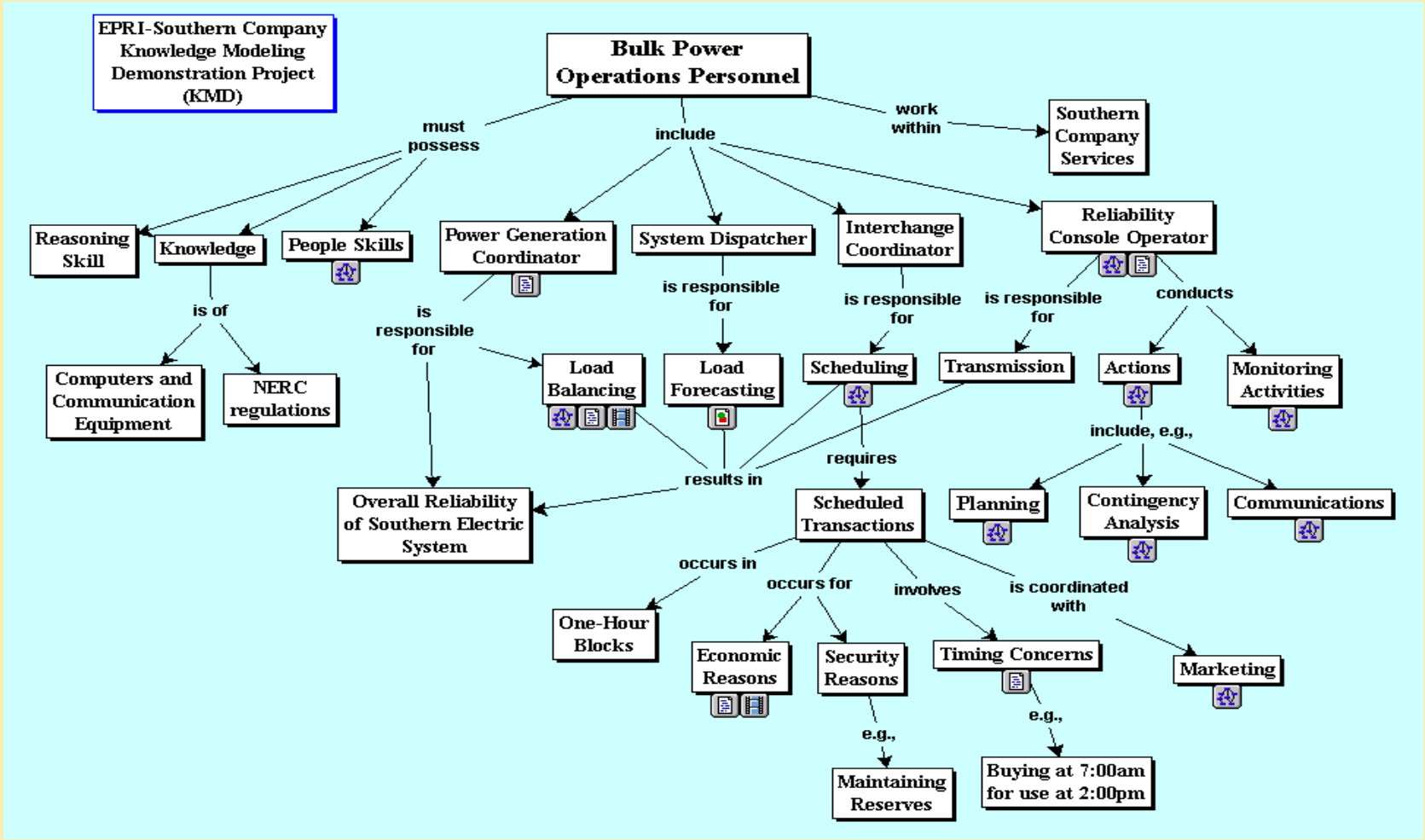
The Veterinary School faculty built this concept map to guide them in building a revised curriculum



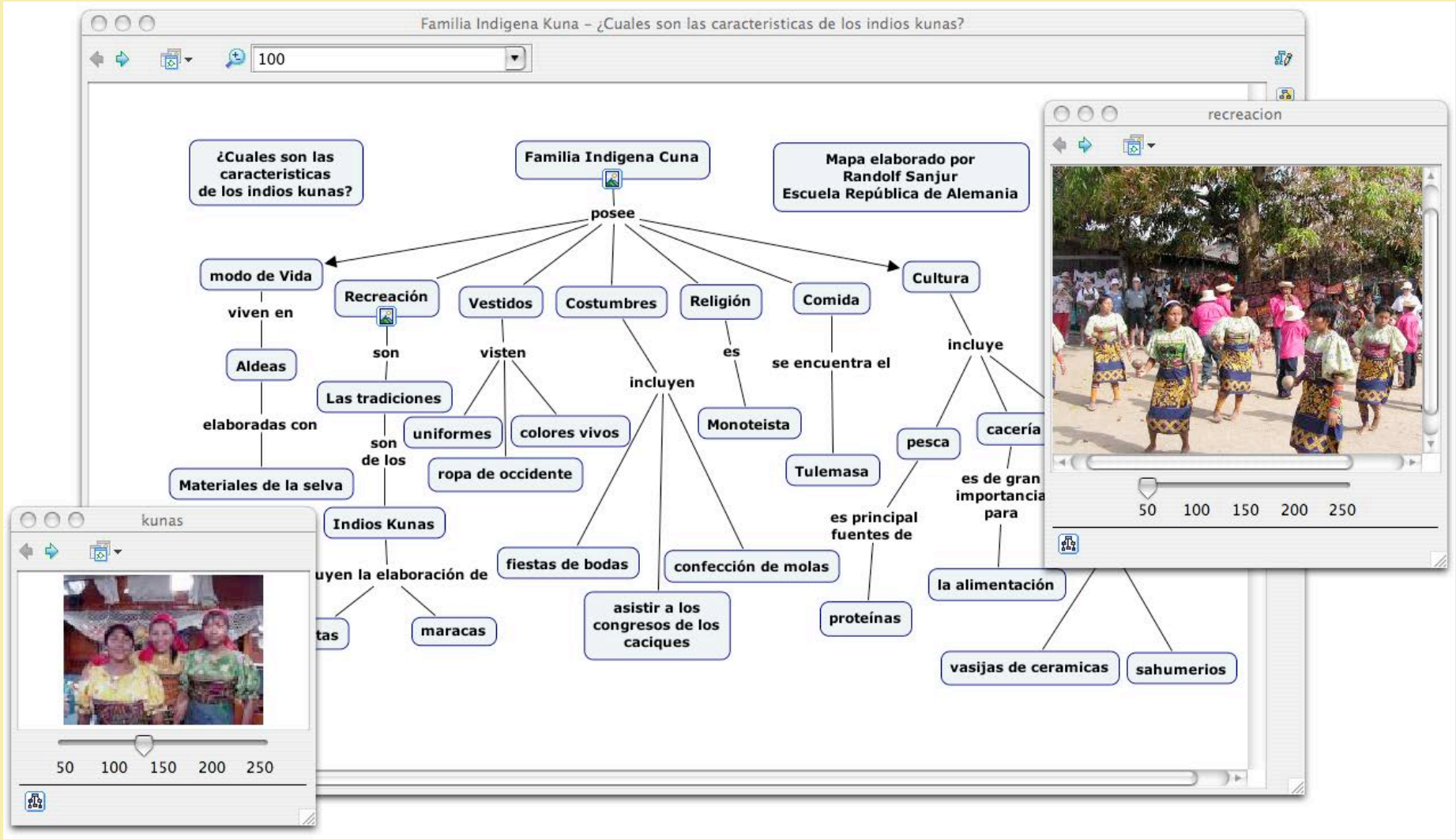
Using CmapTools, we found we could train team members to elicit and capture expert's knowledge in two days



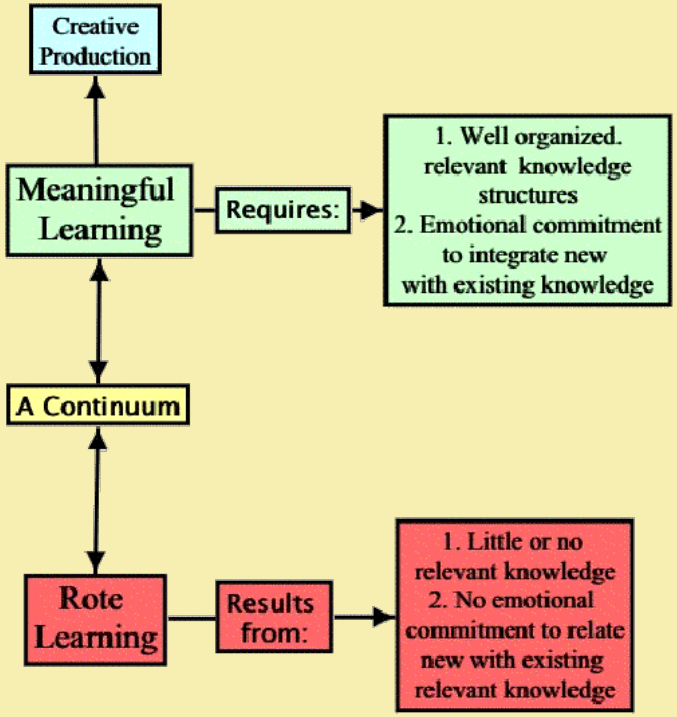
This is one example of a concept map derived from interviewing an expert in bulk electric power management. Icons on concepts access other digital resources



This concept map was prepared by 5th grade students in Panama. Attached to concepts on this Cmap were clips from two videos made by the students. Other resources were also attached.



By 1987 I argued for:
Human Constructivism:
Humans create new knowledge by using high levels of meaningful learning



In 1990 Alan McAdams and I began teaching Ausubel's theory and ideas and tools to facilitate meaningful learning to Students in the Johnson Graduate School of Management at Cornell University.

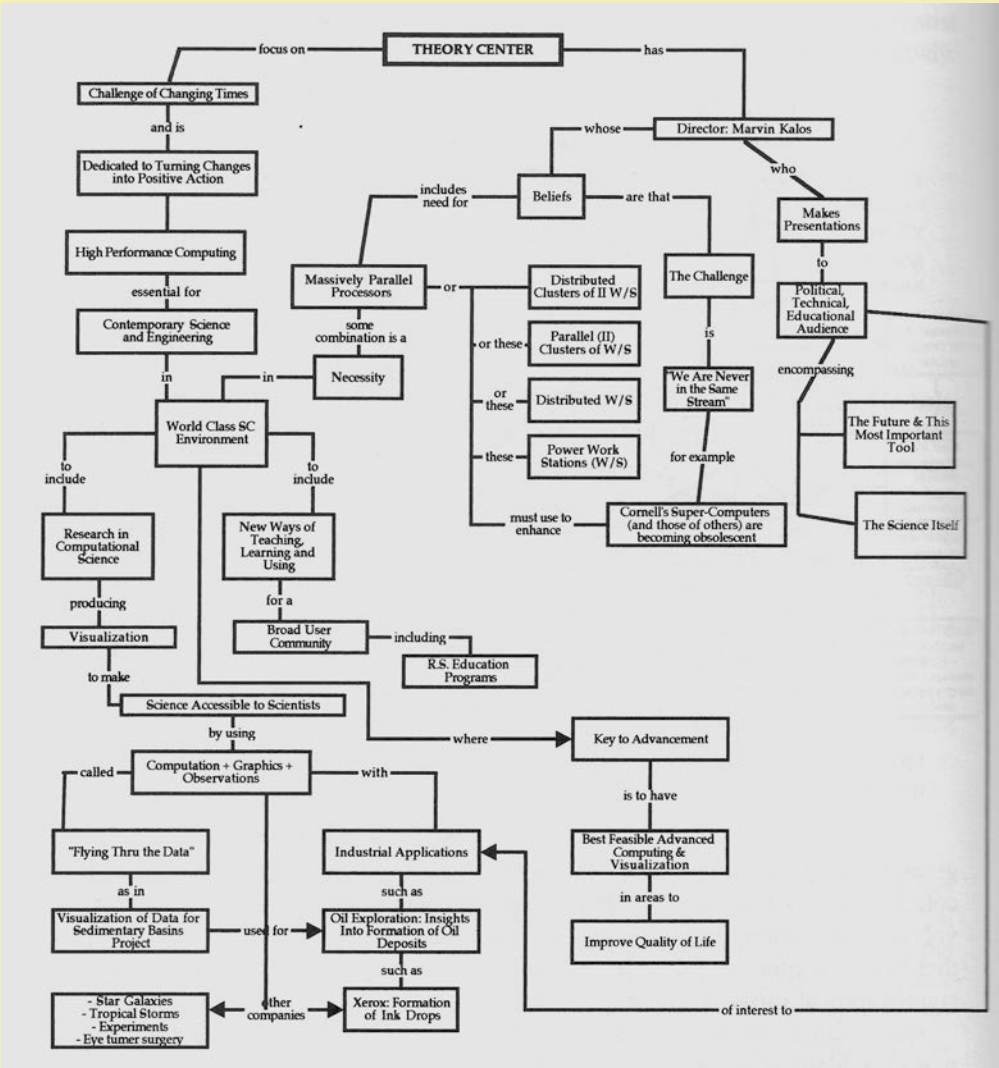
Professor Alan McAdams

After basic instruction in learning theory, interviewing, and concept mapping, teams of two to four students interviewed upper management persons in selected businesses, and then concept mapped the interviews.

Professor Alan McAdams

A 3-member team interviewed all senior staff of the Cornell University Theory Center.

They found great differences in staff's views on the Center's mission.



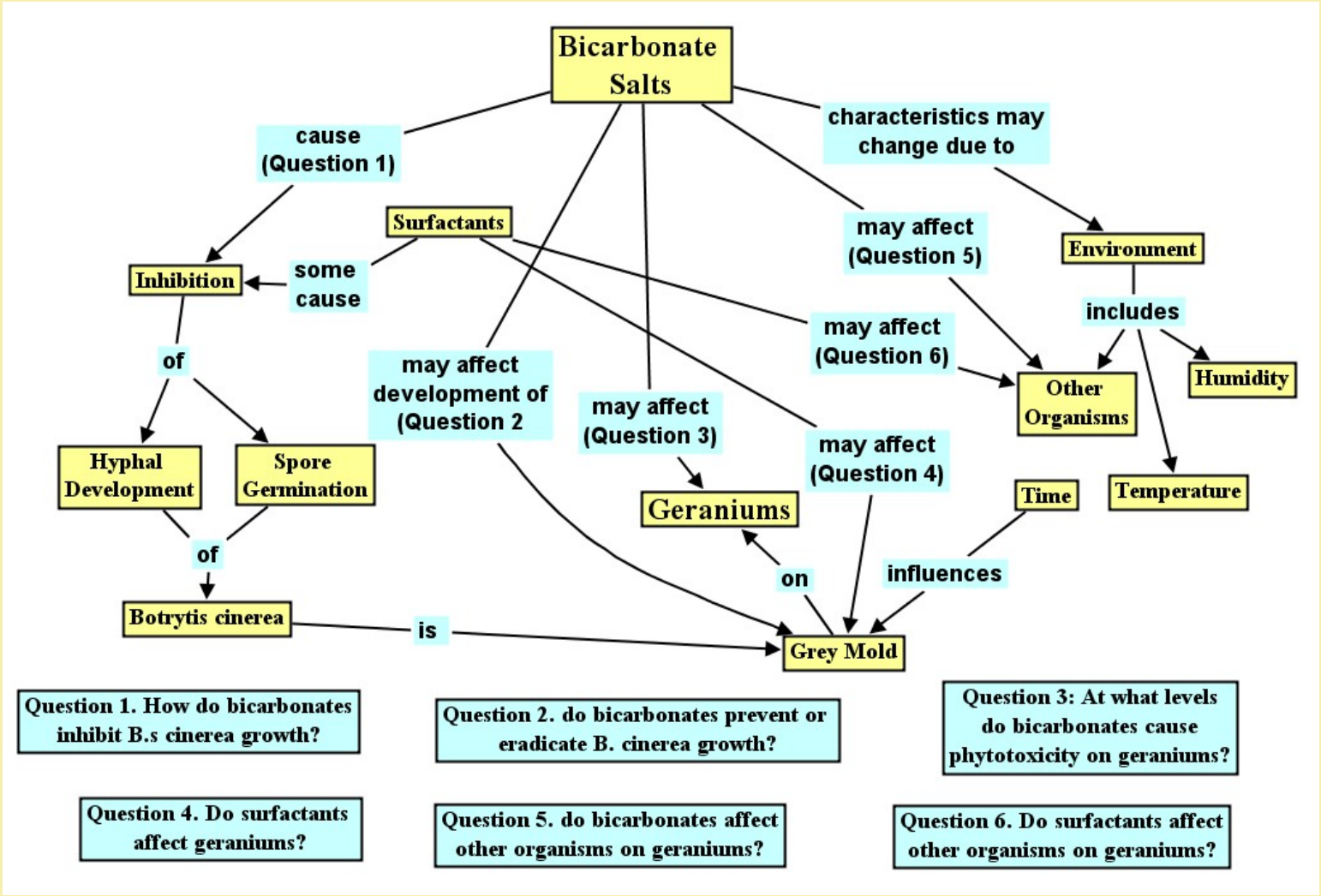
Concept map of Cornell Theory Center organization

Kodak Company in Rochester, New York was one of the first companies our class worked with.

Kodak

Using concept maps of interviews with managers, we were able to demonstrate to Vice President Verne Dyke that there were communications problems in his organization.

One of my students used concept maps to summarize her literature search and found 6 unanswered questions. These became her PhD thesis questions.



After open heart surgery in 1994 Joan asked if I could retire so we could spend winters in Florida where it is warm, flat and sea level?

Joan has been my best critic, a great mother and my joy in life!

Beautiful as Ithaca is in summer, winters can be very cold, icy, and physically challenging.
I resigned from my position at Cornell in 1995.

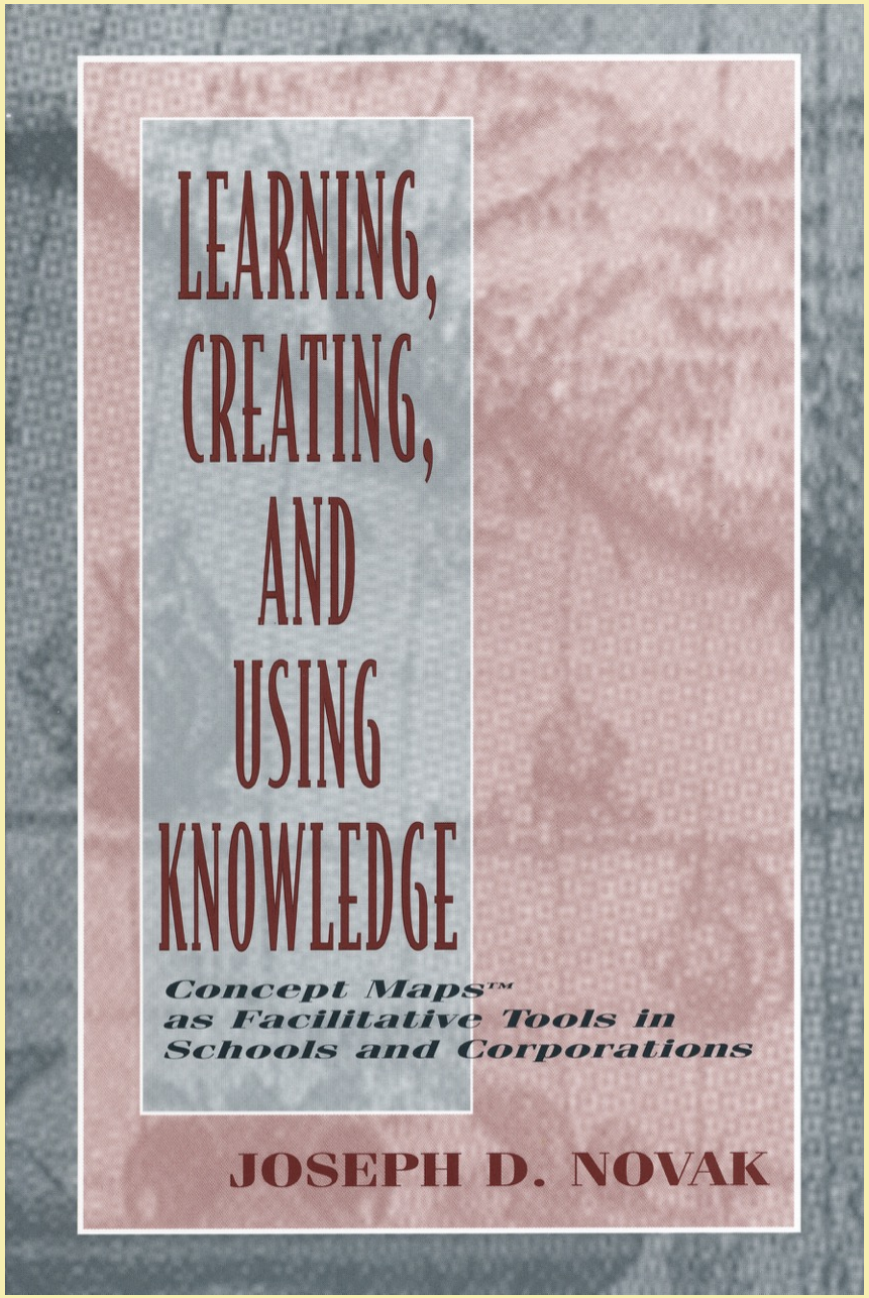
I had been consulting with Larry Huston, Vice President for knowledge and Innovation, at the old headquarters at Ivorydale in Cincinnati, Ohio. Huston wanted more of my time.

Having served as Professor at Cornell University for 28 years, I was eligible for full retirement. I decided to try full time consulting with Procter and Gamble and other organizations' 1995.

Larry Huston, VP for
Knowledge and Innovation
at Procter and Gamble

Retirement gave me more time to write and I completed an update of my Theory of Education in 1998.

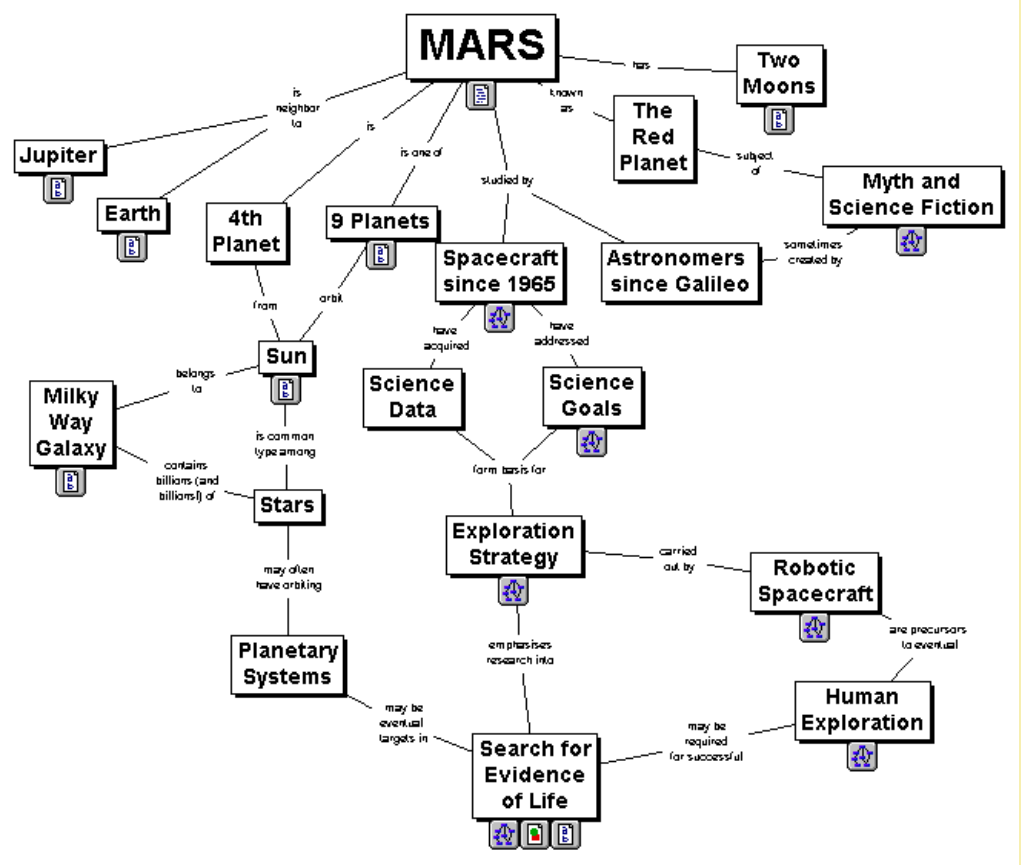
This book also included more of my experiences applying my ideas in corporations and other organizations.



I also had more time and joined IHMC to work on projects with NASA, Navy, National Security Administration, Electric Power Research Institute and other organizations

One of the projects done with NASA to explored the feasibility of manned exploration of Mars.

Various digital resources were attached to concepts in this map.



With added improvements in CmapTools, it became possible to propose in 2004, with Alberto Cañas, a

New Model for Education

The New Model has three features:

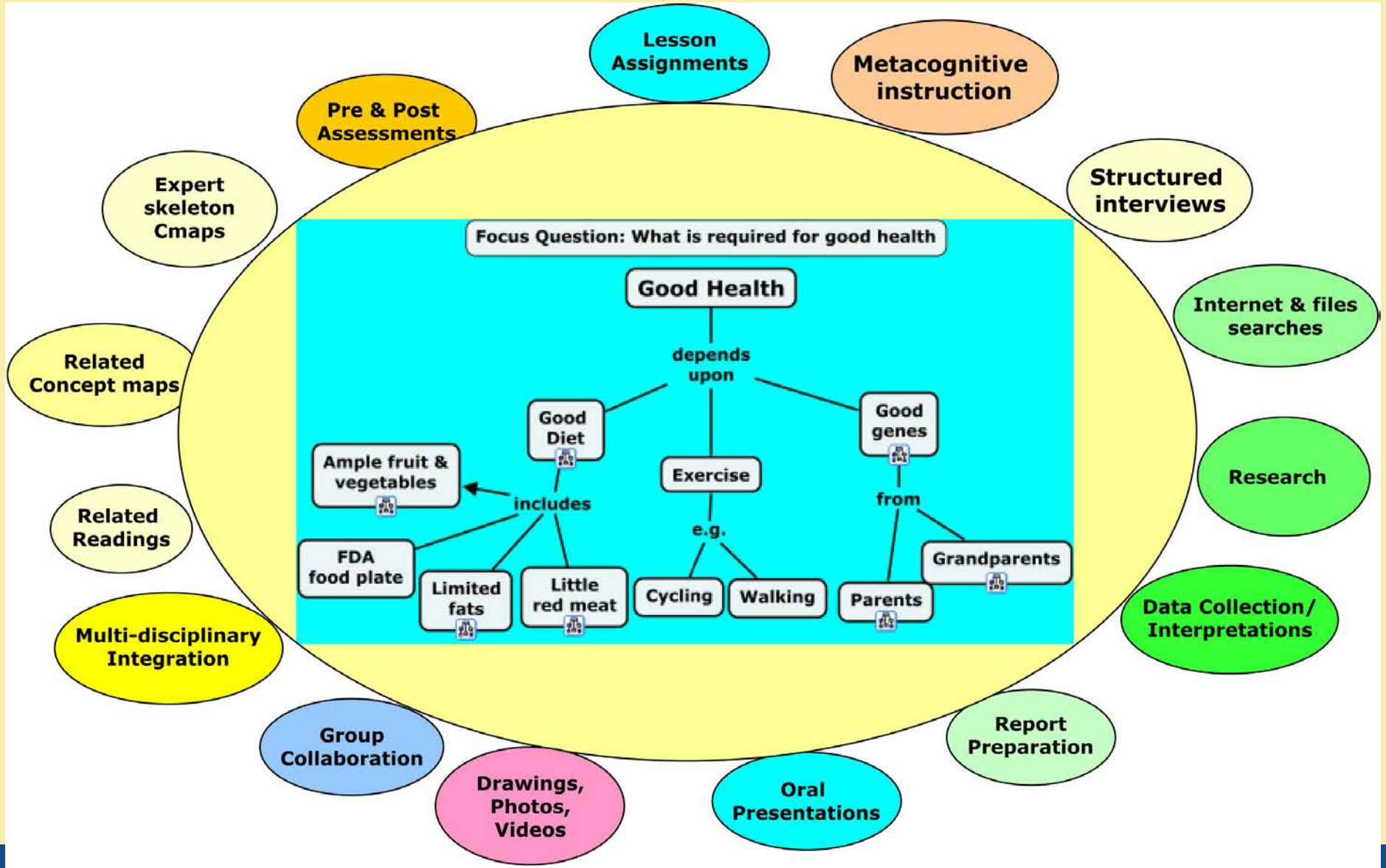
1.(optionally) Begin with an “Expert Skeleton “ concept map, to assure student team begin with a valid start, or begin with a map of student’s initial’s understanding

2.Iteratively work on the topic, investigating and adding digital resources to the map using the internet and other sources of information.

3.Prepare summary reports and make written and/or oral presentations.

The “New Model” has students working in teams and utilizes all forms of instruction to build a “Knowledge Model” for the topic of study

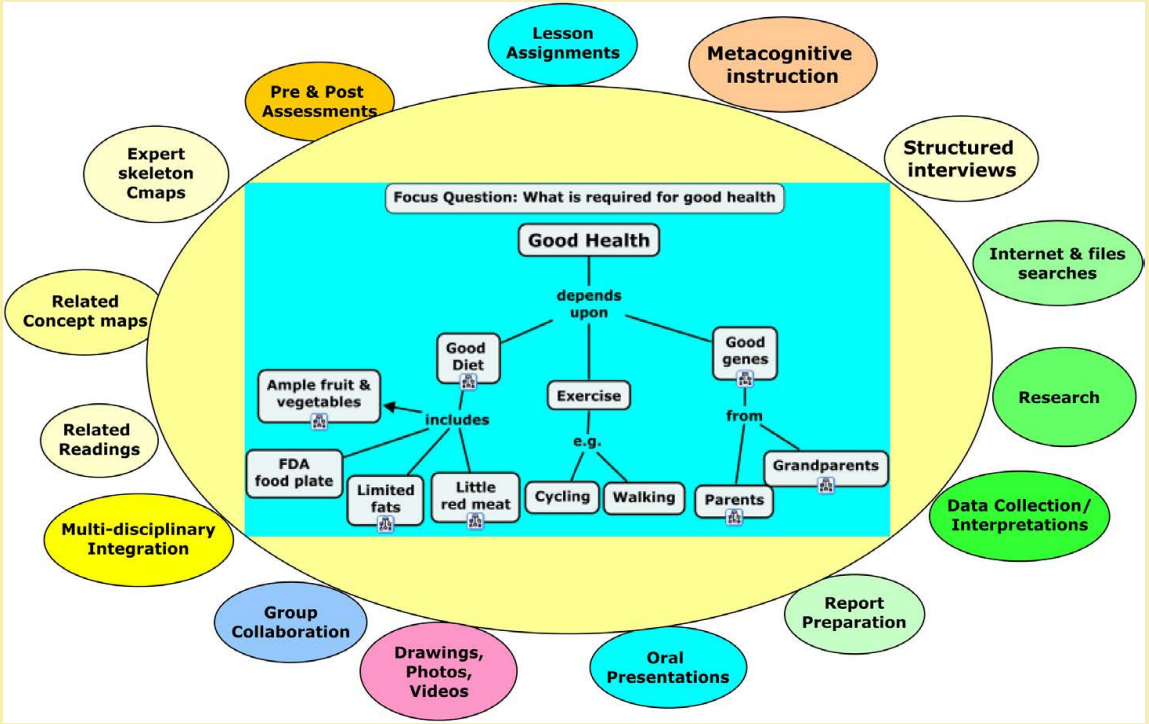
Using strategies indicated in small ovals, the study team adds concepts and digital resources



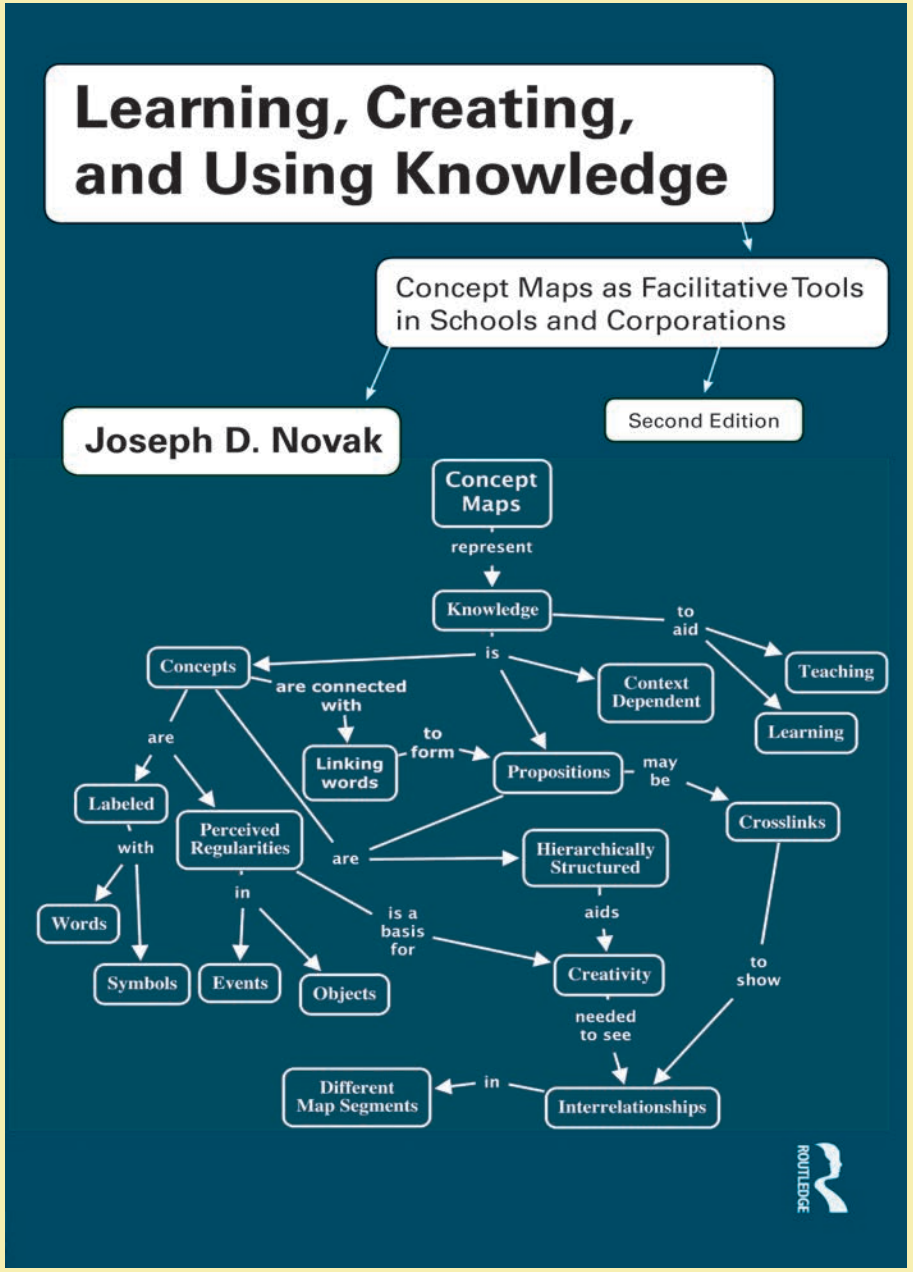
Using the New Model, the classroom becomes a learning center with computers and project work areas for team research activities

Teacher's role changes from information provider to coach and facilitator of team researches.

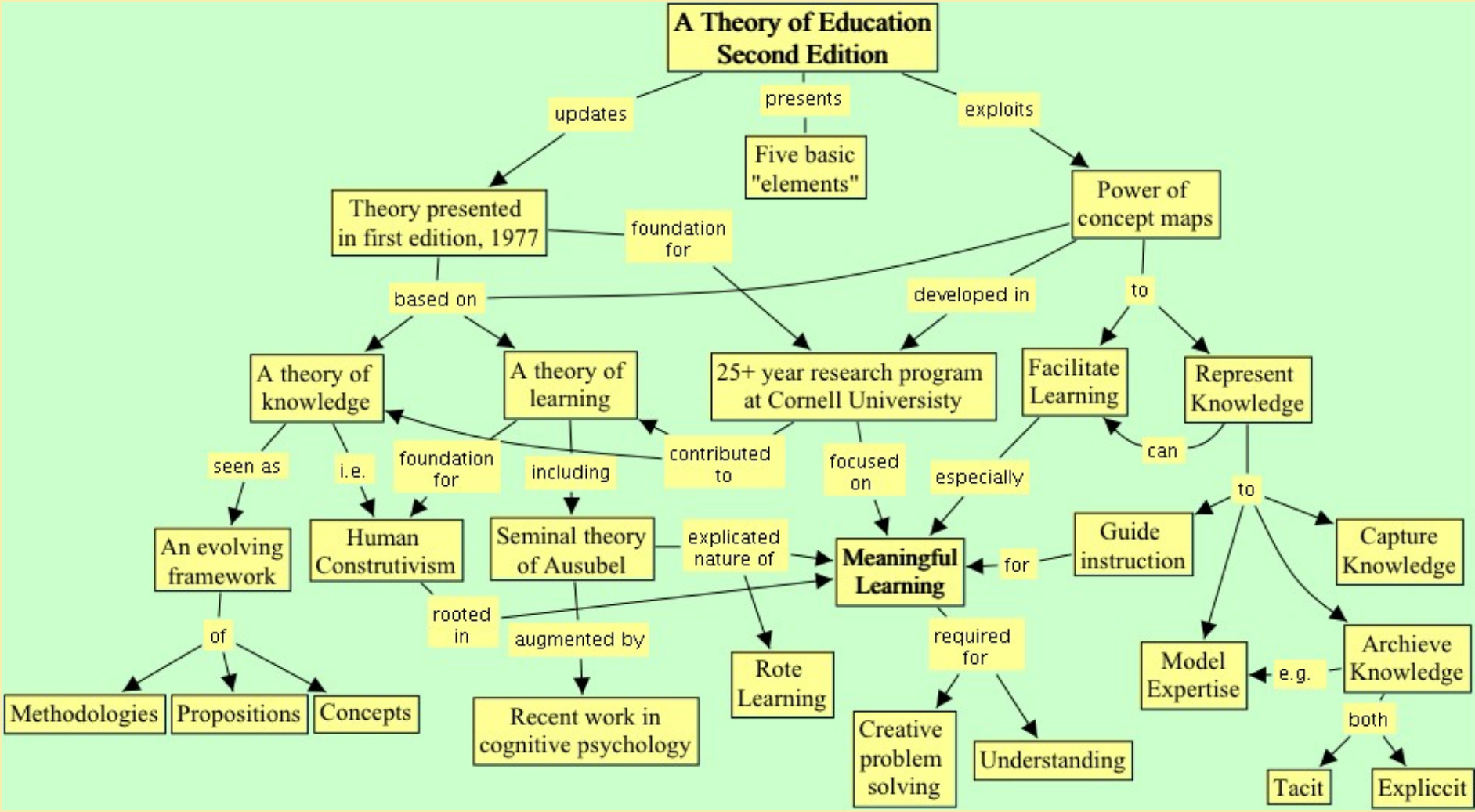
Both students and teachers participant in evaluating projects



The 2nd edition
of this book expands
on the ideas presented
and also presents
my Theory of Education
and a New Model
for Education
(Routledge, 2010)



My 2010 book further updates my Theory of Education



Meaningful Learning is a profound concept and it takes years to understand it deeply. Then one sees that this is true:

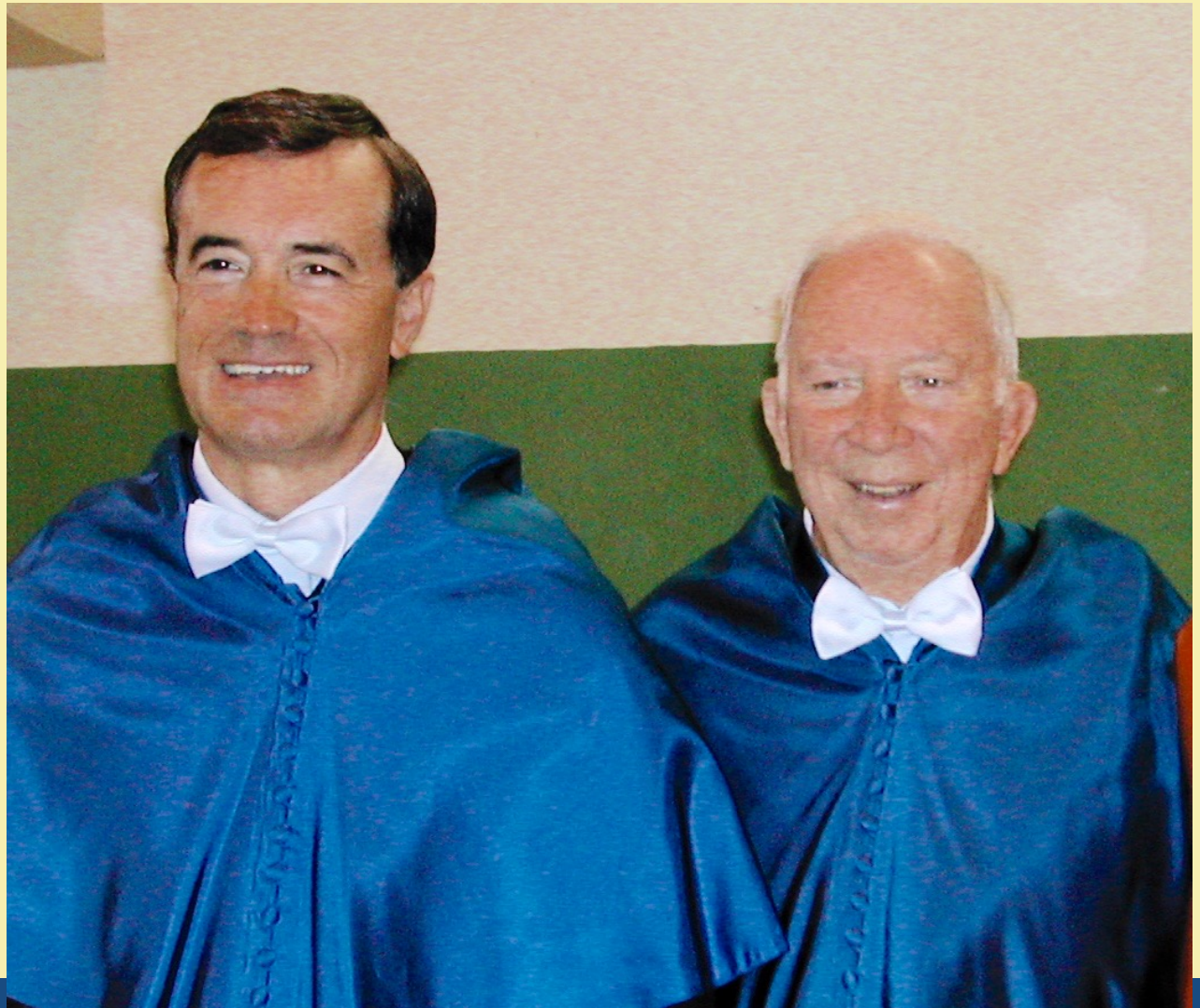
A Theory of Education

Meaningful Learning underlies the constructive integration of thinking, feeling, and acting leading to empowerment for commitment and responsibility.

J. Novak

Ricardo Chrobak was one of more than 350 graduate students and visiting professors who studied with me over the years. He was instrumental in arranging for a series of workshops and lecture in Argentina in 1998, and also for an Honoray Doctorate I received from his university in 1998.

Fermin Gonzales, a visiting professor from Spain, was instrumental in arranging for an Honorary Doctorate at his University in Pamplona Spain.

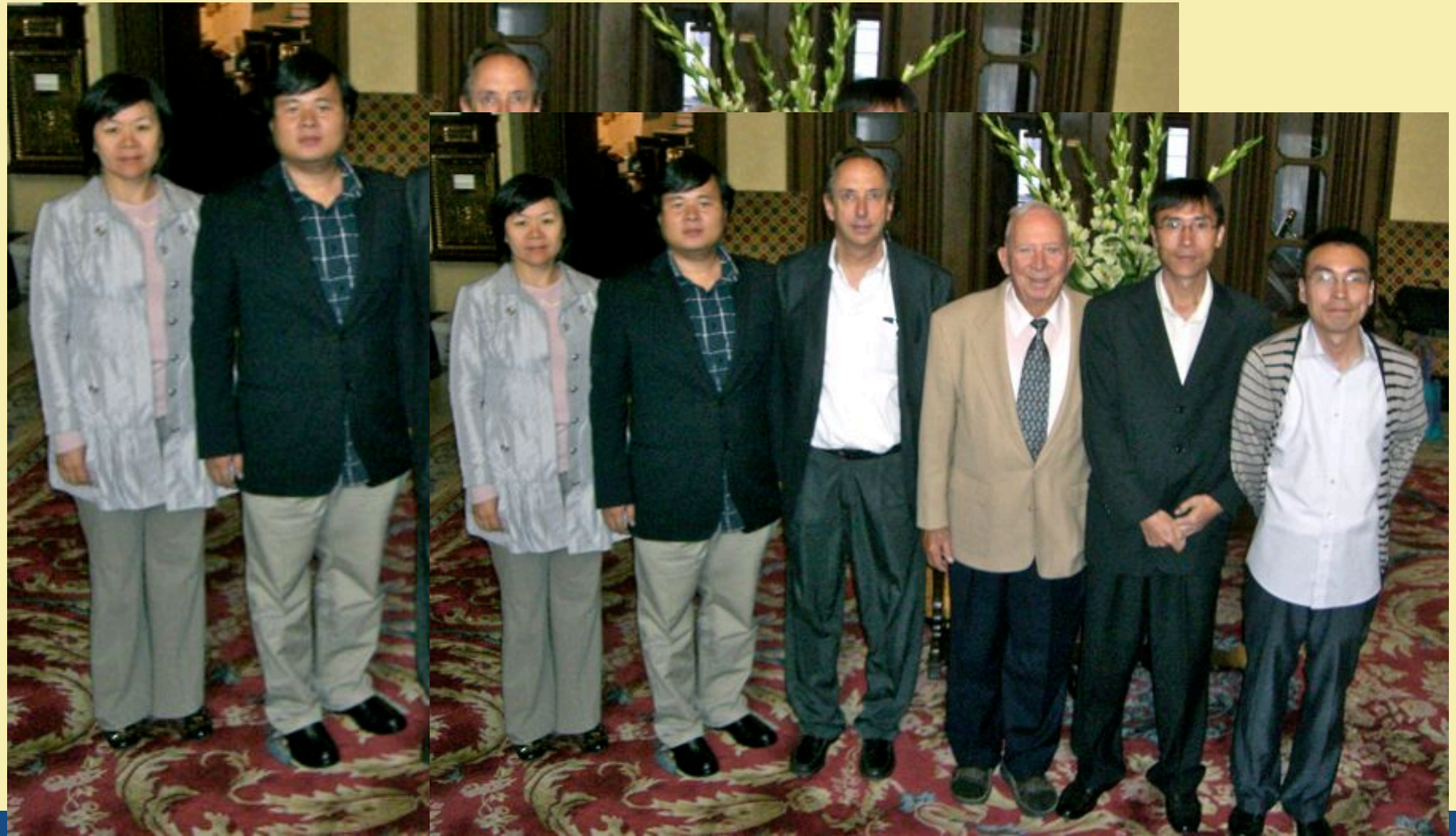


I have received Honorary Doctoral Degrees from universities in Argentina (1998), Spain (2002, shown below) and Italy (2006)

Currently I am working with a team, led by Professor Jinshan Wu and colleagues at the Beijing Normal University to implement the tools and ideas created in the last half-century by my teams.

Jinshan Wu and I at August workshop

Alberto Cañas and I (center) and the team from Beijing Normal University at a four-day workshop held in Cleveland, Ohio, 2013.



Thank You