Organized to improve science teaching—through research

NARST NEWS

NATIONAL ASSOCIATION FOR RESEARCH IN SCIENCE TEACHING

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Thaddeus W. Fowler, Editor

PRESIDENT

Linda R. DeTure
Education/Human Development
Rollins College, Winter Park, FL

Strategic Planning

Greetings. Hope your summer has been a time for relaxation and rejuvenation. As we direct our energies toward fall, it is time to focus on the business and direction of NARST, perhaps with some strategic planning in mind.

At the NSTA Board Meeting in Vail, CO, one of the nation's lovlier spots, the affiliate presidents met with NSTA officers to begin to explore those relationships. As a result, an ad hoc committee was formed to study the NSTA-affiliate relations and to establish guidelines for policy. The results will be presented to the affiliate boards (AETS, CESI, CSSS, NARST, NSSA, SCST) in the fall and to the NSTA Board in the winter. Membership input for the committee would be most welcome.

Partly because of the national attention on the state of science education, congress has mandated several studies. One of those, from the Office of Technology Assessment, has asked for direct participation from NARST members. I urged your cooperation in a letter earlier this summer. Because of the policy implications, please take the time to respond to the questionaire and return it to Richard Davies.

A second congressionally mandated study examined problems and opportunities in science education that might be influenced by NSF policy and initiatives. Although science education organizations did not directly participate, we do have the opportunity to react before congressional hearings convene in the spring. A study group of which I was a part recommended that the document "Opportunities for Strategic Investment in K-12 Science Education" and a questionaire, be mailed out to the membership of NSTA and each of the affiliate organizations. When you receive it, in newsprint form, please make note in your comments of what is missing as well as what is present.

As one last request, I would like to ask you to be thinking about he purpose of NARST and the role of research as it relates to classroom practice. It is an issue I would like the membership to address later this year.

Among other things this summer, I have moved. Should you be unable to reach me at the office, my new address and telephone number are: 950 Live Oak Street, Maitland, FL 32751; 305-539-0033. It is a privilege for me to act as your president and to represent NARST. Please keep me informed of your needs and wishes.

1988 NARST ANNUAL MEETING

The 1988 annual meeting of the National Association for Research in Science Teaching will be held April 10 through April 13 (noon), 1988 at the Lodge of the Four Seasons, Lake Ozark, Missouri. The NARST meeting will follow the National Science Teachers Association meeting in St. Louis.

As in previous years, NARST members will be able to travel to and from the meeting by chartered bus. Glenn Markle is making arrangements for the bus transportation. NARST members may also drive to Lake Ozark or may fly from the St. Louis airport on Trans World Express to the Lee C. Fine airport where a van from the Lodge will meet them.

The Lodge of the Four Seasons comes equipped with golf courses, indoor and outdoor swimming, indoor racquetball courts, and other opportunities for activities in addition to those planned by the NARST Program Committee.

Tentative Program

Sunday, April 10

12:30-5PM	Board luncheon and meeting
2PM-5PM	Training sessions
5PM-7PM	Dinner (on your own)
7:30PM-9PM	General Session
9:30PM-11PM	Reception for NARST members

continued

Monday, April 11

8:30AM-10AM	Concurrent Sessions
10AM	Coffee break
10:30AM-12 Noon	Concurrent Sessions
12Noon-2PM	Lunch (on your own)
2PM-4PM	General Session
5:30PM-7:30PM	Dinner (on your own)
7:30PM-10PM	Networking Sessions

(NARST standing committees will hold breakfast meetings on either Monday or Tuesday mornings from 7:30-8:30 A.M. Committee chairs will be provided with details concerning these meetings.)

Tuesday, April 12

8:30AM-10AM	Concurrent Sessions
10AM	Coffee break
10:30AM-12Noon	Concurrent Sessions
12Noon-2PM	Awards Luncheon
2:30PM-4PM	Concurrent Sessions
4:15PM-5:45PM	Concurrent Sessions
6PM	Board Meeting and Dinner
6PM-7:30PM	Dinner (on your own)
7:30PM-??	Continuation of networking activities or recreation

Wednesday, April 13

8AM-9:30AM	Concurrent Sessions
9:45AM-11AM	Concurrent Sessions
11AM-12Noon	Business Meeting
12Noon	Checkout

Networking Sessions

Frequently science education researchers express the need for individuals, at different institutions, with common research interests to collaborate on research questions. During the 1988 NARST annual meeting there will be opportunities for such activities to begin. Several NARST members have been asked to convene discussion groups on Monday evening. This is also a call for other NARST members to suggest additional areas for collaborative research that might be convened on Tuesday evening. If you are interested in serving as a convener for a research area, please send me a description of the research topic so that sessions can be organized for Tuesday evening. If you cannot serve as a convener, please suggest an individual who might serve and include his/her address and phone number.

The Monday evening groups are as follows:

1) Constructivist Research: John R. Staver and Anton E. Lawson, conveners

The focal points of discussion in this group will be constructivist models of knowledge acquisition, and what research based on such models says about improving teaching and learning in science. The co-conveners, John R. Staver and Anton E. Lawson, have conducted extensive research based on a Piagetian constructivist model. Their research has included studies on the methods and formats of reasoning assessment, the effects of a variety of cognitive variables on reasoning development and concept acquisition, analyses of students' problem solving, the effects of inquiry methods, particularly the learning cycle, on reasoning development and concept acquisition, and the explication of a neurological model of knowledge construction as well as a theory of instruction based on constructivist principles.

NARST members interested in participating in this group may wish to contact the conveners prior to the April meeting to suggest activities for the session. They should write or telephone either:

John R. Staver
College of Education
Box 4348
The University of
Illinois at Chicago
Chicago, IL 60680
(312) 413-2406

Anton E. Lawson
Dept. of Zoology
Arizona State
University
Tempe, AZ 85287
(602) 965-2540

2) Science-Technology-Society Research: Peter A. Rubba, convener

Individuals in attendance at the 1988 NARST meeting at the Lake of the Ozarks who have an interest in STS education are invited to join an informal discussion on the directions precollege STS education research might take in the coming years. The discussion will focus on research needs in STS education at the precollege level.

NARST members may want to contact the convener prior to the April meeting. They should write or telephone:

Peter A. Rubba
Chambers Building
The Pennsylvania State University
University Park, PA 16802
(814) 865-2161

3) Misconceptions Research: Joseph D. Novak, convener

Whether one calls them misconceptions, preconceptions, naive theories, or alternative frameworks, science education researchers are beginning to get a clear understanding of the problems involved. Misconceptions appear to be stable, hard to move. Different approaches will be discussed and issues considered.

continued

NARST members may want to make contact with the convener to suggest specific activities and issues for discussion. Write or telephone:

Joseph D. Novak
404 Roberts Hall
Cornell University
Ithaca, NY 14853
(607) 255-2267

4) Research on Memory Systems: Marianne Betkouski Barnes, convener

The science education community would benefit from a three-step, research-based model that would allow science education researchers, in the final step, to make recommendations to classroom teachers. The first step is to establish an inter-disciplinary approach to research on how the brain and mind learn and remember. By collecting and consolidating available data and engaging in dialogue with researchers in other fields, we can determine what data are pertinent to educational needs. Only then will we be able to approach the second step, the planning of education research based on comprehensive theory. These research results can then lead to the third step, the outlining of actual classroom implications. All three steps must be dynamic and open to new findings.

NARST members interested in participating in this group may wish to contact the convener to suggest specific topics for consideration or other items. Write or telephone.

Marianne Bethkouski Barnes
University of North Florida
College of Education and Human Services
4567 St. Johns Bluff Road, S.
Jacksonville, FL 32216
(904) 646-2578

5) The Use of Computers in Science Education: Gerald Abegg, convener

NARST members who are interested in participating in a sharing session on using computers in research in science education are invited to bring their ideas, software, and related materials.

Additional information may be discussed with the convener. Write or telephone:

Gerald Abegg
Science Education
Boston University
605 Commonwealth Ave.
Boston, MA 02215
(617) 353-4259

6) International Science Education Research: Arthur L. White, convener

NARST members who are interested in conducting, or who are interested in collaborating in, research efforts in countries other than the United States are invited to attend this session.

For more details, write or telephone:

Arthur L. White
Science Education
The Ohio State University
1945 North High St.
Columbus, OH 43210
(614) 292-4121

7) Ethnographic or Naturalistic Research in Science Classrooms: Kenneth Tobin and James J. Gallagher, co-conveners

No descriptive paragraph was received by the time this material had to go to press for the NARST newsletter, but the group is scheduled to meet. Check the next issue of the NARST newsletter for more information.

The form the networking activities will take will depend on the people who participate in the discussion groups. The NARST newsletter is available as a forum for communication. Perhaps some groups will be able to work out an electronic mail system for sharing ideas and information.

NARST members with suggestions for additional topics for networking activities should send their suggestions to:

Patricia E. Blosser
1988 NARST Program Chair
ERIC Clearinghouse for Science, Mathematics and Environmental Education
1200 Chambers Road
Columbus, OH 43212,

no late than October 31, 1987.

Please plan your schedule of activities for this coming spring to include attendance at the 1988 NARST meeting!

Nominations Requested

Distinguished Contributions to Science Education Research Award

The National Association for Research in Science Teaching seeks to improve Science Education through research. To this end the Association desires to recognize and reward individual(s) who have made significant contributions to Science Education through research. Contributions may be of several types, including but not limited to empirical, philosophical or historical research, evaluative studies, policy related research and

continued

studies reflecting new techniques to be applied in research. To be considered, an individual should have contributed over a period of many years (at least 15) and should be considered at the pinnacle of his/her career.

The award will be made to an individual who has over a period of many years (at least 15):

1. made a continuing contribution(s) to Science Education through research;
2. provided notable leadership in Science Education through research; and
3. had a substantial impact on Science Education through research.

This award is intended to be the highest recognition NARST can bestow for contributions to Science Education through research. The award will be bestowed only when a superior candidate has been identified by the awards committee.

To apply, a nominator or candidate should submit 10 copies of the following **by January 15, 1988**:

1. a cover letter, not to exceed 5 pages in length, describing the nature of the contributions of the individual, including specific documentation as to why these contributions are considered outstanding and substantive;
2. up to five letters of support, each not to exceed two pages in length, which provide evidence of extraordinary contributions of the individual; and
3. a curriculum vita including a complete list of publications and accomplishments.

Dr. Michael J. Padilla, Chairperson
NARST Awards Committee
Department of Science Education
University of Georgia
Athens, GA 30602

PRESIDERS, DISCUSSANTS WANTED

NARST members who are willing to serve as presiders or discussants for concurrent sessions of the 1988 annual meeting, to be held April 10-13, 1988 at the Lodge of the Four Seasons, Lake Ozark, MO. are requested to write

Patricia E. Blosser
1988 NARST Program Chair
ERIC Clearinghouse for Science, Mathematics and Environmental Education
1200 Chambers Road
Columbus, Ohio 43212

and let her know of their willingness to participate. If there is some specific research area in which a member feels more competent to serve as a discussant than in other areas, he/she should specify this. It is the intent of the 1988 NARST Program Committee that all concurrent sessions should have a discussant for the 1988 meeting.

Submissions Invited —

1987 NARST Outstanding Paper Award
1987 NARST Practical Application Award

Each year at the annual meeting of the Association the NARST Awards Committee identifies persons to be recognized by the organization whose papers, presented at the meeting of the preceding year, are judged to be outstanding in one of each of two areas:

Contributions to science education research and
Practical applications of research to classroom practice.

The NARST Awards Committee invites all persons who presented papers at the 1987 meeting in Washington, D.C. to submit copies of the complete paper and abstract for consideration for the Outstanding Paper Award or for the Practical Application Award. These awards will be presented at the next NARST meeting in St. Louis.

The papers in each category will be judged on (1) significance of the problem investigated, (2) conceptual background, (3) research approach, (4) methodology, (5) significance of outcomes, (6) conclusions, (7) communication of information, and (8) overall uniqueness. Additionally, the papers submitted for the Practical Applications Award will be judged on (9) evidence of practical applications for practitioners.

Please send, **by September 15, 1987**, the ten (10) copies of your paper and abstract (a copy of the abstract needs to accompany each copy of the paper), a cover sheet of information including:

Name
Address with zip code
Telephone numbers
Request for review for the Outstanding Paper Award
or
Practical Application Award

and a self-addressed post card (which will be returned to you upon receipt of your materials) to:

Fred N. Finley
370 Peik Hall
159 Pillsbury Drive, S.E.
University of Minnesota
Minneapolis, MN 55455

NARST
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Research Matters . . . To the Science Teacher

DEFINITION AND ASSESSMENT OF THE HIGHER-ORDER COGNITIVE SKILLS

Audrey B. Champagne

Imagine glass cylinders containing different quantities of sand. Students are supplied with three cylinders, one of which is completely filled with sand, and an inclined board. They are encouraged to observe the motion of the cylinders as they roll down the incline. Then students are shown a fourth cylinder and asked to predict how that cylinder will roll down the incline. How would your students respond to this exercise? What evidence would convince you that a student had used a higher-order cognitive skill? Suppose your colleagues are also observing the exercise. Will they agree with your interpretations of the students' behavior? My experience suggests that you and your colleagues will probably not agree. However, this is an empirical question—if you doubt my premise, try the experiment. The exact manipulative exercise is not important, but having the students *and* some colleagues participate is crucial.

Observers interpret performance on tests of the higher-order cognitive skills differently because there are no agreed-upon operational definitions of this skills. Developing such definitions is difficult, because our understanding of the skills is limited. For example, we know very little about the relationships between the higher-order skills and the lower-orderdskills. Improved instruction and assessment of higher-order cognitive skills is contingent on developing operational definitions of those skills. This is the aim of this paper.

How are lower-order skills distinguished from higher-order skills?

- Are the two levels distinguished by age? Do children, by definition, engage only in lower-order thinking and adults engage only in higher-order thinking?
- Are the two levels distinguished by the frequency with which we observe them in the population? Are higher-order skills by definition rarer than lower-order ones?
- Is content the distinguishing characteristic? Are higher-order skills only exhibited in the context of a formal discipline—mathematics, physics, economics—or can they be exhibited in practical situations such as automobile repair or dressmaking?
- Are definitions of higher-order skills idiosyncratic—that is, does an observer categorize a skill as higher-order if it produces a solution to a problem that the observer could not do?

If you accept the assertion that operationally defining the higher-order thinking skills is difficult but potentially useful; then, you might try collecting and categorizing cognitive skills like naturalists collect and categorize plant and animal specimens. You can collect samples from practitioner journals, research journals in science education and the cognitive sciences, teachers' manuals for science textbooks, curriculum guides, and technical manuals for standardized science tests. When a number of skills have been identified, it is possible to build a taxonomy for the skills.

I found such a collection and categorization activity useful in illuminating some of the uncertainties in our understanding of the higher-order cognitive skills. The ordered list of skills that I collected is displayed in Figure 1. The list is quite long, but undoubtedly incomplete. You will have little difficulty collecting new skills and adding them to my list.

Figure 1 - A Collection of Cognitive Skills

Higher-Order Cognitive Skills
Lower-Order (Algorithmic)
Generic
  Metacognitive
    Assess Understanding
    Assess Validity of Generalizations
    Test Facts Against Rules of Evidence
  Reasoning
    Logical
      Inductive
      Deductive
    Analogical
    Creative
    Verbal
    Spatial
    Qualitative
    Quantitative
Discipline (Content) Specific
Task Specific
  Problem Solving
    Patterns of Knowledge
      Generic Problem Schemata
        Rate
        Limit
        Proportion/Ratio
      Discipline
        Formulas
        Algorithms
        Facts
        Rules
    Procedural Skills
      Heuristics (Strategic Knowledge)
        Evaluate Progress
        Constraint Satisfaction
        Progressive Refinement
        Means-ends Analysis
        Setting Goals
        Monitoring Progress
        Making and Adapting Plans
        Problem Decomposition
        Problem Decontextualization
        Elaboration
      Reasoning (Rule Based Information Processing)
Inquiry
  Generic
  Discipline Specific
    Scientific
      Discipline Knowledge
      Procedural Knowledge (Conducting an Inquiry)
        Planning and Implementing an Investigation
          Problem Definition
          Hypothesis Generation
          Apparatus Selection
          Observation
          Data Management and Analysis
            Identify Patterns
            Graphing
          Extrapolation
          Generalization
          Modeling Mathematical
Learning

The first sort in my taxonomy produces two categories of cognitive skills, higher-order and lower-order. Leaving aside for the moment which skills belong in which category, and which criteria influence this decision, the relationship between the higher- and lower-order

skills is an issue central to the practice of science teaching and to theory in psychology. Are the higher-order skills simple concatenations of lower-order ones or are the two kinds of skills qualitatively different? Your answer to this question will profoundly effect the way you teach these skills. If you believe that higher-order skills are concatenations of the lower ones, your teaching strategy will probably be based on analysis of higher-order skills that breaks into simpler skills. Each of the simpler skills is then taught. The assumption underlying this strategy is that when the individual skills are all learned, the higher-order ones will be also. This basic idea of building skills from the bottom up pervades our educational practice and was the theoretical basis for the instructional model used in *Science: A Process Approach* (SAPA).

If, on the other hand, you believe that higher-order cognitive skills are qualitatively different from concatenations of lower-order ones, your instruction will probably be more like that used in the Elementary Science Study (ESS) materials. The assumption underlying the instructional model used in the ESS materials, is that the higher-order skills develop as the result of understanding related phenomenon.

My taxonomy proceeds to sort the higher-order skills into three categories: problem solving, learning, and inquiry (See Figure 2). There are other ways in which they can be sorted, such as according to the kind of cognitive task, they might have been sorted according to the discipline or context in which the skills are demonstrated. The result of a discipline-based sort is illustrated in Figure 3. These sorts produce different categories and illuminate another important issue that has both practical and theoretical importance: Are the higher-order skills task or discipline specific?

Figure 2 - Higher-Order Cognitive Skills Sorted According to Task

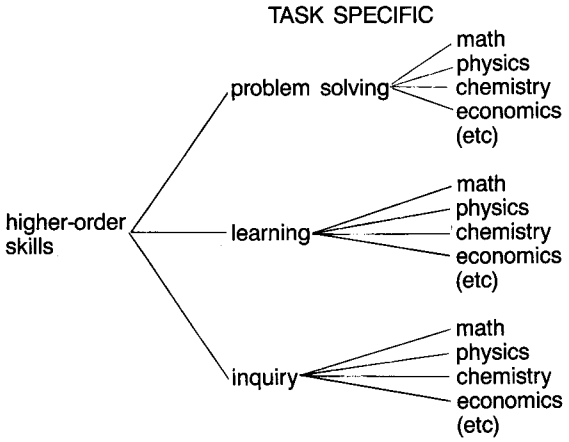
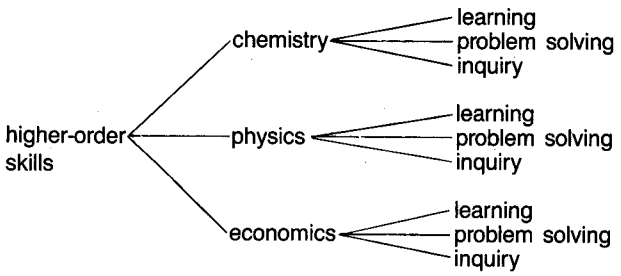


Figure 3 - Higher-Order Cognitive Skills Sorted According to Discipline



This question is the subject of major research efforts in cognitive psychology. The goal of this research is to understand the relationship between knowledge about a discipline and performance of problem solving, learning, and inquiry skills in the context of the discipline. The current research in cognitive science implicates discipline knowledge in successful performance of most higher-order thinking skills. Studies of experts' problem solving confirms the importance of discipline knowledge and illuminates important differences in the discipline knowledge 'of experts and novices.[1] Experts' knowledge is highly structured in ways that facilitate problem solution. This suggests that when students practice the solution of problems, they are not only learning how to solve the problems. They are also restructuring knowledge of the discipline in ways that will facilitate future problem solution. Problem solution serves as both a method for learning (structuring) content and a way of demonstrating understanding of the content. Another significant characteristic of experts' knowledge is that much of it is automatic. The simple formulas, algorithms, facts, and rules of the discipline are recalled and applied so rapidly that most experts do not even mention that they are using them unless specifically asked. This suggests that some memorization is in order if students are to act like experts. They just can't do problems without basic information.

Experts have another kind of knowledge that facilitates problem solution. This is knowledge about problem schemata. Upon reading a textbook problem, an expert will often identify it as a momentum problem, or a kinetic energy problem, or a mixture problem, or a rate problem. Experts categorize the problem by comparing it with problem schemata stored in their memories. No matter what the physical context described in the particular problem, the expert immediately matches it with the appropriate problem type in her repertoire of problem schemata. Having categorized the problem the expert also has available a method for solving the problem.

With all of this talk about the importance of knowledge, you might get the idea that there are no generic problem solving skills. This is not the case. Expert problem solvers also exhibit procedural skills that facilitate problem solving. Some of those skills are listed in Figure 1. Some investigators in the field call these procedural skills heuristics. Others call them strategic knowledge. The use of these different terms further confuses the distinction between knowledge and cognitive skills.

The many theoretical issues surrounding the relationship between knowledge and cognitive skills are by no means resolved. In addition, the theoretical issues have corresponding instructional ones. Do the higher-order skills transfer? In practice, that is, in teaching and testing, the skills are generally treated as if they are discipline specific. However, educators and laymen alike often talk about the skills as if they are generic. If students learn to think scientifically in science class, will they think scientifically in contexts outside science class? Popular belief aside, the mounting evidence is that students leave their scientific knowledge and thinking skills in science class and use other knowledge and skills in their encounters with the real world.

Renewed emphasis on teaching the higher-order skills requires that science teachers reconsider some basic questions about the relationship between cognitive skills and discipline learning. Are these skills best taught/learned in the context of a discipline, or in separate skill-development courses that focus on rational thinking, problem solving, inquiry, and critical or creative thinking? Do the higher-order cognitive skills transfer? If so, under what conditions? Are the sciences particularly good disciplines for learning the higher-order skills? If so, how should instruction be modified to produce better results? The answers to these questions are not at all clear.

Much of the work in cognitive psychology suggests that use of the higher-order cognitive skills is closely linked with discipline specific knowledge. This conclusion is based primarily on research on problem-solving and learning-to-learn skills. Consequently, the conclusion is limited to these specific higher-order thinking skills. The findings may be quite different for higher-order skills such as metacognition, and logical, analogical, inductive or deductive reasoning.

All of this comes back to the original point: As a community of educational practitioners and researchers, we need to be more scientific in our approach to teaching and assessing the higher-order cognitive skills. Common operational definitions for these skills are a necessary condition for more scientific teaching and research to attain the all-important goal of science education: scientific thinking in students.

Selected References

Segal, J. W., Chipman, S. F. & Glaser, R. (Eds.) (1985). *Thinking and Learning Skills. Volume I: Relating Instruction to Research.* Hillsdale, New Jersey: Lawrence Erlbaum Associates.

deBono, E. (1976). *Teaching Thinking.* London: Temple Smith.

Lockhead, J. & Clement, J. (Eds.) (1979). *Cognitive Process Instruction.* Philadelphia: Franklin Institute Press, 1979.

Linn, M. C., Pulos, S., Gans, A. (1981). Correlates of formal reasoning: Content and problem effect, *Journal of Research in Science Teaching, 18,* 435-447.

Dr. Audrey B. Champagne is a senior program analyst in the Office of Science and Technology Education of the American Association for the Advancement of Science. She is a member of the National Association of Research in Science Technology, an association dedicated to the improvement of science teaching through research.

[1]An expert in these studies is an advanced graduate student or PhD. A novice is typically a junior or senior majoring in a discipline. The problems used in these studies come from texts used in elementary or intermediate undergraduate courses.

The National Association For Research in Science Teaching is an organization that seeks to improve science teaching through research. For further information, contact the NARST Executive Secretary:

Dr. Glenn Markle
401 Teacher College
University of Cincinnati
Cincinnati, Ohio 45221

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Research Matters . . . To the Science Teacher

METACOGNITIVE STRATEGIES TO HELP STUDENTS LEARNING HOW TO LEARN

By Joseph D. Novak

Strategies to help people learn go back to our educational origins. For example, Socrates developed the technique of Socratic questioning, where he sequentially asked questions to draw out the knowledge he believed was in the minds of all persons, slave or emperor. While there is still much we do not know about learning, we know that knowledge must be acquired by the individual, and that knowledge previously learned influences the acquisition of new knowledge. We know that learning can be essentially by *rote* memorization, with little interaction with previous learning (and usually very short retention) to highly *meaningful* learning where the learner integrates new concepts, propositions and images into previously acquired structures. We know that the learner *chooses* to learn by rote or meaningfully and part of the task of teachers is to help the learner choose powerful meaningful learning approaches. *Metacognitive* strategies are strategies that empower the learner to take charge of her/his own learning in a highly meaningful fashion.

Metacognitive strategies include *metalearning*, or learning about meaningful learning, and *metaknowledge*, or learning about the nature of knowledge. Our research has shown that few of the students we have studied at the secondary or college level have had any formal metacognitive instruction. Some students have had instruction on "how to study", but this deals primarily with techniques for time management, concentration, test taking, and memorization. Metalearning strategies help the learner understand that meaning derives from the concepts and concept relationships we have and new relationships we assimilate into our existing knowledge frameworks. The learner becomes aware of the limited capacity of Short-Term Memory (STM); only about seven "chunks" of knowledge can be manipulated at a time; and the important role that the organization of knowledge in Long-Term Memory (LTM) plays in what we perceive in a message and nature of the "chunks" we can use in STM. Thus a learner who has knowledge organized into large, integrated conceptual frameworks can assimilate more related knowledge in less time and with greater usefulness.

Metaknowledge strategies help students to understand that concepts are constructed from perceived regularities in objects or events and that we use language or symbolic labels to designate these regularities. Creativity is involved in constructing new concepts, and meaningful learning is the principal process by which humans acquire most of their usable knowledge. The interplay between various concepts, principles, theories, and philosophies as they are involved in selecting or interpreting observed objects or events is a necessary part of metaknowledge instruction. When successful, metaknowledge strategies lead to understanding how humans *construct* knowledge and also offer practice in the process of constructing knowledged*claims* and value *claims* about some observed regularities in objects and/or events. Thus a science student comes to understand how a laboratory experiment illustrates the ways in which scientists have constructed knowledge claims about the observed events or objects. They also learn that all knowledge claims are accompanied by at least an implied value claim (i.e., this knowledge claim is *worthwhile*), and they learn to discriminate between knowledge claims and value claims.

In our work at Cornell University, we have developed two tools that aid in metacognitive learning. The *concept map* (see Figure 1) when constructed by students helps to illustrate that we use language labels to construct concept and propositional relationships about a domain of knowledge. The concept map thus serves as a tool to illustrate the hierarchical, conceptual/propositional nature of knowledge. It also serves as a tool to help learners organize their cognitive frameworks into more powerful, integrated patterns. Thus, concept maps serve both as metaknowledge and metalearning tools.

Vee diagrams (see Figure 2) are a tool to help students construct the interacting set of elements that are involved in knowledge production. Vees serve as a scaffolding or normative device assuring that all of the elements receive due consideration in the process of seeking knowledge and value claims directed by the focus question. Our experience has been that Vee diagramming is more challenging than concept mapping for both students and teachers. This derives in part from the *positivist* philosophy embedded in most school and college learning, whereas Vee diagramming is rooted in an event-centered, *constructivist* philosophy now generally accepted by philosophers (C. F. Brown, 1979; K. Popper, 1982; E. von Glaserfeld, 1984).

Concept maps and Vee diagrams are valuable tools that help students "unpack" the knowledge in text, laboratory or lectures, and they are powerful tools for curriculum design. These metacognitive tools show promise not only for the improvement of learners, but also for the empowerment of teachers and curriculum planners.

References:

Bransford, John. (1979) *Human Learning, Understanding and Remembering.* Belmont, CA: Wadsworth.

Brown, H. I. (1979) *Perception, Theory and Commitment: The New Philosophy of Science.* Phoenix Edition. Chicago: University of Chicago Press.

Mayer, Richard E. (1983) *Thinking, Problem Solving, Cognition.* New York: W. H. Freeman.

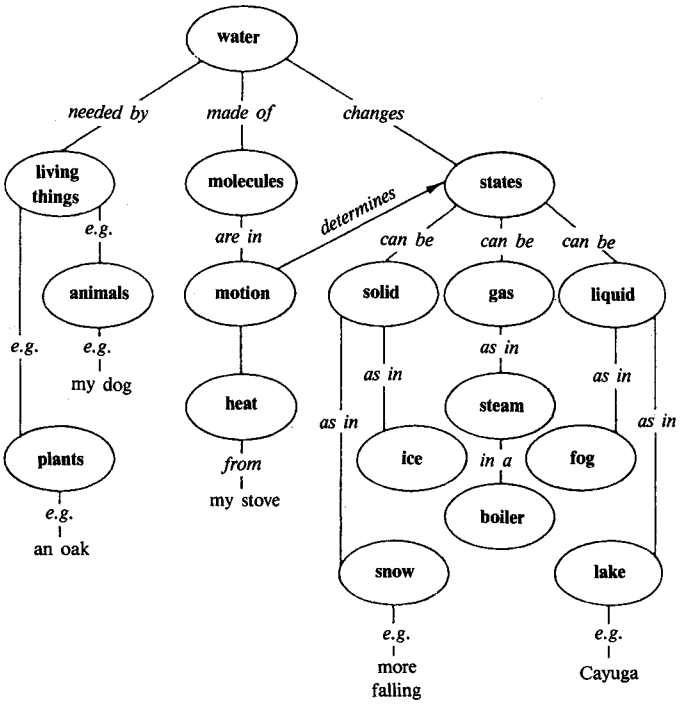
Novak, Joseph D. (1985) "Metalearning and Metaknowledge Strategies to Help Students Learn How to Learn." In Leo West and Leon Pines (eds) *Cognitive Structure and Conceptual Change.* San Diego, CA: Academic Press.

Novak, Joseph D., D. Bob Gowin and Gerard T. Johansen. (1983) "The Use of Concept Mapping and Knowledge Vee Mapping with Junior High School Science Students." *Science Education* 67 (5).

Popper, Karl. (1982) *Unended Quest: An Intellectual Autobiography.* London: Open Court.

von Glaserfeld, Ernst. (1984) "Reconstructing the Concept of Knowledge." Paper presented at the Seminar on Constructivism, Archives of Jean Piaget. Geneva.

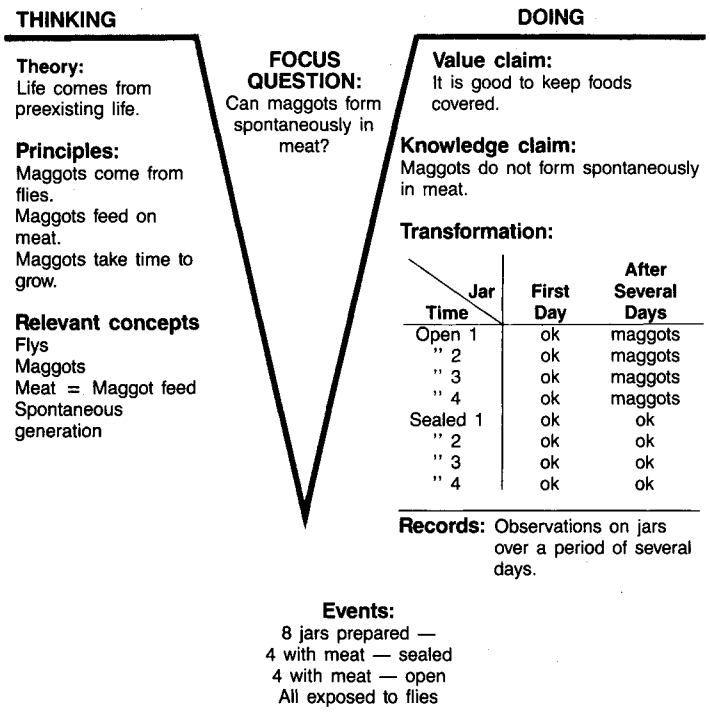
Figure 1. *Learning how to learn*



A concept map for water showing some related concepts and propositions. Some specific examples of events and objects have been included (in Roman type outside ovals).

Figure 2.

The use of the Vee for evaluation



A Vee diagram prepared from the description of an experiment in a high school biology textbook. This kind of analysis helps students to focus carefully on relevant details of an experiment.

Dr. Joseph P. Novak is Professor of Education at Cornell University. He is a member of the National Association for Research in Science Teaching, an organization that actively improves science teaching through research.

The National Association For Research in Science Teaching is an organization that seeks to improve science teaching through research. For further information, contact the NARST Executive Secretary:
Dr. Glenn Markle
401 Teacher College
University of Cincinnati
Cincinnati, Ohio 45221

For further information on this topic, contact Dr. Joseph D. Novak, Department of Science and Mathematics Education, Cornell University, 404 Roberts Hall, Ithaca, New York 14853-5901.

Second Call for Proposals
1988 NARST Annual Meeting

Patricia E. Blosser, Program Committee Chair

This is a second call to NARST members and others to submit proposals for the program for the 1988 NARST Annual Meeting.

To promote a broad research base, the Program Committee encourages proposals that describe any of a variety of types of research. Please consider the following types of research: Experimental, Survey, Ex Post Facto, Evaluation, Historical, Philosophical, Case Study, Naturalistic, and other types. Standard guidelines appropriate for reporting each type of research are found in most research methods texts and should be followed in preparation of proposals and abstracts. In general the proposals should include *Objectives* or *Purpose of the Study*, *Design and Procedures*, *Findings* or *Results*, and *Conclusions.*

An individual may present only one paper, but may be listed as a co-author of another paper and may participate in a symposium or as a presider or discussant. Presenters are strongly encouraged to stimulate discussion around thier presentation. Overhead projectors and screens will be provided; participants needing to use other equipment are expected to provide their own. All presenters must register at the NARST meeting.

Persons wishing to submit proposals need to send:

1. Two copies of the completed cover page provided on back of Leadership Directory.
2. Six copies of a three to six page proposal with bibliography. Please omit author name(s) and other identifying information from the proposal.
3. Six copies of an abstract of *no more than* 500 words, to be published in the collection of NARST abstracts, so form and accuracy are important. Please omit author name(s) and other identifying information.
4. Two self-addressed, stamped, envelopes, to be used to acknowledge receipt of proposals and the Program Committee's final decision.
5. Two 3 x 5 in. cards containing *typed* name, address, and telephone number of the author(s) and the title of the paper.

Send this material to:

Patricia E. Blosser
Chair, NARST Program Committee
ERIC Clearinghouse for Science and Environmental Education
1200 Chambers Road, Rm 310
Columbus, OH 43212
(614) 292-6717

DEADLINE: MATERIALS MUST BE POSTMARKED NO LATER THAN OCTOBER 1, 1987.

All proposals will be reviewed anonymously by the members of the Program Committee. Standard criteria will be applied in the proposal review. The criteria are:

Significance of the problem and conclusions for the advancement of research in science education, as evidenced by the link to or departure from previously published research theories, methods, or conclusions.

Clarity of expression.

Appropriateness of the procedures and conclusions, given the stated purpose and results.

The following types of proposals have served as the basis of NARST Annual Meetings.

1. **Contributed Papers:** Brief 15-minute reports of research. These are grouped by the Program Committee to accommodate three or four per session. This format accommodates persons who have not planned to report their research with other members of a team. Discussants are usually assigned to these sessions. Presenters must provide discussants with a copy of the paper before the annual meeting.
2. **Paper Sets:** Several related studies originating from a common base of research are presented in a single concurrent session, accommodating from three to five persons who may divide a single report representing a major research effort in terms of time, number of researchers and/or geography. This format also allows for common elements of design or approach to be presented once rather than repetitiously. A discussant may be assigned to the session if one is not already identified in the proposal.
3. **Panels:** Panels are constituted to provide a mechanism for debating or discussing serious issues in science education. Each panel has a moderator, who may or may not organize the panel, but who is expected to regulate the flow of discussion or debate. Proposals should describe various aspects of the issue and the diverse views represented by the speakers.
4. **Symposia:** Symposia proposals should be submitted as a package listing participants on the cover sheet. The summary should address itself to the individual presentations and to the thread that ties the papers together. Symposia should promote discussion of current or needed research. Following a brief presentation by each member of the symposium interaction among presenters and the audience is expected. Proposals should describe the common research interests of symposia members, their varied backgrounds, positions or experience, without naming the individuals.
5. **Poster Sessions:** Poster sessions are designed to enable researchers to share information on research in progress. These sessions combine the graphic display of materials with an opportunity for individualized, informal discussions of the research. Authors are encouraged to bring copies of the full paper for distribution to interested participants.

continued

6. **Round Table Discussions:** Round Table Discussions are used to provide a thorough analysis of a paper by a group. Presenters have an hour in which various aspects of the study are examined by others in a discussion format. One or more papers may be discussed simultaneously in a round table format. If members agree to present their research in this format, they are expected to bring materials such as protocols, instruments, computer printouts, experimental curriculum materials, and logs to aid in the discussion. This format is not conducive to presentations which require the use of audio-visual equipment.
7. **Research Methods Seminar/Workshop:** This format is designed to enable NARST members to acquire new research skills or update old ones. These one or two hour sessions are planned for intensive involvement by those in attendance, and presenters are expected to provide resources for study and discussion.

The Program Committee wishes to accommodate as many papers as possible and asks support from proposers if it is necessary to reassign some papers from one format to another.

NARST HISTORICAL RECORDS NEEDED

NARST is one of the oldest (60 years) and most respected professional organizations in the field of Education in the world. NARST members Paul Joslin and Karen Murphy are writing an official history and need the help of every member.

Unfortunately, prior to 1973 there was no effective effort to save valuable records. To establish a NARST archive, Joslin and Murphy need written records dated before 1973. If you have any of the following, please donate them to the NARST archive:

Annual meeting programs
Newsletters
Abstracts of papers presented at annual meetings
Executive Board minutes, records, correspondence
Committee records, correspondence
Significant, interesting correspondence
Personal recollections of interesting incidents

If you have items you would prefer not to donate at this time, please make photocopies. Where necessary NARST will attempt to reimburse photocopying and shipping costs. You may also prefer to make an audio recording of recollections.

Send materials to Paul Joslin, Center for Teacher Education, Drake University, Des Moines, IA 50311. Phone: (515) 271-2114.

INTERNATIONAL ISSUES

UNIVERSIDAD DE PANAMA— MICHIGAN STATE UNIVERSITY ACADEMIC EXCHANGE PROGRAM

(Dr. Deyanira Barnett H.)

Universidad de Panama and Michigan State University submitted an application for support of an Academic Exchange Program, September, 1985 - August, 1988. The application was funded by the U.S. Information Agency and provided for the two-way visits of Dr. Deyanira Barnett and Elizabeth de Molina, from the Universidad de Panama, and Dr. James Gallagher and Alejandro Gallard, from Michigan State University. The Inter-American Seminar on Science Education held in Panama, December 9-15, 1984 was the starting point for this project. The program provided for development of linkages in the fields of science and technology education among others.

The visits were very productive. While at MSU, Profesors Barnett and de Molina engaged in intensive research skills training with Drs. F. Erickson, E. Smith and J. Gallagher. This provided background in ethnographic research and research on conceptual change teaching in science education. Also, it was possible to visit junior and senior high schools, observe science classes and talk with science teachers.

During their visits to Panama, Dr. Gallagher and A. Gallard conducted seminars and worked with university staff and school teachers on a research program and information exchange in science education from both urban and rural setting.

Five research studies were initiated as a result of the July seminar. Progress report of these studies were presented last December in the Third National Scientific Congress at the Universidad de Panama. The January visit provided opportunity to work with each of the five teams especially on techniques of data analysis and reporting.

At present, important advances have been made in planning for a Master's degree program. Also, next summer Armando Contreras, from MSU, will conduct a Seminar on Applicaiton of Research Findings to Science Teaching.

The progress of the project has been excellent in meeting the intended goals. There is an interest in both universities to explore ways to maintian the work between the two institutions in science education.

COVER SHEET FOR NARST PROPOSAL
1988 ANNUAL NARST MEETING, LODGE OF THE FOUR SEASONS, LAKE OZARK, MO.

(Please type the requested information)

1. Title _____

_____

2. First author presenting paper

   Name _____ Phone ( ) _____

   Institution _____

   Address _____

   _____ Zip _____

3. Name and Institutional Address of Co-Authors(s) and, if appropriate, Sub-titles (please include zip code for all co-author(s))

_____

_____

_____

_____

_____

_____

_____

4. Signature _____ Date _____

5. Type of activity proposed (check appropriate entry)

   ☐ Contributed Paper ☐ Paper Set ☐ Panel ☐ Symposium ☐ Poster Session
   ☐ Round Table ☐ Research Methods Workshop/Seminar

6. Special Instructions or Comments:

7. Descriptors that would identify the topic of the proposal:

_____

8. Are you a member of NARST? _____ Yes _____ No

9. Please include the following materials with your proposal
   (Omit author name(s) and identifying information in abstracts)
   - Two completed cover sheets
   - Six copies of a 500-word abstract (to be published)
   - Three to six page proposal with bibliography (6 copies)
   - Two self-addressed, stamped envelopes
   - Two 3 × 5 index cards containing name, address and telephone number of author and paper title

PROPOSALS MUST BE POSTMARKED NO LATER THAN October 1, 1987

NARST News

NARST News is published and mailed to members on the first of the month of March, June, September, and December. Contributions need to be received one month before the publication date. Send contributions to the editor:

Dr. Thaddeus W. Fowler, Editor
NARST News
College of Education
University of Cincinnati
Cincinnati, OH 45221-0002

First priority will be given to regular *NARST News* features and other articles will be published as space permits. Please submit copy in printed form and, if possibly, also as a text file on a "five inch" floppy MS-DOS computer disc (WordPerfect preferred).

NEW AAAS BOOK

This Year in School Science 1986: The Science Curriculum contains valuable information and insights about the science that is taught in the nation's schools. Reports from research studies discuss the amount and kinds of science and mathematics that are taught. In some cases, practice in the United States is compared to practice in other countries.

The book will be useful to anyone who is thinking about the purpose and structure of school science, or pondering the difficulties associated with developing and implementing new science curricula.

This Year in School Science 1986: The Science Curriculum is a publication of the National Forum for School Science project of the American Association for the Advancement of Science. The softcover price is $12.95 ($9.95 for AAAS members), plus $1.50 *per order* for shipping and handling. Orders should be sent to: Sales Office, AAAS, 1333 H Street, N.W., Washington, DC 20005. Requests for further information should be sent to me, in the Office of Science and Technology Education, at the same address.

NEW "TEACHING TEACHERS" COLUMN FOR *SCIENCE AND CHILDREN*

Articles are being sought for a new *Science and Children* column concerned with practical issues and activities of elementary teacher education in science. Brief articles of "how to" and "what works best" in developing good elementary science teaching skills among preservice and inservice teachers will be considered. Articles may describe activities and discuss issues from elementary science methods to staff development programs. *Science and Children* manuscript guidelines should be followed and articles can be sent to Dr. Michael Kotar, Department of Education, California State University, Chico, CA 95929-0222.

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