NARST NEWS

NATIONAL ASSOCIATION FOR RESEARCH IN SCIENCE TEACHING

Organized to improve science teaching through research

Lawrence C. Scharmann, Editor
Center for Science Education
Kansas State University, Manhattan, KS

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PRESIDENT'S COLUMN

Russell H. Yeany

RESEARCH AND TEACHER EDUCATION

There is more focus on teachers and teacher education now than at any other time in the history of formal education. Much of this is in the form of criticism of teachers and our teacher preparation programs. The arguments range from charges that teachers need more content courses and less education courses to rebuttals that professors in content courses provide such poor instructional models that the task of training teachers to use more effective and appropriate pedagogy is hopelessly confounded by the prior experiences. Some argue that preservice teachers should not study pedagogy, curriculum theory, etc. until they have received a liberal arts or science degree. Others claim that working with preservice teachers early in their college or university experience and actually getting them into real teaching situations is essential to the development of a good teacher. All of the arguments focused on teacher education have some merit and make some sense when viewed in the context of the logic and assumptions brought to the debate. For example, if college science teaching is generally offering poor and inappropriate models of the way science should be taught, then one can agree that counter models should be presented to the preservice teachers early in their experiences. However, if one is to assume that the "better teachers" have degrees in one of the sciences and acquire teaching credentials after and separate from their study of the arts and sciences, then an argument that teacher education should be reserved as a post baccalaureate experience is more acceptable.

How is it that we find ourselves in a situation where there is little definitive knowledge that can be used to answer the

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Second Call for Proposals 1992 NARST Annual Meeting

This is a call to NARST members and others to submit proposals for the program for the 1992 NARST Annual Meeting. The 1992 annual meeting will be held in Boston, MA, on March 21 through 25, 1992. All presenters must *register* for the NARST meeting.

The Program Committee encourages the submission of proposals that describe any of a variety of types of research including, but not limited to: case study, experimental, descriptive survey, documentary analysis, ex post facto, evaluation, historical, naturalistic, and philosophical.

<u>Proposal Categories, Preparation and Review</u>

Proposals should fit into one of the seven categories of concurrent sessions presented at NARST annual meetings. Criteria and description of each category follow. Except in the case of poster sessions and seminars/workshops, it is anticipated that the research on which the session is based *will have been completed prior to proposal submission.*

1. **Contributed Papers:** This format accommodates three or four 15-minute reports on research papers by individual researchers or groups of researchers. Contributed papers are grouped by the Program Committee. Discussants usually are assigned to such sessions. Presenters must provide discussants with a copy of the research paper before the annual meeting and are encouraged to distribute copies of the paper at the session. A *Contributed Paper proposal should include:* 1) an abstract, and 2) a three to six page, double spaced, synopsis (objectives or purpose of the study, significance, design and procedures, findings or results, and

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PROPOSALS (continued)

conclusions) with bibliography (not counted into the six pages.) The materials should be stapled together in the upper left corner.

2. **Paper Sets:** This category accommodates several related research papers (or a single paper), reporting on several studies which originate from a common base of research, study, significance, design and procedures, findings or results, and conclusions) with bibliography (not counted into the six pages.) The materials should be stapled together in the upper left corner.presented in a single concurrent session. The 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 identified in the proposal. Presenters must provide the discussant with a copy of the research papers before the annual meeting, and are encouraged to distribute copies of the papers at the session. A *Paper Set Proposal should include:* 1) an abstract, and 2) a three to six page, double spaced, synopsis (objectives or purpose of the study, significance, design and procedures, findings or results, and conclusions) with bibliography (not counted into the six pages) *for each paper* proposed for presentation. The materials should be stapled together as a unit in the upper left corner.

3. **Poster Sessions:** Poster sessions are designed to enable researchers to share information on research *that may be in progress.* Poster sessions combine the graphic display of materials with an opportunity for individualized, informal discussions of the research. Authors are encouraged to bring copies of a paper for distribution to interested participants. A *Poster Session Proposal should include:* 1) an abstract, and 2) a three to six page, double spaced, synopsis of the research to date (e.g., objective or purpose of the study, significance, design and procedures, findings or results, and conclusions) with bibliography (not counted into the six pages). The materials should be stapled together in the upper left corner.

4. **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 have organized the panel, but who is expected to regulate the flow of discussion or debate. Panel members must provide the moderator with a copy of the paper in which their views on the issue are presented in a scholarly manner and are encouraged to distribute copies of their papers at the session. A *Panel Proposal should include:* 1) an abstract, and 2) a double spaced introduction, which describes the issue focus of the panel, the research interests of panel members, and their varied backgrounds, *without naming the individuals* (maximum of two pages), and 3) a three to six page, double spaced, synopsis with bibliography (not counted into the six pages) *of each paper* proposed for presentation in the panel. These materials should be stapled together as a unit in the upper left corner.

5. **Symposia:** 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. *A symposium proposal should include:* 1) an abstract, and 2) a double spaced introduction, which describes the research focus of the symposium, the research interests and professional backgrounds of symposium members *without naming the individuals* (maximum of two pages), and 3) a three to six page, double spaced, synopsis with bibliography (not counted into the six pages) of each paper proposed for presentation by a symposium member. This should be stapled together as a unit in the upper left corner.

6. **Round Table Discussions:** Round Table Discussions are used to provide a thorough analysis of one or more papers by a group of researchers. Presenters have an hour in which various aspects of the study are examined by others, the round table panel, in a discussion format. The researcher must provide round table panel members with a copy of the paper at least *two months* prior to the annual meeting. In addition, they are expected to bring materials such as protocols, instruments, computer printouts, experimental curriculum materials, and logs to aid in the discussion. A *Round Table Proposal should include:* 1) an abstract, 2) a three to six page, double spaced synopsis (objectives or purpose of the study, significance, design and procedures, findings or results, and conclusions) with bibliography (not counted into the six pages) of the research paper to be discussed, and 3) a description of each round table member, including their varied backgrounds, and respective research expertise, *without naming the individuals* (maximum of two pages). These materials should be stapled together as a unit in the upper left corner.

All proposals will be reviewed anonymously by the members of the Program Committee. The following criteria will be applied during the proposal reviews.

> Significance of the program and conclusion 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.
>
> Adherence to the proposal preparation criteria presented herein, *including the deadline.*

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PROPOSALS (continued)

An individual may present in only one contributed paper or paper session at the Annual Meeting but may be listed as a co-author on other papers and may participate in a symposium, round table, seminar/workshop as well as serve as a presider or a discussant. Presenters are strongly encouraged to stimulate discussion around their presentations. Overhead projectors and screens will be provided. Participants needing other equipment are expected to provide that equipment. All presenters *must register* at the NARST meeting.

PROPOSAL SUBMISSION

Persons wishing to submit proposals need to send:

1. Two (2) copies of the completed cover page (provided with this newsletter).
2. Two (2) copies of an abstract of no more than 200 words for concurrent sessions and all symposia. ALL abstracts must be formatted in "camera-ready" style for eventual publication in the collection of NARST abstracts. Use the form supplied with this newsletter.
3. Six (6) copies of the proposal *as described under the respective concurrent session type* above. Please omit the name(s) and identifying information about the proposer and other session participants.
4. Two (2) self-addressed, stamped, envelopes which will be used to acknowledge receipt of the proposal and the Program Committee's final decision.
5. Two (2) 3 x 5 inch typed cards containing name, address, and telephone (Fax and Bitnet, if possible) numbers of the individual proposing the concurrent session as well as the title of the session.

Send this material to: Dr. Emmett Wright, Chair, NARST Program Committee, College of Education, Kansas State University, Manhattan, KS 66506.

DEADLINE: MATERIALS MUST BE POSTMARKED NO LATER THAN SEPTEMBER 15, 1991.

PRESIDENT (continued)

questions and charges leveled at teacher education? Part of the answer lies in the nature of our research related to the teacher and our ability to answer questions regarding how teachers construct and apply their knowledge of the content, the learner, the pedagogy, the social context, etc. There is an urgent need to intensify our research efforts in science education to better understand the science teacher.

Much of our research related to science teacher education focuses on teacher preparation program evaluation or tests specific treatments targeted to change teacher's attitudes, behaviors, skills, and so forth. We know something about a few things that have positive impact on science teachers. But, we know precious little about how teachers acquire the knowledge of teaching; how they process it; how the knowledge interacts with belief systems, attitudes, and perceptions; how decisions are made to apply the knowledge in the context of the science classroom; or, how these decisions are compromised by inadequacies in the teacher's knowledge or dominating variables in the social setting.

The research agenda designed to generate a basis for our understanding of how science teachers develop and apply their knowledge needs to be systematically examined by the research community. The teacher education research agenda needs to be mapped out in such a way that the results will begin to provide answers to issues in the debate over our ability to prepare teachers and how this preparation can best be accomplished.

There are different ways that the agenda can be influenced and the findings applied. One suggestion that I will make is that the National Science Foundation take the initiative to commission and convene a task force (sometimes referred to as a "blue ribbon committee") to draft the agenda. This process should involve significant input from the research and science teacher education community. Initial drafts could be presented and debated at NARST and AETS meetings. It would not be necessary that universal agreement be attained. But, we should strive for a general consensus on the major questions that need to be addressed and make suggestions on how the research should be approached so that the findings are relevant to the major issues and so that they are additive and contribute to the whole. This process can lead to a formalization of the research agenda and help to target some of our research efforts on the pressing issues.

In order for the findings to have some influence on science teacher preparation, we need to develop a stronger expectation that science teacher preparation be theory driven and researched based. One way to achieve this is to provide some incentives. Funding agents such as the NSF, Eisenhower grants, and private foundations should demand that the research basis be apparent in any teacher preparation or teacher enhancement proposal. But, closer to home, we, in our own institutions, should not be satisfied with an intuitive approach to science teacher preparation. We should continually be generating a research based argument for every learning experience included in our teacher education programs.

Award for Distinguished Contributions to Science Education Research

The National Association for Research in Science Teaching seeks to improve Science Education through research. To this end the Association desires to recognize individuals who

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AWARD (continued)

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 studies reflecting new techniques to be applied in research.

The award is given to an individual who meets the following eligibility criteria: 1) has been involved in research in science education for at least a period of 20 years; 2) has been an active NARST member (i.e., held office or served on a committee); and 3) has made exemplary, seminal contributions to research in science education with consistency.

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:

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; and

2. a curriculum vita including a complete list of publications and accomplishments.

Send all materials to:

Dr. Kenneth G. Tobin, Co-Chair
NARST Distinguished Contributions Committee
Department of Science Education
Florida State University
Tallahassee, FL 32306

Deadline: September 15, 1991

Submissions Invited -- 1991 NARST Outstanding Paper Award

Each year at the annual meeting of the Association, the NARST Awards Committee identifies person(s) to be recognized by the organization whose paper, presented at the meeting of the preceding year, is judged to be outstanding in the area of:

Contributions to science education research

The NARST Awards Committee invites all persons who presented papers at the 1991 meeting at Lake Geneva, WI, to submit copies of the complete paper and abstract for consideration for the Outstanding Paper Award. This award will be presented at the next NARST meeting in Boston.

The paper 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.

Please send, **by September 15, 1991**, eight (8) copies of your paper and abstract (a copy of the abstract need to accompany each copy of the paper), a cover sheet of information including:

Name, Address with zip code, Telephone numbers, and a self-addressed post card (which will be returned to you upon receipt of your materials) to:

Dr. Thomas Koballa, 212 Aderhold Hall
Department of Science Foundation
University of Georgia
Athens, GA 30602
(404) 542-1763

NARST Announcements

Dr. John W. (Jack) Renner, professor emeritus of science education and physics at the University of Oklahoma, died August 10th after a long illness. Jack, the author of 30 books and monographs, more than 100 articles in professional journals, and past president of NARST (1980), was an internationally respected science educator. Jack was especially instrumental in redesigning science curricular approaches based on the concept of the learning cycle.

Mrs. Mary McCurdy, elementary educator, Lincoln, Nebraska, died July 27th after a prolonged illness. Mary was the wife of Donald McCurdy, current NARST Board member and former NSTA President. Mary was an impressive, enthusiastic, and exceptionally motivating elementary science teacher. In recognition of her special science teaching talents, NSTA has established an endowed lectureship which bears her name.

Dissertation Video Available A teaching video entitled **Word Perfect Dissertation** has recently been completed. The video, with an accompanying IBM-compatible learning disk (for Learn Key), explains how to create each part of a dissertation using Word Perfect. For more information, contact Robert Hogan, Ed.D., NOVA University (1-800-541-6682 at extension 7459).

International Conferences Announced--Dr. Avi Hofstein, of the Weismann Institute of Science, Chairman of the Organizing Committee, announces an international

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COVER PAGE FOR NARST PROPOSAL
1992 ANNUAL NARST MEETING, BOSTON, MASSACHUSETTS

(Please type the requested information)

1. Title ____

____

2. First author presenting paper

   Name ______________________ Phone (____)______________________

   Institution ____

   Address ____

   ____ Zip ______________

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

   A. ______________ B. ______________ C. ______________

   ______________ ______________ ______________

   ______________ ______________ ______________

   ______________ ______________ ______________

4. Signature ______________________________________ Date ______________

5. Type of activity proposed (check appropriate entry)
   ☐ Contributed Paper ☐ Paper Set ☐ Panel ☐ Symposium ☐ Poster Session ☐ Round Table

6. Special Instructions or Comments:

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

   ____

8. Are you a member of NARST? ______Yes ______ No. If not, you must join to be on the program.

9. Please include the following materials with your proposal: (Omit author name(s) and identifying information in your proposal).

   - Two completed cover pages
   - Two copies of no more than a 200-word abstract in camera-ready format (use format supplied with this newsletter on the reverse side of this page)
   - Three to six page proposal with appended bibliography (6 copies)
   - Two self-addressed, stamped envelopes
   - Two 3 x 5 index cards containing name, address and telephone number of author and paper title

10. Do you plan an NSTA presentation?

PROPOSALS MUST BE POSTMARKED NO LATER THAN SEPTEMBER 15, 1991

ABSTRACT PREPARATION

All abstracts will be published in the form and condition in which you submit them. Thus, any error(s) made in your abstract will also appear in our final printed copy. Therefore, care must be taken in preparing your abstract. **THE FOLLOWING INSTRUCTIONS ARE TO BE USED AS A GUIDE FOR PREPARING YOUR ABSTRACT. ABSTRACTS NOT MEETING ALL REQUIREMENTS WILL BE REJECTED.**

1. Length of Abstract: Limited to 200 words. Note: all abstracts in excess of 200 words will be cut at the end of the sentence nearest the 200 word limit.
2. Typing: Type the abstract *single spaced, 1/4 inch inside* the marked area shown below. You must keep your abstract within the limits of the 4 1/2 inch square. Note: use a typewriter with a carbon ribbon; dot-matrix type is unacceptable since it is not suitable for use as camera-ready copy.
3. Titles: Use a cogent title reflective of the abstract's content. Begin the title at the left-hand margin (1/4 inch from the edge of the form). The entire title should be Capitalized.
4. Author(s) and Institution(s): Immediately follow the title with the name(s) of the author(s) and institution(s). Note: Underline the name of the author primarily responsible for making the presentation.
5. Abstract Text: Double space between title-author heading and abstract text. Begin the first word 'flush-left' and type the entire abstract as a single paragraph.

SAMPLE ABSTRACT

CONFIDENCE LEVEL IN TEACHING SCIENCE, CRITICAL THINKING, AND IN THE USE OF VARIED TEACHING STRATEGIES.
Catherine G. Yeotis and Linda Bakken, Wichita State University

The purpose of this study was to measure any change in the confidence level of teachers who participated in four weeks of intensive instruction. The 175 participants received two hours of specific science content information and three hours of instructional methodology information daily. Confidence level was measured by a twelve-item Likert Scale instrument designed by the authors of the study. Pre and post scores were analyzed for any significant change. Results indicated that both groups (elementary and secondary) reported significant gains in confidence levels. Statistical analyses conducted on each of the three focus areas of the instruction supported the aim of the project.

TYPE YOUR ABSTRACT BELOW

NARST

September 1991, No. 27

Research Matters - to the Science Teacher

PEDAGOGICAL CONTENT KNOWLEDGE: TEACHERS' TRANSFORMATIONS OF SUBJECT MATTER

Kathryn F. Cochran, Div. of Research, Eval. and Devel.
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> "Those who can, do. Those who understand, teach."
> Shulman, 1986, p. 14

The early history of teacher education was primarily focused on the teacher's knowledge of subject matter content (Shulman, 1986). However, for the past few decades, teacher education research has been mainly focused on the effectiveness of general pedagogical methods independent of subject matter content (Ball & McDiarmid, 1990) such as the teacher's use of questions, the design of assignments and curriculum, and student evaluation. This work has revealed that there are a number of instructional strategies which significantly improve student achievement; including wait time, preinstructional strategies, the use of concrete examples and manipulatives, and formative testing (see Hofwolt, no date, for a review in the context of science education). For the most part, these issues have been researched in the general classroom context, isolated from specific subject matter. Where content has been included, it has served primarily as a control variable rather than a topic of specific interest.

Recently, there has been a renewed recognition of the importance of teachers' science subject matter knowledge, both as a function of research evidence (e.g., Ball & McDiarmid, 1990; Carlsen, 1987; Hashweh, 1987), and as a function of recent literature from reform initiatives such as the Holmes Group (1986) and the Renaissance Group (1989). Not surprisingly, it has become clear that both teachers' pedagogical knowledge and teachers' subject matter knowledge are crucial to good science teaching and student understanding (Buchmann, 1982, 1983; Tobin & Garnett, 1988).

The Nature of Pedagogical Content Knowledge

In addition to teachers' subject matter (content) knowledge and their general knowledge of instructional methods (pedagogical knowledge), Shulman (1986; 1987) has suggested that there is a third major component of teaching expertise called pedagogical content knowledge. This notion has been a major outcome of the Knowledge Growth in Teaching Project at Stanford University conducted by Shulman and his colleagues and students (e.g. Carlsen, 1987; Grossman, Wilson, & Shulman, 1989; Gudmundsdottir, 1987a, 1987b; Gudmundsdottir & Shulman, 1987; Marks, 1990), and represents a new, broader perspective in our understanding of teaching and learning. A recent special issue of the Journal of Teacher Education (Ashton, 1990) has been entirely devoted to this topic.

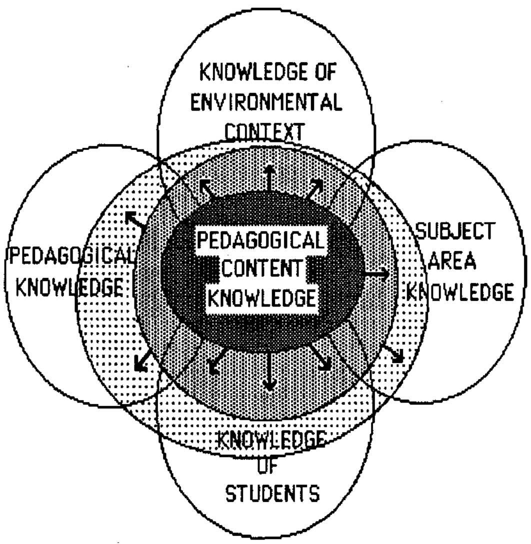
Pedagogical content knowledge is a type of knowledge that is unique to teachers, and is based on the manner in which teachers relate their pedagogical knowledge (what they know about teaching) to their subject matter knowledge (what they know about what they teach). It is the integration or the synthesis of teachers' pedagogical knowledge and their subject matter knowledge that comprises pedagogical content knowledge. According to Shulman (1986) pedagogical content knowledge

> . . ."embodies the aspects of content most germane to its teachability. Within the category of pedagogical content knowledge I include, for the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations - in a word, the ways of representing and formulating the subject that make it comprehensible to others . . . [It] also includes an understanding of what makes the learning of specific concepts easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning. (p. 9)

Pedagogical content knowledge is that form of knowledge that makes science teachers teachers rather than scientists (Gudmundsdottir, 1987a, b). Teachers differ from scientists, not necessarily in the quality or quantity of their subject matter knowledge, but in how that knowledge is organized and used. In other words, an experienced science teacher's knowledge of science is organized from a teaching perspective and is used as a basis for helping students to understand specific concepts. A scientist's knowledge, on the other hand, is organized from a research perspective and is used as a basis for developing new knowledge in the field.

Two other components of teacher knowledge also differentiate teachers from subject matter experts. One component is teachers' knowledge of students' abilities and learning strategies, ages and developmental levels, attitudes, motivations, and prior knowledge of the concepts to be taught. Students' prior knowledge has been especially visible in the last decade due to literally hundreds of studies on student misconceptions in science and mathematics. The other component of teacher knowledge that contributes to pedagogical content knowledge is teachers' understanding of the social, political, cultural and physical environments in which students are asked to learn. The model in Figure 1 shows that these four components of teachers' knowledge all contribute to the integrated understanding that we call pedagogical content knowledge; and the arrows indicate that pedagogical content knowledge continues to grow with teaching experience.

Figure 1. PCK in the experienced teacher.



Research Evidence

Hashweh (1985, 1987) has conducted an extensive study of three physics teachers' and three biology teachers' knowledge of science and the impact of that knowledge on their teaching. All six teachers were asked about their subject matter knowledge in both biology and physics, and they were asked to evaluate a textbook chapter and to plan an instructional unit on the basis of that material. Given a concept like photosynthesis for example, the biology teachers knew those specific misconceptions that students were likely to bring to the classroom (such as the idea that plants get their food from the soil) or which chemistry concepts the students would need to review before learning photosynthesis. The biology teachers also understood which ideas were likely to be most difficult (e.g. how ATP-ADP transformations occur) and how best to deal with those difficult concepts using a variety of analogies, examples, demonstrations and models. The biology teachers could describe multiple instructional "tools" for these situations; but, although they were experienced teachers, had only very general ideas about how to teach difficult physics concepts. The physics teachers, on the other hand, could list many methods and ideas for teaching difficult physics concepts, but had few specific ideas for teaching difficult biology concepts.

Predictably, when the teachers in Hashweh's study were asked about their subject matter knowledge outside their fields, they showed more misconceptions and a less organized understanding of the information. Within their own fields, they were more sensitive to subtle themes presented in textbooks, and could and did modify the text material based on their teaching experiences. Moreover, they were more likely to discover and act on student misconceptions. The teachers used about the same number of examples and analogies when planning instruction in both fields, but those analogies and examples were more accurate and more relevant in the teachers' field of expertise.

Other studies, many of them conducted as part of the Stanford project, have shown that inexperienced teachers have incomplete or superficial levels of pedagogical content knowledge (Carpenter, Fennema, Petersen, & Carey, 1988; Feiman-Nemser & Parker, 1990; Gudmundsdottir & Shulman, 1987; Shulman, 1987). A novice teacher tends to rely on unmodified subject matter knowledge (most often directly extracted from the curriculum) and may not have a coherent framework or perspective from which to present the information. The novice also tends to make broad pedagogical decisions without assessing students' prior knowledge, ability levels, or learning strategies (Carpenter, et al., 1988). In addition, low levels of pedagogical content knowledge have been found to be related to frequent use of factual and simple recall questions (Carlsen, 1987). These studies also indicate that new teachers have major concerns about pedagogical content knowledge, and they struggle with how to transform and represent the concepts and ideas in ways that make sense to the specific students they are teaching (Wilson, Shulman, & Richert, 1987). A study by Grossman (1985, cited in Shulman, 1987) shows that this concern is present even in new teachers who possess the substantial subject matter knowledge gained through a master's degree in a specific subject matter area.

These and other results show that pedagogical content knowledge is highly specific to the concepts being taught, is more than just subject matter knowledge alone, and develops over time as a result of teaching experience. What is unique about the teaching process is that it requires teachers to "transform" their subject matter knowledge for the purpose of teaching (Shulman, 1986). This transformation occurs as the teacher *critically reflects* on and *interprets* the subject matter; finds multiple ways to *represent* the information as analogies, metaphors, examples, problems, demonstrations, and/or classroom activities; *adapts* the material to students' developmental levels and abilities, gender, prior knowledge, and misconceptions; and finally *tailors* the material to those specific individual or groups of students to whom the information will be taught. Gudmundsdottir (1987a, b) describes this transformation process as a continual restructuring of subject matter knowledge for the purpose of teaching; and Buchmann (1984) discusses the importance of science teachers maintaining a fluid control or "flexible understanding" (p. 21) of their subject knowledge, i.e. be able to see a specific set of concepts from a variety of viewpoints and at a variety of levels, depending on the needs and abilities of the students.

Recommendations for Teachers

1. The first recommendation that can be made for teachers is for them to begin to more often reflect on or think about why they teach specific ideas the way they do. Teachers know much more about teaching subject concepts to students than they think. This is pedagogical content knowledge; and many teachers are not aware of it and don't think about this knowledge as important. It is important, though, because it determines what a teacher does from minute to minute in the classroom, as well as influencing long term planning.

To become more aware of this knowledge and to be able to more clearly think about it, teachers can find ways to keep track of this information, just as they ask students to do with the data collected in lab assignments. One way is to keep a personal notebook describing their teaching, even just once a week or so for a few of the difficult concepts. Another strategy is to videotape or audiotape a few class periods to simplify the recording of classroom events. Then teachers can start to think about the following types of questions. Which ideas need the most explanation? Why are those ideas more difficult for the students? What examples, demonstrations, and analogies seemed to work the best? Why did they work or not work? Which students did they work best for?

2. Teachers can try new ways of exploring how the students are thinking about the concepts being taught. Ask students how and what they understand. Ask them what "real life" personal situations they think science relates to. Try to get inside their heads and see the ideas from their point of view.

3. Start more discussions with other teachers about teaching. Take the time to find someone you can share ideas with and take the time to learn to trust each other. Exchange strategies for teaching difficult concepts or dealing with specific types of students. Get involved in a peer coaching project in your school or district. District faculty development staff or people at a local university can help you get one started and may be able to provide substitute support. Ask about telephone hot-lines and computer networks for teachers.

4. Get involved in action research projects. Much of the newest and most important research is being conducted by teachers. Take a class at your nearest university and find out what is going on. Get involved with a mentor teacher program or a teacher on special assignment program. Join organizations and go to conferences such as the national or regional National Science Teachers Association or the National Association for Research in Science Teaching meetings. There are also often summer workshops and institutes in specific fields in science at many universities and colleges.

Where Should We Go From Here?

Contemporary research has focused on how to describe teachers' pedagogical content knowledge and how it influences the teaching process. We have yet, however, to clearly understand how it really develops and how better to enhance pedagogical content knowledge in preservice and inservice programs. Teacher involvement in research and university preparation programs is crucial for the development of this important idea and its usefulness for the improvement of science teaching.

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NARST Presidential Address
April 9, 1990, The Abbey, Lake Geneva, WI

Look Who's Coming to School? And What are We Doing About It?

by

Jane Butler Kahle

At its meeting last fall, the Executive Board of NARST reconsidered the membership eligibility section of the association's by-laws. The Board recommended changing that section to read, ". . . members who are working toward improving science education through research". The change deleted several restrictive phrases, including one that recommended advanced graduate work. Approval of the changes by the membership signified support for members with more diverse interests and activities. And yet, where is that diversity?

At this meeting, some have recalled distinguished papers and professors who were part of NARST's previous meeting at the Abbey. I, too, recall our last meeting at Lake Geneva, where I was inspired by a general session speaker, who was a high school science teacher. LeRoy Lee spoke eloquently about the effect of research on classroom practice. Yet, in the intervening decade, NARST has not had another practicing teacher as a general session speaker.

Today, I want to focus on the improvement of science teaching and, I would add, learning through research. Research that will depend on members with diverse experiences and interests. Research that will involve collaborations with schools and teachers. Research that will require a different forum and focus than it has had in the past. Research that is demanded by changing demographics. Let us start by looking at who is coming to school and what they are learning in science. I apologize to our international members because I will mainly present U.S. data. However, my general message - changing research priorities - is applicable internationally.

In 1983, A Nation at Risk warned that inadequacies in precollege education were undermining our national productivity and that the effect was as devastating as an attack by a foreign power (National Commission on Excellence in Education, 1983). A comparison of results from the first (1970) to most recent (1986) National Assessment of Educational Progress' *Survey of Science* shows that the gender gap has doubled among 13-year-olds. And, although scores of both our Hispanic and African-American youth are rising, they are still dramatically lower than the scores of majority students, which have not improved over the three decades. In addition, for many countries the Second International Science Survey are bleak (IEA, 1986). Yet, few research studies in the U.S. or elsewhere systematically and systemically address the achievement decline, and only a few of us include race and/or gender as variables in our research.

Furthermore, both U.S. and other nations' demographics suggest that our research must focus on more diverse learners. Just who is coming to school and who will be our future scientist or engineer? She, or he, will look very different from today's scientist, and she or he will more likely come from a different place. Traditionally, our technical labor pool has come from rural communities and largely has been white and male. Today - worldwide - we are an urban population, and in the U.S. over one third of us are ethnic or racial minorities. Yet, Black, Hispanic, and American Indian youth are less likely than non-Hispanic white or Asian students to finish high school, to attend college, to enter a four year baccalaureate program, to choose a science or engineering field, to earn a bachelor of science degree, to enter graduate school, or to earn a graduate degree. Women are somewhat more likely than men to graduate from high school, to enter higher education, and to earn an associate, bachelor's, or master's degree. However, they are far less likely to choose a natural science or an engineering field or to advance to a doctoral degree (Vetter, 1990). Recently, the persistence of women and minorities in the science and engineering educational pool has been discussed in the U.S. and elsewhere as the pipeline issue. As we all know, although girls and minority children make up an increasing percentage of our students, proportionately fewer of them enter the pipeline to scientific careers.

A strong argument has been made that some of the attrition is due to school organization, specifically the tracking of students. Ray Marshal, chair of the Action Council on Minority Education in the U.S., states that to "... improve the education for the most disadvantaged will improve the whole system" (Marshal, 1990, no page). He identifies as a special problem the tracking that commonly occurs in secondary schools, stating that "if a student hasn't taken algebra by the eighth or ninth grade, opportunities in math and science are closed" (Marshal, 1990, no page). Furthermore, he warns that as a nation the U.S. has about 20 years to deal with the issue of a two-tier educational system, one that educates minorities on the second tier. In other nations, the two-tier system is based upon both the percentage of students who leave school at the end of 10th grade and upon what curricula is chosen by those who complete grades 11 and 12. The result of both practices results in a two-tier system of education in most countries. Yet, few studies have analyzed the effect of tracking on who takes, and who succeeds in, science.

Changing demographics in the U.S. indicate the need for such research. By 2020, white and minority populations will equal out, and by 2080, whites will become the minority group in the United States. Juxtaposed with those data is the following description of who is coming to school in the U.S. and, I suspect, elsewhere.

> "Today 1 in 6 babies in the U.S. has a teenage mother. And of today's 3-year-olds, 60% will be raised by a single parent at sometime before they are 18, and more than half of them will live in poverty." (Morrison, 1990, p.30).

As the population changes, more of them will be raised by mothers, who have less education and less interest in, or understanding of, science. Demographics tell us that although only 4% of white, 5% of black and 10% of Asian mothers have had less than 10 years of education, over 37% of Hispanic mothers have 10 years of education or less. Yet, Hispanics are the most rapidly growing component of our population. In spite of widely publicized and discussed information about who is coming to school, not a single research paper at this meeting addressed science education for Hispanic children.

Among those who go to school, who persists to study science and why. Again, the surveys present a bleak picture. For example, one half of U.S. high school graduates have dropped out of math after ninth grade; 60% have had no physics or chemistry; and 80% have not studied physics. Those who come to school spend less time on homework and more time watching television than do their peers around the world. Only 27% of U.S. students spend two or more hours on homework each day. However, 73% of U.S. students watch television three or more hours/day, the highest percentage reported from the sixteen countries studied, many of which are represented here. However, U.S. students like school and are confident that they can do well in both math and science.

Recently fifth graders in three countries (United States, Japan, and Taiwan) were followed as they progressed through school from 1980 to 1990 (Stevenson, 1990). Their achievement levels and attitudes were assessed and compared. Over the decade, the achievement gap between U.S. students and their Japanese and Chinese counterparts widened. The U.S. students fell further behind their counterparts as they progressed from elementary through secondary school. Likewise a gap grew between the confidence levels expressed by the three international groups. In this case, the U.S. students became more confident than either their Japanese or Taiwanese peers. The U.S. students stated that they liked math and science, didn't think those subjects were difficult, and didn't need to study math and science for their future jobs and careers. In addition, U.S. parents expressed more satisfaction with both the schools and their children's progress in them than did the parents of Japanese and Taiwanese students. Furthermore, U.S. parents stated that they thought that their children were good at math and science.

In spite of student confidence and parental approval, a national study of U.S. eighth graders indicates that nationally 18% of them have repeated one grade, and 2% have repeated more than one grade. Furthermore, these eighth graders spent four times as much time watching television as they did on homework. Although two-thirds of the students surveyed planned to go to college, only one-third of them intended to take a college-preparatory course in high school.

The children who are coming to school are very different from their earlier counterparts, but those of us who are teaching them are not. For example, the percentages of minority teachers range from 9% in grades K-3 to 5% in grades 10-12. So one of our challenges is to provide a research base that assists potential teachers, most of whom are white (and, in the case of science, three quarters of whom are male), in understanding and in reaching diverse students.

Recently I had an opportunity to search the international and U.S. literature regarding instructional techniques that increase the achievement of children from different races and cultures and for teaching behaviors that have proven successful with groups who are traditionally under-represented in science. That is, I was searching for research-based examples that analyzed differences in the ways children learned science and the provided pedagogical techniques that addressed any identified differences. Not surprisingly, my list of references was short, and few entries were based on the teaching and learning of science. Last year when one of my doctoral students was completing his review of the literature concerning the efficacy of cooperative learning groups, he found that his primary source was the analysis of the case study literature, used in many MBA programs. The few school-based studies identified were done in elementary schools; yet, as a group, science educators espouse cooperative learning groups in science.

A quick survey of the last year of Journal of Research in Science Teaching issues (March 1990 to March 1991) revealed that only two articles out of 70 concerned issues of gender, while two papers addressed the teaching and learning of minority students. Yet, half of our students are girls and women and increasing proportions of them represent minority groups. I do not think that the dearth of papers reflects editor or reviewer bias; I simply think that the research is not being done.

We have a commonly acknowledged crisis in science education's systems, curricula, and teacher education programs that have failed for the children that will fill our classrooms. And so I ask? "What are we going to do about it?" I have used my platform as president to encourage all of us to address problems in the schools, to increase collaborations between schools and colleges and universities, to build a substantial body of knowledge that can change teacher practice and enhance student learning. A group as prestigious as the National Research Council has called for more research on the teaching and learning of science. In its recent publication, Fulfilling the Promise: Biology Education in our Nation's Schools, the Council makes two explicit recommendations:

1. Research is needed on what makes education programs for teachers effective.

2. Research is required to assess the effects of magnet schools on the students they serve and on the associated neighborhood schools (NRC, 1990, pp. 109 and 113).

Furthermore, one of the 11 items placed on its leadership agenda is: "Identifying research needs in science education." For the first time, a group of scientists has called upon us, the science educators concerned with research, to play a role in determining national policy. In order to meet that challenge, we need to involve a wide variety of researchers, teachers, and administrators who will work together to improve science teaching through research.

How will we respond? Will we accept the challenge to improve teaching and learning for more diverse students? We know who is coming to school. I challenge each of us to use our research skills to make school a more hospitable place in which all students may learn and grow.

Thank you very much for your attention and for your active support of NARST during the past year.

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conference entitled **"Science Education in Developing Countries: from Theory to Practice".** The conference will focus on current research on learning and teaching and its implications to science education in the areas of the learner, teacher, classroom, and curriculum. In each area special reference will be given to developing countries. The conference will be held in Jerusalem, ISRAEL, January 3-8, 1993. For additional information, contact Dr. Avi Hofstein, Department of Science Teaching, Weizmann Institute of Science, Rohovot, 76 100, ISRAEL.

A second international opportunity for consideration by NARST members will occur between February 2nd and February 4th, 1992 in San Juan, Puerto Rico, as the organizers representing the International Consortium for Research in Science and Mathematics Education make their call for papers. This is the fourth such International Conference; the current theme is **The Improvement of Science and Mathematics Teaching and Learning.** Papers that describe any of a variety of types of research including case study, experimental, descriptive survey, documentary analysis, and evaluation are encouraged. Workshops for elementary and/or secondary teachers are being considered also. Proposals are due by September 30, 1991. For additional information contact Dr. Pamela F. Abder, New York University, 239 Greene Street, 218 East Building, New York, NY 10003 (914-362-8815; FAX: 212-995-4049).

In July of 1993, ICASE, with funding from UNESCO, will host "Conference '93: Forward to the Next Century and Scientific and Technological Literacy". One hundred funded delegates, assisted by about 400 supporting participants, will analyze and discuss at least six perspectives related to scientific and technological literacy: 1) Definitions and goals; 2) The role of the student in acquiring literacy; 3) The knowledge base required for literacy; 4) The role of the teacher in creating an appropriate learning environment; 5) Needs in teacher education; and 6) Authentic and valid assessment for such literacy. The end product of these deliberations should be a series of papers which can shed some new light on this critical and controversial subject. For additional information, contact: Dr. John Penick, Professor of Science Education, University of Iowa, Iowa City, IA 52242 (319-335-1168; FAX 319-335-1188; BITNET: CEDPENWY@UIAHVS).

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