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Paper Title: FOCUS ON CHILDREN'S IDEAS ABOUT SCIENCE - An Integrated Program of Instructional Planning and Teacher Enhancement from the Constructivist Perspective
Author: Shymansky, James & Matthews. Charles

Abstract: FOCIS is a recently-completed five-year project to develop a program that integrates science instructional planning and teacher enhancement. Separate modules of videotaped and printed materials have been developed (1) for use by science methods instructors in college-based courses for teachers and teacher candidates and (2) for inservice teachers and their local curriculum coordinators or workshop leaders in school district-based programs for teacher enhancement and curriculum design. The underlying FOCIS intention is to help teachers approach their curriculum planning and teaching in ways that restructure their own understanding, as well as their students' understanding, of the science topic. From a constructivist perspective, the primary planning strategy employs studying the structure and evolution of students' ideas on the science topic--with assistance from a science consultant who has expertise on the topic and from a "learning activity" consultant who has experience and expertise on teaching the topic by means of activities that help to challenge and refine students' ideas in the direction of scientists' ideas on the topic. Concept mapping and associated interviews constitute the main FOCIS strategies for studying student ideas. The primary FOCIS teaching strategy employs accessing, analyzing, and challenging student ideas. The paper emphasizes the nature and use of the FOCIS videotape/print modules for teachers (and teacher candidates) and their "science methods" instructors and for in-service teachers and their in-service leaders.

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# FOCUS ON CHILDREN'S IDEAS ABOUT SCIENCE
## An Integrated Program of Instructional Planning and Teacher Enhancement from the Constructivist Perspective[1]

James Shymansky
Professor of Science Education
University of Iowa
Iowa city, IA 52242 USA
Telephone 319/335-1167
FAX 319/335-1188

Charles Matthews
Professor of Education
Maharishi International University
Fairfield, IA 52557-1045 USA
Telephone 515/472-2314
FAX 515/472-1189

for the
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on
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## ABSTRACT

FOCIS is a recently-completed five-year project to develop a program that integrates science instructional planning and teacher enhancement. Separate modules of videotaped and printed materials have been developed (1) for use by science methods instructors in college-based courses for teachers and teacher candidates and (2) for inservice teachers and their local curriculum coordinators or workshop leaders in school district-based programs for teacher enhancement and curriculum design. The underlying FOCIS intention is to help teachers approach their curriculum planning and teaching in ways that restructure their own understanding, as well as their students' understanding, of the science topic. From a constructivist perspective, the primary planning strategy employs studying the structure and evolution of students' ideas on the science topic--with assistance from a science consultant who has expertise on the topic and from a "learning activity" consultant who has experience and expertise on teaching the topic by means

of activities that help to challenge and refine students' ideas in the direction of scientists' ideas on the topic. Concept mapping and associated interviews constitute the main FOCIS strategies for studying student ideas. The primary FOCIS teaching strategy employs accessing, analyzing, and challenging student ideas. The paper emphasizes the nature and use of the FOCIS videotape/print modules for teachers (and teacher candidates) and their "science methods" instructors and for in-service teachers and their in-service leaders.

## INTRODUCTION--CONSIDERING THE NEED FOR THE FOCIS APPROACH

The "Focus on Children's Ideas About Science" (FOCIS) project is for change in science education. The project has produced materials that are intended to bring about changes in the curriculum and in the teachers. The last decade has witnessed discussions (Linn et. al., 1987) and calls (American Association for the Advancement of Science, 1989) for change that have echoed each other in what appears to be a common slogan: "Less is more." This slogan can be applied to a variety of curricular issues in science education. Controversy continues about how much science is adequate for young children and youths. Little agreement exists regarding how much science background is necessary in order for teachers to teach science effectively.

Holmes group advocates (Holmes Group, 1986) assert that teachers having only an undergraduate education degree are not prepared adequately to teach science. They recommend at least an undergraduate degree in the discipline, something that few practicing or graduating teachers have and something few school administrators consider necessary (Hollis-Melton, 1986; Tulloch, 1986; O'Neill, 1986). A few science educators (Yager et. al., 1988) have even suggested that some science coursework beyond fifty semester hours may be a waste of time. Other science educators (Lawrenz, 1986) have found teachers with misconceptions about topics in what appears to be adequate credit in courses that include the topics. Most agree that quantity is

of some importance, but it is clear that the quality of the curriculum and the quality of its teaching impact in important ways on teachers and the children they teach.

The findings of a recent study (Shymansky et. al., 1993) of the impact of the FOCIS approach suggest that it is useful to implement the approach and to study the results in a variety of settings. The tentative indications are that teacher understanding of a science topic is enhanced when the FOCIS materials and approach are used to bring student ideas about the topic and ways to examine those ideas into dominance in teacher education activities. The study analyzed teacher-constructed concept maps and found an increase in total map scores and in the number of central propositions incorporated in the maps. There were indications of a reduction in the number of misconceptions held initially by the teachers. Added to the fact that the science topics under consideration were directly related to what each teacher was teaching, this provides a strong motive for use of FOCIS to teach science to science teachers and teacher candidates.

"Focus on Children's Ideas About Science" is what the title suggests--and more. In addition to focusing on children's ideas about a particular science topic, FOCIS brings out the teacher's ideas about the topic, scientists' ideas about the topic, and the ideas and resources of a learning activity specialist on the topic. FOCIS intends to deal specifically with what a teachers needs to know in order to teach a science topic to students who have specific ideas about the topic.

Why are teachers, teacher candidates, science methods instructors, and local school district curriculum specialists interested in an approach to teaching and learning science that involves focusing on children's ideas about science? Curriculum design, or instructional planning, is clearly a responsibility of anyone who teaches science. All science programs that are currently on the market require a considerable amount of planning by the teacher. It is equally as important that each person who teaches science continue to enhance himself or herself as a teacher by continuing to learn the science that they teach. Focusing on the student's ideas about science involves overlapping processes of accessing the ideas, analyzing the ideas, and

challenging the ideas. Each of these requires teachers to acknowledge **their own** ideas about the science topics they intend to teach and simultaneously helps them to refine their own ideas about the topics--in the direction of the ideas that currently are accepted in the scientific community.

Although FOCIS materials are appropriate for us in a variety of settings, they have been structured with two specific settings in mind. (1) There are nine FOCIS modules available for use in a college-based course for teachers and teacher candidates. Each module includes printed materials and a 30- to 60-minute videotape. (2) FOCIS materials and services for a school district-based workshop series include the services of a FOCIS project consultant, a printed guide for school district leaders (who are trained by the FOCIS project consultant), nine videotapes with associated activity descriptions (which are demonstrated by the FOCIS project consultant) for inservice teachers, and recommendations and assistance for FOCIS extension activities.

The FOCIS modules have been designed for use by science methods instructors who wish to integrate them into their courses for teachers and teacher candidates. The emphasis for such teachers and teacher candidates is on preparing themselves with an approach that they understand and can use in a sustained fashion over many years and, in some instances, can teach to their colleagues. The FOCIS workshop sessions have been structured in four basic phases for use by local school district science curriculum specialists (in conjunction with a FOCIS project consultant) who wish to develop an on-going systematic program of curriculum development and teacher enhancement.

For both the college-based programs and the school district-based programs, the FOCIS materials help science educators to understand and apply the FOCIS approach to an integrated program of instructional planning and teacher enhancement. Instructional planning and teacher enhancement are two areas which traditionally have been treated as separate activities. Despite the fact that most school districts require some or all its teachers to work on instructional planning, districts rarely provide opportunities for teachers to learn new skills or background specific to the instructional programs which the teachers plan. On occasions when such opportunities are

made available, they are usually one-shot or short-lived workshops. When teachers are not prepared to implement a new instructional program, one of two things usually happens: (1) Either the new program is radically distorted and possibly rendered ineffective by teachers who adjust the programs to fit what they are already doing, or (2) the new program is discarded or ignored after a short time when teachers get frustrated trying to make it work. Instructional planning and teacher enhancement are interdependent. They both require new learning of subject matter and of teaching strategies and skills.

This is especially difficult for beginning teachers and even more difficult for teachers whose own education has not included those science topics on which they are called to teach. Many teachers at all levels have little or no special preparation in certain science topics they are asked to teach. Many new programs are based on assumptions that require teachers to entertain radically new ideas about both teaching and learning. Considering the scope of science topics with which each science teacher needs to be knowledgeable and the fact that ideas about teaching and learning are often weakly-conceived but firmly entrenched, helping teachers develop science background and improve their views about and strategies for teaching and learning requires time and commitment. This is best accomplished when pre-service or inservice courses and workshops provide a beginning for processes that can be implemented over a sustained period of time--extending far beyond the course or workshop enrollment.

Teachers need time to grow and develop, time to interact with science and education experts, time to reflect on their ideas and attitudes about teaching and learning, and time to develop their new ideas. If teachers are using these FOCIS materials before becoming full-time teachers, they are fortunate. They will be in a much better position to assume and maintain their responsibilities for planning instruction and developing their own abilities to understand, use and teach science. If teachers are using the materials while taking time-out from full-time teaching for college-based programs or while participating in inservice workshops sponsored within their own school district, their teaching experience and the consequent knowledge of student ideas will be valuable.

The FOCIS program, whether for college-based science methods courses or for district-based inservice programs, is designed to produce substantive reform in science teaching through a long-term, integrated program of instructional planning and teacher enhancement. It is designed to help teachers and teacher candidates start a process that they will continue long after the course or workshop series has ended. Teachers will be able to work individually or in groups on their own science teaching, one topic at a time. They will also have the opportunity to develop the views and skills that can help in school and district implementation across a two-to-four-year period.

## UNDERSTANDING THE FOCIS APPROACH

The FOCIS approach is based on the notion that effective science teaching allows students to build on what they already know. Such science teaching requires that teachers have a deep understanding of both students' science and scientists' science. In FOCIS the emphasis is on helping teachers develop this deep, dual understanding.

Understanding the FOCIS approach requires understanding learning as an active process of building knowledge structures. This is consistent with Jean Piaget's understanding that learning is an intellectual adaptation process in which new experiences and ideas interact with what a learner already knows. It is also consistent with constructivism as understood by Novak (1987), who identified "construction" as that which:

> *. . . involves at times recognition of new regularities in event or objects, inventing new concepts or extending old concepts, recognition of new relationships (propositions) between concepts, and . . . major restructuring of conceptual frameworks to see new higher order relationships.* (p. 356)

The FOCIS approach recognizes the role of Piaget's assimilation, accommodation, and disequilibration in learning. FOCIS also acknowledges the constructivist's emphasis on the role of prior context-specific knowledge structures. FOCIS sees these structures as acting as both filter and facilitator of new ideas and experiences and helps teachers to understand that these

knowledge structures are, themselves, transformed during learning. The learner is active, dealing with the input through his or her existing conceptual frameworks (Osborne, & Freyberg, 1985).

FOCIS is an approach to science education that emphasizes both science teacher enhancement and science program development. Single- and multi-grade planning by teachers at the classroom, school, or district level is based on both student-held ideas and accepted scientific ideas. FOCIS activities and materials are designed to help teachers access more accurately what students already know about particular science topics and work more effectively with consulting scientists and educators (starting with the course or workshop leader) in order to use both students' science and scientists' science in designing science learning activities.

In order for teachers to access and analyze what the student knows and to design science curricula that challenge student ideas appropriately, FOCIS teacher development includes helping teachers confront and develop their own science ideas. Thus, the FOCIS approach serves as a powerful medium for helping teachers identify the science they need to know for teaching specific science topics to their students.

The FOCIS approach takes advantage of teachers' examination of **their own science** and **their students' science** in light of **scientists' science**. This increased knowledge is aimed at both science program development and teacher enhancement. If teachers and teacher candidates can work as a team (either a "real" school district team or "simulated" team), better experiences and products are ensured. In each case, FOCIS program development is undertaken one science topic at a time. Ideally, each teacher who will be involved in the implementation of the topic will be involved in its development. FOCIS is not a science curriculum but, rather, an approach and a program for science program development and teacher enhancement. Consequently, science programs can be tailored over time to the interests and strengths of teachers and students within individual institutions or districts.

## USING THE FOCIS APPROACH

As indicated above, two FOCIS programs currently are available. Nine modules, each consisting of printed materials and a videotape are available for use in a college-based course. A program divided into four basic phases, a series of extensions, and the services of a FOCIS project consultant is available for use in school district-based workshops for inservice teachers. Using the FOCIS program in either setting requires: (1) a leader or instructor, (2) a science consultant, (3) a science learning activity consultant, (4) a set of FOCIS videotapes and activity guides, and (5) a group of teachers or teacher candidates who can work individually or in teams.

The leader in the district-based setting utilizes services and resources provided by a FOCIS project consultant, a scientist, and a learning activity expert. The course leader in the college-based setting either serves in three closely-related and overlapping capacities (#1, #2, and #3 above) or arranges for other specialists to serve as consultants in one or more of the capacities. If other individuals serve as consultants, it is the course leaders responsibility (in concert with the teachers and teacher candidates who are enrolled) to orient the consultants to the FOCIS approach. FOCIS materials describe the roles of (1) the course leader, (2) the science consultant, and (3) the science learning activity consultant.

The science consultant and the science learning activity consultant must have specific expertise in the particular science topic that is chosen by the teachers and teacher candidates. The science consultant is an expert on the particular science topic that is the focus of the course or workshop series. The learning activity consultant is experienced in both science and pre-college science teaching. The learning activity consultant suggests and demonstrates specific activities that challenge children's ideas and help them refine their own concepts in the direction of the accepted scientific concepts.

The course or workshop leader has the major task of preparing teachers and teacher candidates to access student ideas and to analyze and use them in science program development. The leader also prepares teachers to be active in using the services of the science consultant and the learning activity consultant. The leader helps to bring out the teachers' expertise on

children's ideas as well as the teachers' ideas and their clearly-focused science questions for the consultants.

Both before and after the topic has been planned and taught, each teacher makes a concept map for the science topic. These maps are used to establish a record of teacher enhancement in science and are provided to assist the leader and consultants in their planning.

Specific information is given to the science consultant to assist in making specific preparations for working with the particular group of science teachers so that the science consultant addresses those science concepts that are appropriate for this particular group of teachers and their students. It is emphasized that the primary role of the science consultant in the FOCIS approach is to help teachers understand the major ideas associated with the science topic they have chosen. The science consultant does this by helping teachers bridge the gaps between specific students' ideas and the generally accepted views of the scientific community on those ideas. The science consultant represents conventional scientific knowledge in terms of both process and content. It is <u>not</u> the science consultant's responsibility to identify and demonstrate activities which are appropriate for elementary or secondary school students. However, it is suggested that the science consultant use an activity approach rather than a "chalk talk" approach in teaching the teachers.

The first step in preparing the science consultant for his or her sessions with teachers is to give the consultant copies of the teachers' individual concept maps or a "composite" map from the group. To assist the science consultant in focusing on specific concepts, appropriate comments and questions from teachers are provided. Teacher comments and questions for the science consultant are derived from children's concept maps, predictions, and questions--as well as from teachers' concept maps, comments, and questions.

Using ideas and examples provided in the FOCIS materials, the leader helps teachers and teacher candidates analyze student and teacher concept maps, journals, questions, and predictions. In this way, the group formulates suggestions and questions for the science consultant. Teachers are

encouraged to plan how they will share their students' questions, their ideas, and their concept maps with the science consultant during the session(s) with the science consultant.

If the course leader is different from the science consultant, the course leader meets with the science consultant in order to (1) view and discuss the videotape, "Working with Science Teachers: Tips for Science Consultants," (2) go over the teachers' and children's concept maps and questions, and (3) discuss a tentative set of activities that the science consultant will plan for the session(s) with the teachers.

If the course leader is different from the science consultant, the leader acts as co-leader with the science consultant during the session(s) with the science consultant. He or she takes an active leadership role during the workshop with the science consultant in various ways--such as encouraging teachers to participate in hands-on activities, suggesting that more or less time be devoted to a particular topic or question, reminding teachers of "concerns" they expressed in preparing for the science consultant, and helping teachers focus their questions more specifically (or more generally) when appropriate.

Unless the course leader has the expertise, it has been found that a specialist on science learning activities for elementary or secondary school students is needed. Identifying and preparing a learning activity consultant depends on a variety of factors. Ideally, the resource person understands and is experienced in accessing and analyzing children's ideas and in using them in teaching science. The activity consultant brings activity ideas and materials that work to help children test and refine their own science ideas. This consultant suggests activities and materials that are specific to the topic under development and relevant to such variables as specific student ideas and grade levels. The course leader identifies and prepares the activity consultant--who is usually an elementary or secondary school faculty member, a local science education consultant, or a university faculty member who is a specialist in science education.

Clearly, the teachers' and teacher candidates' knowledge of science and of students is of critical importance. The science teacher must be committed

to developing both knowledge of the scientists' ideas about science and knowledge of children's ideas about science. The course leader helps to refine and focus the teachers' expertise. The FOCIS approach depends on attention simultaneously brought to a science topic, to student ideas about the topic, and to how to teach in a way that reflects both the ideas of the scientific community and the ideas of the student. The power of this approach is that, in the process, both the teacher's understanding of the science topic and the teacher's knowledge of how to teach the science topic are enhanced.

In order to use the FOCIS activities, each teacher should be encouraged to bring to early (and subsequent sessions) any textbooks and resource materials they would like to use in teaching the science topic. Emphasis in using FOCIS activities is on practical and efficient ways of preparing science topics for effective inclusion in the science curriculum across one or more grade levels.

## USING FOCIS ACTIVITIES

Identifying Major Science Ideas

It is critical that course leaders and science consultants, as well as science teachers, be effective in their key FOCIS roles. In large part, the effectiveness of the science consultant is dependent on the course leader and the teachers. They must **prepare for** the science consultant and also **prepare** the science consultant. The science consultant must understand how to work as a team member in helping teachers to understand scientists' ideas about the topic which they have selected. The science consultant needs focused questions and information from the teachers. The science consultant is responsible for laying out the "conceptual landscape" for the key ideas in the science topic. In identifying discrepancies between students' ideas and scientists' ideas, the science consultant helps teachers in their own understanding of the science topics. From this, teachers can identify the most effective ways of teaching--taking advantage of both the students' ideas and the scientists' ideas.

The leader helps both the science consultant and the teachers to understand what the FOCIS approach is and how they use their expertise in implementing the approach. Identifying a science topic for the initial experience with the FOCIS approach is so important that a word of caution is appropriate. When teachers are asked to identify topics for curriculum design projects in their school district, there is a strong tendency to identify the most exotic topics--topics that previously they have not been able to bring successfully into their curriculum. What are the disadvantages of selecting an exotic or unfamiliar topic?

Our own experiences as well as time-tested principles of teaching tell us to use familiar content when introducing an unfamiliar process. Even though the FOCIS approach is simple, it is important that teachers discover the subtle intricacies of the approach within a successful experience. After some practice with the approach, teachers can tackle more complicated, or at least less familiar, topics. The advice, put briefly, is: Choose a familiar topic for the first experience with the FOCIS approach. Choose a topic that each teacher

or teacher candidate has taught or, at least, a topic about which they are somewhat knowledgeable.

One of the leader's main responsibilities for the initial FOCIS experience is to ensure that the science consultant assumes a role as a team member. Since a teacher in any school district may be asked to lead inservice activities, it is important that the course leader allow teachers and teacher candidates to be aware of how a science consultant can be prepared to assist or to conduct workshop sessions. Similarly, it is important that the course leader teach (by example) how to help teachers to be active rather than passive in their learning of science from the science consultant. If a familiar science topic is chosen, the task is much simpler.

The FOCIS approach to "identifying major science ideas," is emphasized in videotapes and the associated activity guides for three FOCIS modules. The first module, "FOCIS: An Approach to Curriculum Design and Teacher Development," is intended primarily for the initial orientation of the teachers. A second module, "Studying Student Ideas in the Classroom," is used to help teachers see how to use their normal interactions with students in exploring students' ideas about science. A third module, "Working with Science Teachers: Tips for Science Consultants," is directed specifically toward the science consultant's role in the FOCIS approach.

## Learning how to Concept Map

The FOCIS approach emphasizes the importance of teachers determining the ideas that students already have--particularly prior to teaching a new science topic. One of the key FOCIS activities deals with "concept mapping," a technique for representing what is understood about a particular topic or set of ideas. Based on Ausubelian learning theory and popularized in the writings of Novak and Gowin (1984), the concept map has become important as a teaching, learning, and knowledge-accessing tool. The FOCIS modules help to teach teachers how to make a concept map and how to teach mapping to their students. This includes helping teachers to explore the

power of concept maps in promoting meaningful learning and higher-order thinking in both teachers and students.

## Mapping the Science Topic

Using their knowledge of concept maps, teachers and teacher candidates work in small groups to develop a concept map of the major ideas of the science topic they have selected. The small groups then merge their maps into an initial composite map. This mapping process is intended to stimulate discussion and debate among the teachers about conceptual matters. Unresolved issues about the maps establish a basis for discussions, demonstrations, and other activities that will be led by the science consultant.

In making the concept maps, it is essential that teachers be made to feel comfortable with both what they know about the science topic and what they do not know about the topic. They must be ready to reveal their own concepts, regardless of whether they perceive them as correct. The essence of the FOCIS approach is to bring out concepts and then to find ways to refine them. Of course, this process cannot succeed until the teacher is comfortable in bringing out his or her own ideas.

The course or workshop leader and the teacher participants play critical roles in establishing teachers' feelings of confidence and comfort within the group. During sessions in which teachers have their initial experience in applying the FOCIS approach to a science topic, the course leader leads the activities that help teachers to map their own science ideas. With subsequent science topics, teachers and teacher candidates assume more responsibility--until they are able to lead others through the process.

## Learning How to Interview Students

The FOCIS modules have been found to be most useful if activities on "learning how to interview students" start during the early class or workshop sessions and are repeated for each science topic. As soon as teachers have

identified a science topic and made their own concept maps, they begin to consider how to find out what and how their students think about the topic. Emphasis on finding out about student ideas culminates in individual interviews in which teachers construct for each interview a concept map that reflects the ideas each student expresses in the interview. Most teachers have found that it is most useful to teach their students how to construct their own concept maps. Then it is possible for the teacher to interview individual students on the basis of a concept map which the student has constructed.

Identifying informal approaches to finding out about student ideas on science topics is often the most challenging for the teachers. In the early modules of the FOCIS series, teachers identify questions and/or predictions to ask of students--in order to access student ideas. Just as it is often difficult for teachers to reveal ideas about which they are not sure, it is often awkward for students to state decisions and explanations unless they have been "validated" by an authority such as the textbook or the teacher. The workshop or course leader helps in bringing out the resourcefulness of the teachers in deciding the approaches and the specific strategies to use in these initial quests for student ideas.

At this early stage, the leader must encourage teachers to "make a start"--regardless of their uncertainty. Only one guideline is necessary at this point: **Find out what and how the student is thinking--without changing the student idea or the manner in which the student expresses the idea**. Use any ideas the teachers have on how to find out about student thinking--so long as it does not change the student's idea. What usually is found is that emphasis on not changing the student idea relieves teachers of some pressure. Teachers can ask questions or request predictions and explanations without the obligation of knowing what the "correct" response is. Teachers can ask questions that do not have single correct answers. The one single intention in this activity is to find out (without changing it) what and how students think about the science topic.

Sometimes teachers cannot come up with questions or predictions to use in these early quests for student ideas. One straight-forward approach that has worked is to identify text-book illustrations (such as photographs, drawings, graphs, or tables) that can be shown to a student in order to ask:

What meaning do you see in this? How does "this" relate to "that?" What would you add to this in order to have a complete explanation?

Another effective strategy consists of three steps. (1) Say to either an individual student or a group: "I'm going to read a paragraph. It has some correct ideas and some incorrect ideas in it. I want you to listen and then tell me what part of the paragraph agrees with your own thinking and what part does not agree with your own thinking." (2) Read a passage (paragraph or page) that is an explanation for some phenomenon that is relevant to the topic that your workshop group has selected. (3) Give students time to describe (orally or in writing) their ideas.

After becoming familiar with concept mapping (and perhaps after learning how to teach it to students), teachers and teacher candidates focus on the clinical interview as a strategy for probing student ideas about the science topic under consideration. The student ideas provide a starting point for instruction, but more importantly, a **focus for curriculum design**. Teachers learn how to use concept maps as a tool in interviewing students. Either constructing a concept map from an interview with a student or using concept maps that the student has made, teachers conduct the interviews that are necessary in order for their curriculum design to take advantage of student ideas on the science topic being developed. These interview findings are also shared with the consultants in order to help in keeping the session(s) properly focused.

## Analyzing Student Ideas

The next step in the FOCIS approach involves activities in which teachers analyze the scientific merit of the students' ideas from their interview data and classroom interactions with students. In this phase, teachers develop science background that is critical to their understanding of their particular science topic and to their planning for teaching the topic. This is done primarily during FOCIS sessions in which the teachers are preparing for the science consultant and during the sessions with the science consultant. The challenge of analyzing student ideas has been found to be easier if teachers

bring to the session with the science consultant clear indications of what the students' ideas are on the topic.

Planning Single- or Multi-Grade Instruction

After student ideas are **accessed** and **analyzed**, teacher teams are ready to set parameters for teaching the topic. Based on their analyses of student ideas, the teams discuss and set plans for teaching the major ideas of the topic at specific grade levels that are represented in their team. Rather than simply dividing the ideas among by grade level, teachers discuss together the need to teach and re-examine the major ideas at every grade level. There are three FOCIS modules, consisting of videotapes and associated printed activity guides on "Using Student Ideas in Teaching Science:" (1) "Getting Started," (2) "Interactive Strategies, and (3) "Challenge Strategies." From the FOCIS perspective, the major emphasis in teaching science is the **challenge** of the student's own ideas--by the teacher and by the students. FOCIS planning involves accessing student ideas, analyzing student ideas, and deciding how best to challenge student ideas.

## USING THE FOCIS MODULES IN A COLLEGE-BASED SCIENCE METHODS COURSE

There is some repetition in the different FOCIS modules (especially the printed activity guides) in order to make it convenient for groups to vary the sequence in which the modules are used for teachers or teacher candidates. Each FOCIS module includes a printed guide and a videotape. Each videotape is 30 to 45 minutes in length. Although the modules may be used in whatever sequence works best for a particular group, the following sequence has been found by most groups to be ideal:

1. "SCIENCE CURRICULUM REFORM: An Action Plan for Change" is recommended for use in providing an orientation to the remaining modules.

   Dr. James Shymansky introduces current thinking on school science reform and invites each teacher or teacher candidate to

use the FOCIS approach as a way of being more effective and feeling better about teaching science, as well as for preparing for leadership in refining his or her own science curriculum. The videotape is useful for individuals and groups (both pre- and inservice teachers) who are considering ways of examining and improving their science teaching and their science program.

2. "STUDYING STUDENT IDEAS IN THE CLASSROOM" provides an overview of "accessing" student ideas and is recommended for use in an early session--in order to give teachers time and opportunity to identify students who will serve as students for the teachers' application of the FOCIS approach.

   Dr. Charles Matthews introduces some ideas and examples on how to use normal classroom interactions with students for the purpose of identifying and probing student ideas. He invites teachers to identify ways to use this information about student ideas in shaping their science teaching and their science curriculum.

3. "WORKING WITH SCIENCE TEACHERS: Tips for Science Consultants" provides an overview of "analyzing" student ideas and is recommended for use in an early session--so that teachers can begin to anticipate the most useful ways of preparing for the science consultant.

   Dr. Matthews introduces ideas and questions on how the science consultant can prepare for and use the questions and ideas of teachers in helping teachers refine their own science concepts. Dr. Matthews invites both the science consultant and the teachers to make careful preparations for such sessions. Teachers use the videotape and the associated activities to develop plans for identifying their questions and suggestions for the science consultant.

4. "USING THE CONCEPT MAP TO FIND OUT WHAT STUDENTS KNOW" is recommended for use in following-up Module #2.

   Dr. Shymansky and Dr. Joe Novak introduce the theory and development of concept mapping as a means of "ascertaining what the learner already knows." It is intended to help teachers focus their energy and expertise on student ideas and to help teachers shape their science curriculum accordingly.

5. "USING THE CONCEPT MAP AS A GUIDE IN PLANNING THE CLINICAL INTERVIEW" is a module that can be used independently of other modules. It is recommended for use as a follow-up to Module #4.

   Dr. Matthews presents a series of ideas and examples that help in planning a clinical interview on the basis of a student's concept map. He shows how initiating change in a science curriculum on the basis of students' ideas requires planning ways to probe the student's concepts beyond what the student can put on paper. This module is structured for the teacher who intends to interview on the basis of a student-constructed map, but provides helpful suggestions that can be applied to situations in which the teacher constructs the map from ideas the student provides during the interview.

6. "CONDUCTING A CLINICAL INTERVIEW ON THE BASIS OF THE STUDENT'S CONCEPT MAP" is recommended for use in refining the teacher's understanding of the use of concept maps and in helping to improve interview skills.

   Dr. Matthews raises questions and presents examples to help teachers decide how to conduct a clinical interview on the basis of a student's concept map. The interview examples are intended to show techniques that teachers will want to avoid as well as techniques teachers may wish to use. The videotape helps teachers to identify their own guidelines for conducting clinical interviews as a means of examining their students' science concepts. It is useful whether teachers are interviewing on the basis of student-constructed maps or are constructing the maps for students during or following the interview.

7. "USING STUDENT IDEAS IN TEACHING SCIENCE: Getting Started" is recommended for use with or without the preceding modules. Modules #7, #8, and #9 are quite flexible and have been useful in a variety of settings.

   Dr. Shymansky introduces a series of examples of how a classroom teacher gets started teaching a particular science topic. Both "good" and "bad" teaching examples are shown in

order to stimulate thought about what is best for teachers' own teaching.

8. "USING STUDENT IDEAS IN TEACHING SCIENCE: Interactive Strategies"

   Dr. Matthews presents some examples of how a science teacher can teach by accepting and using students' existing concepts, by building students' confidence in their own ideas, and by giving students opportunities to refine their ideas about science. He emphasizes the importance of teachers being critical of the examples depicted in the videotapes and of teachers using their own ideas in developing guidelines for teaching. Both "good" and "bad" teaching examples are shown.

9. "USING STUDENT IDEAS IN TEACHING SCIENCE: Challenge Strategies"

   Dr. Matthews presents a variety of effective and not-so-effective examples of how a teacher can take advantage of students' science concepts as well as their confidence in those concepts. Examples deal with both challenging students to support their explanations with evidence and challenging students to find observations that support or refute their ideas about science topics.

## USING THE FOCIS WORKSHOP MATERIALS IN A DISTRICT-BASED WORKSHOP SERIES

A Sample Basic FOCIS Workshop Sequence for a First Science Topic

The following sequence of topics and activities represents a basic, or minimum, FOCIS workshop series for a school district. It represents but one way for inservice teachers to learn the FOCIS approach by applying it to a first science topic. Topics and activities that are identified for a "Workshop Session" are intended for groups of teachers working together. Those activities that are identified as "Outside Activities" are intended for individual teachers to carry out in their own classrooms and to share in the next workshop session. Topics and activities that are identified briefly below are

elaborated in a printed guide for the FOCIS leader and in a guide for the teacher.

The leader's guide assists school district leaders in associating each of the following with the materials in their "FOCIS Library." The leaders' planning will depend on their own assessment of conditions in their school district. After the FOCIS project consultant leads teachers in applying the FOCIS approach to one or two science topics and after teachers have applied the approach to two or three additional topics under the supervision of the district FOCIS leader (or leadership team), it is anticipated that teachers will have found the FOCIS approach to be a natural and continuous process, requiring a minimum of workshop activity. Individuals and groups of teachers will be able to use the approach independently for long-term curriculum planning as well as for short-term Lesson planning.

Phase One SCIENCE CURRICULUM REFORM: An Action Plan for Change

Workshop Session: Background and rationale for "FOCUS ON CHILDREN'S IDEAS ABOUT SCIENCE: An Approach to Curriculum Design and Teacher Enhancement"

Workshop Session: Preliminary scope of the first science topic; individual teacher concept maps of the science topic

Workshop Session: Informal classroom strategies for studying student ideas--such as planning informal interviews with student, prediction activities, and student journals

Outside Activities: Initial gathering of student ideas--using such strategies as prediction sheets and journals

Phase Two CONCEPTUAL ISSUES REGARDING STUDENT IDEAS ABOUT SCIENCE: Concept Mapping and Other Strategies for Studying Student Ideas

Workshop Session: Identifying conceptual problems in ideas gathered from students

Workshop Session: Preparing for clinical interviews with students

Workshop Session: Teachers constructing group concept maps

Outside Activities: Gathering student ideas about the science topic; using such strategies as concept mapping and the clinical interview

Phase Three ORGANIZING INFORMATION ON STUDENT IDEAS: Preparing for the Workshop(s) with the Science Consultant

Workshop Session: Presenting student and teacher concepts about the science topic

Workshop Session: Comparing student and teacher concepts about the science topic

Workshop Session: Identifying questions about students' and scientists' ideas about the science topic

Outside Activities: Gathering student ideas and formulating teacher questions about the science topic

Phase Four ANALYZING RELATIONSHIPS BETWEEN SCIENTISTS' IDEAS AND STUDENTS' IDEAS: Workshop with the Science Consultant

Workshop Session: Working with the science consultant to analyze student and teacher science concepts

Workshop Session: Working with the science consultant to refine student and teacher science concepts

Workshop Session: Each teacher making a second concept map of the topic and comparing it to his/her first concept map (from Phase One)

Workshop Session: Reviewing FOCIS purposes and roles

Outside Activities: Gathering more student ideas through interviews and "normal" classroom events; planning and refining activities to be more consistent with accessing, analyzing, and challenging student ideas about the current and subsequent science topics

A Sample Activity Series for Extending the Basic FOCIS Workshop Activities

The following sequence of topics and activities represent an extension of the "basic" FOCIS workshop series identified above. It represents further teacher and curriculum development with emphasis on multi-grade planning and refinement of learning activities.

Extension Activity #1--Creating grade level outlines for the science topic

Workshop Session: Using FOCIS videotapes and printed activity ideas to get started basing classroom strategies on student ideas; ideas for getting students started with competence and confidence

Workshop Session: Using the expertise and resources of the learning activity consultant to identify and develop specific learning activities

Outside Activities: Initiating the FOCIS topic in the classroom while facilitating student competence and confidence

Extension Activity #2--Basing classroom strategies on student ideas--keeping students involved

Workshop Session: Using FOCIS videotapes and printed activity ideas to establish and maintain FOCIS interactive strategies; ideas for helping students access and express their own ideas and the ideas of others

Outside Activities: Sustaining the FOCIS topic in the classroom while encouraging interactions that help students access and express their own ideas and the ideas of others

Extension Activity #3--Basing classroom strategies on student ideas--challenging student ideas

Workshop Session: Using FOCIS videotapes and printed activity ideas to establish and maintain FOCIS challenge strategies; ideas for helping students challenge and refine their own ideas and the ideas of others

Workshop Session: Recognizing the power of focusing on student ideas when teaching science by each teacher making a third concept map of the topic and comparing it to the first concept map (from Phase One) and the second concept map (from Phase Four)

Outside Activities: Using science lessons to help students challenge and refine their own ideas and the ideas of others

A Sample Workshop Sequence for Subsequent FOCIS Teacher Enhancement and Curriculum Design Topics

After teachers have applied the FOCIS approach to the first science topic, they can be much more self sufficient in applying it to a second topic and subsequent topics. The "routine" steps for subsequent topics normally will include:

Step 1--IDENTIFYING THE SCIENCE TOPIC AND STUDENT IDEAS ABOUT THE TOPIC

Workshop Session: Identifying the new topic in a cross-grade-level workshop session; each individual teacher making a concept map for the topic; planning specific preliminary student interviews and prediction activities for students

Outside Activities: Studying student ideas on the topic--using such strategies as predictions, journal entries, concept mapping, and clinical interviews

Step 2--PREPARING FOR THE SCIENCE CONSULTANT

Workshop Session: Analyzing student ideas and preparing questions for the science consultant

Outside Activities: Teachers continuing to collect information from students; the FOCIS leader or teachers preparing the science consultant

Step 3--WORKING WITH THE SCIENCE CONSULTANT

Workshop Session: Presenting student and teacher science concepts to the science consultant

Workshop Session: Evaluating and refining student and teacher science concepts

Workshop Session: Each teacher making a concept map of the topic

Outside Activities: Teachers continuing to collect information from students; the FOCIS leader or teachers preparing the activity resource consultant

Step 4--PLANNING ACTIVITIES AND IDENTIFYING MATERIALS

Workshop Session: Planning the classroom activities with the activity resource consultant

Outside Activities: Trying out the classroom activities

Step 5--CREATING GRADE-LEVEL OUTLINES

Workshop Session: Creating grade level outlines that reflect plans for "revisiting" the science topic at each of the grade levels represented by the teacher team

Workshop Session: Each teacher making a concept map of the topic

Outside Activities: Trying out the activities from the grade-level outlines and preparing reports back to the teacher teams

## CONCLUSIONS

FOCIS integrates teacher enhancement with curriculum design. It is clear that the key to a successful science curriculum is the teacher. It is the teacher who ultimately determines the curriculum. During the last five years the FOCIS project has developed nine videotapes that emphasize the simultaneous enhancement of science teachers and development of science curriculum. By helping teachers understand and develop skills in accessing, analyzing, and challenging student ideas, both student preconceptions and scientist conceptions become essential parts of science teacher education and science teaching. Although these videotapes may be used singly or in various combinations in a variety of settings, two specific programs are recommended.

(1) For use in college-based courses for teachers and teacher candidates, nine FOCIS modules are available. Each module consists of a 30- to 60-minute videotape and a printed set of background ideas and activity descriptions. THese modules may be purchased separately or in any combination at minimum cost. Either the course instructor acts as the science content specialist and the science learning activity specialist or calls on "outside" consultants to serve in these roles. FOCIS materials includes suggestions for preparing a science consultant and a science learning activity consultant.

(2) For inservice programs set up by school districts, FOCIS materials are structured into four basic phases and suggested extension activities. A

FOCIS project consultant implements the FOCIS approach with school district multi-grade level teacher teams and trains a science consultant, a science activity consultant, and a FOCIS leader who is identified by the school district. As FOCIS is applied to two or three science topics the local school district leader gradually assumes the responsibility for sustaining the project in the local school district. The leader becomes independent in using FOCIS print and video materials for subsequent workshop series within the school district.

Further information about the purchase of FOCIS materials and services, including a FOCIS project consultant, are available from the FOCIS project.

FOCIS PROJECT
757 Van Allen Hall
The University of Iowa
Iowa City, IA 52242
Telephone 319/335-1167
FAX 319/335-1188

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