The Minds of Our Own Teachers Guide
is produced by The Private Universe Project at The Harvard-Smithsonian
Center for Astrophysics

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what's inside

1. Introduction

2. About Minds of Our Own

3. Tips for Teachers
   - Eliciting Students' Ideas in the Classroom
   - Planning Effective Science Lessons

4. Advice for Administrators
   - Encouraging Classroom Change
   - Supporting Changing Teachers

5. An Appeal to Parents
   - Establishing Partnerships
   - Helping Children Learn

6. Guide to the Programs
   - Hour 1: Can We Believe Our Eyes?
   - Hour 2: Lessons From Thin Air
   - Hour 3: Under Construction
Section I Introduction

Minds of Our Own: A Force for Science Education Reform

The field of science education is experiencing some of the most comprehensive changes in its history. Research has revealed that our old ways of teaching seldom result in real learning. Even widely accepted approaches, such as using hands-on activities, often fail to translate into meaningful learning. Responses to these findings are both broad and deep. National efforts to set benchmarks and standards for science learning have been published; state frameworks for science education are being revised; and local school boards and experimental “charter” schools are exploring new approaches to fostering science learning in our children.

What do these changes mean to the teacher, the teacher educator, and the curriculum developer? How does reform rely on the support of parents, policy makers, and other members of the educational community? Minds of Our Own is an Instructional Television series designed to engage professional educators and other interested members of the community in issues of science education reform. Through watching Minds of Our Own and performing the activities in this guide, you can make sense of and make use of new teacher-tested approaches to helping students achieve a meaningful learning of science.

Minds of Our Own: The Successor to A Private Universe

In 1985, Matthew H. Schnepe and Philip M. Sadler of the Science Education Department at the Harvard-Smithsonian Center for Astrophysics created A Private Universe, a video program for science teachers. The program opens with a segment in which newly-minted Harvard graduates, dressed in caps and gowns, discuss their theories for the causes of the seasons. The Harvard grads, intelligent and articulate, speak eloquently about their ideas, which are, for the most part, erroneous. Through interviews with high school students and teachers, and scenes of classroom activities, A Private Universe demonstrates how a student’s preconceived ideas and beliefs can pose critical barriers to learning science, whether the learning environment is a public school or a prestigious private college.

Since A Private Universe was released for distribution on video-cassette, it has enriched workshops and presentations for tens of thousands of teachers and education students. A Private Universe has been cited often as being among the most significant works of its kind, influential in bringing to light a major problem in science education to a broad audience. The impact of A Private Universe is reflected in the numerous prestigious awards it has earned and the many positive reviews it has received in both popular and educational publications.
While *A Private Universe* alerted the science education community to a serious problem, *Minds of Our Own* both explores the problem in more depth and proposes a variety of solutions. During the development of the Private Universe Project, resulting in the production of *Minds of Our Own*, the producers conducted a series of nine interactive teleconferences with science educators, including large numbers of K–12 teachers of science, from across the country. Teleconference participants evaluated video material and educational ideas, contributing detailed feedback that helped shape the final programs. *Minds of Our Own* is the first educational video series to be made with such an extensive collaboration between educators and video makers.

**Using Minds of Our Own**

*Minds of Our Own* can be used with a variety of educational approaches. The videos are designed to be used by in-service and pre-service teachers, teacher educators, workshop leaders, school administrators, college and high school students, parents, and the general public. The programs are especially well designed for the following.

- Distance Learning/Telecourses
- Library collections
- Preservice teacher education courses
- Inservice teacher workshops
- High school courses
- Presentations to parent groups, administrators, or the general public

This guide offers you a starting point for using *Minds of Our Own* in a variety of learning situations, including those listed above. In this guide you will learn about the research and philosophy that provides the framework for the programs; you will find explanations of general activities that have been shown to improve science learning in the classroom; and you will be given information and activities specific to each program and to each potential audience group.
Section 2 About Minds of Our Own

Learning is an active, living process. Each time we confront a phenomenon or an idea, we call up the understanding and beliefs we developed from previous encounters. By comparing a new experience with our earlier understanding, we, as learners, construct a concept that makes sense to us.

Unfortunately, many of the science concepts that children and adults construct are at odds with the theories, models, and ideas of scientists. Much of what scientists know about the world makes little intuitive sense in the light of everyday experience. Air can have weight? The Earth moves around the Sun? Objects stay in motion forever unless stopped by a force? Despite the fact that these concepts may run counter to experience, our students will fail to learn science if they cannot understand these and other ideas of scientists.

Teachers need time and experience with students' ideas in order to guide students toward understanding and accepting science concepts. Providing the time and experience for effective science teaching requires the collaboration of teachers, administrators, parents, and policy makers. Minds of Our Own contributes to this collaboration by bringing a large body of research on student learning to a wide audience within the education community. By asking new questions (and old questions in new ways), teachers and researchers are getting some surprising answers about students' ideas — answers that should affect the way we teach science for years to come.

Question:
What ideas do students bring to science lessons?

It seems reasonable to assume that children come to a completely new science topic with open minds. Having never before encountered the content of the lesson in their school work, children may be assumed to be "blank slates" or "empty vessels" ready to be filled with a teacher's facts.

Researchers have confirmed, however, what many teachers and parents have always known. Children's minds are already filled with their own thoughts, ideas, and theories concerning just about everything. Where do children get these ideas? Children — and adults as well — constantly
make sense of everyday experiences; of the words and actions of other people; and of statements and images found in books, films, television, and other media. The resulting ideas, born of experience and thought, can be quite persistent, even when they clash with the science concepts presented by teachers. In Minds of Our Own you will witness examples of typical students whose pre-instruction ideas survive unchanged by classroom experiences. These students range from public school pupils to recent graduates from our finest universities.

The teacher who understands students’ prior ideas can plan focused and effective lessons that will help students to learn, starting with their own ideas and bridging the gap to the ideas of science. Such lessons require a clear picture of students’ initial ideas as well as frequent probing during the lesson. In this way, the teacher can gauge the students’ progress and adjust the lesson to the newly revealed needs of the students.

Minds of Our Own investigates the background of several learning problems. For instance, the discovery that many recent Harvard and MIT graduates cannot make a simple electrical circuit from a battery, a light bulb, and some wire leads the program to investigate how students interpret these ideas in the classroom. Even after high school students study electricity in class and in the lab, many of these students, like their older counterparts at Harvard and MIT, show no understanding of electrical circuits.

The high school students’ teacher, although a skilled and experienced educator, unconsciously assumed that his students already understood the concept of a circuit that he was trying to teach. The result is that the teacher taught only to the students who already understood the ideas of the lesson, leaving many other students confused. When the teacher begins to plan and conduct his lessons with more attention to students’ ideas, we see the quality of the learning improve.

For a list of techniques for probing students’ prior ideas, please refer to Section 3.

Question: Why do students’ prior ideas about science so often disagree with those of scientists?

As stated in the above section, many of the ideas that students bring to the classroom run counter to those held by scientists. In this sense, many children’s ideas can certainly be considered “incorrect.” Transported back in time, however, many of students’ most common ideas would be quite acceptable to some of history’s greatest thinkers. In their natural curiosity and ability to make
connections, many children have rediscovered theories about nature that were held by Plato, Aristotle, and other honored philosophers and scientists.

Rather than being signs of failure, students' non-scientific ideas can be evidence of sophisticated observation and reasoning. Teachers can tap into these natural abilities by guiding students through activities employing some of the techniques used by scientists. Like scientists, students can recognize their own initial ideas and test them through experiments of their own design. Based on their experiments, students can develop theories about the natural world.

Teachers who recognize students' ideas as starting points for exploration, rather than as errors to be replaced with "facts," will transform their classrooms into safe places for students to think and learn. Fear of stating the wrong answer — of making a mistake — can be a major impediment to student participation in traditional classrooms. Students are much more willing to take the chances that lead to learning when their ideas are honored for what they are: good initial efforts at understanding, efforts that can be tested and adjusted, resulting in a higher level of understanding.

Please refer to Section 3 for more tips on guiding students through a meaningful learning process.

**Question:**

How can a teacher help students to truly learn science?

There is no single teaching method that is guaranteed to work better than all others. There are, however, some approaches that are more likely than others to foster meaningful learning. Taking the time to recognize students' ideas as they develop, acting as a guide to learning, and creating a safe place in the classroom for students and teacher to explore together are among the more successful approaches guiding successful practice.

Teaching for meaningful learning — for students to be able to make sense of the ideas taught to them — is well worth the extra investment of time. If the goal of teaching is for students to truly understand the lesson, then teaching without a focus on meaningful learning would be a waste of time and effort, leaving many students with their prior ideas unchallenged and unchanged.

Fortunately for teachers, students' ideas tend to recur in certain predictable patterns. Once a teacher has become familiar with how students tend to interpret experience, less time can be spent on probing
students' ideas. Teaching time can also be focused by emphasizing the small number of fundamental science ideas that students should learn well. These ideas will serve as foundations for later student understanding.

In terms of first steps, the clear message of extensive research and practice in the classroom is to start by uncovering the students' prior ideas. While this may sometimes take a while, many of the approaches listed in Section 3 can be performed efficiently or integrated into the lesson plan.

Starting from the students' initial ideas, the teacher can define his or her goals for learning and then create a lesson plan that achieves these learning goals through a variety of means. The goal of learning will be to help move the students from their initial ideas to the more powerful way of understanding the world that is offered by scientists. The teacher can build into the lesson plan opportunities for frequent probing of the students' developing ideas. In a science lesson, the learning goal is to help students "cross the bridge" from their initial ideas to those accepted by scientists.

For examples of lesson plan approaches, please see Section 3.

**Question:** How can teachers accurately assess the understanding of the students? Any approach to teaching can fail to help some students to learn science. Unfortunately, traditional testing methods often fail to reveal the failure. Clever students have always been able to pass traditional tests through memorizing terms and equations without truly understanding them. Students are very good at giving teachers the answers that they want to hear.

Adopting new approaches to teaching does not mean that traditional testing methods have to be abandoned entirely. Multiple choice and short answer questions can be designed with an eye toward student understanding, rather than emphasizing memorization of vocabulary and equations. True/false questions can be enriched by asking the students to write their reasons for their answers. Approaches to upgrading these traditional methods are outlined in Section 3, as are more recently developed ways of assessing students' understanding. These techniques include portfolios, performance assessment, and out-of-context questions.

Teaching for understanding is more difficult than teaching for memorization. While many students may be able to remember the names and terms associated with a science concept, fewer may truly understand the concept itself. Don't be too hard on yourself (or your students) if fewer of them score well on tests designed for understanding than on tests of memorization. This is a natural part of shifting toward a new way of teaching and learning.
Section 3 Tips for Teachers

Eliciting Students’ Ideas in the Classroom

In the Minds of Our Own video footage we often witness children revealing details about their ideas and beliefs in words, diagrams, and drawings. These video scenes are excerpts of in-depth, on-camera interviews during which researchers questioned students about their ideas. While one-on-one interviews with students will uncover student understanding in the greatest detail, it is, of course, highly impractical for a teacher to interview each student before each lesson. The techniques discussed below have been designed and tested by teachers with an eye toward fitting them into lesson plans with little extra time investment. Many of these techniques function both to uncover student ideas and to help stimulate student learning.

“Just Listening”

Sometimes clues to students’ ideas pop up at unexpected occasions. For instance, a non-scientific answer given verbally in class may be the result of some interesting thinking that can be redirected towards the goals of the lesson. If you dismiss answers as merely “wrong,” you may lose a valuable teaching opportunity. Try to discover why students think the way they do when they give “wrong” answers. Showing respect for the students’ thinking will help you to understand their logic and help you win their admiration and trust, making the classroom a safe place in which to learn. Other occasions when you might find clues to students’ ideas include listening to group discussions as students work on a problem; listening closely to “trivial” statements made to you or to other students about television programs, sports events, stories in the news, or personal experiences; and reading between the lines of students’ learning logs or other written works.

Interview

As mentioned above, interviewing is time-consuming. Occasional brief interviews with just a few students, however, can serve as a way for you to check your impressions of students’ ideas in detail. Limit your interview questions to open-ended ones, rather than those with yes or no answers. Make sure that the students are firmly committed to their answers. Having students draw pictures and diagrams of their ideas as they talk will give you a clearer picture of what they really mean. Remember that the purpose of the interview is to gather information, not to teach. Avoid the natural impulse to lead the student to the “correct” answer through verbal and non-verbal cues.
Ungraded Pre-Tests
A straightforward way of uncovering students' ideas prior to a lesson is to administer an ungraded pre-test. This can be a low-stress experience for students if you emphasize that you are only gathering information to help in your lesson preparation, not testing the students' abilities or achievement. The pre-test may be more revealing if you base the questions on student ideas discovered in previous classes or in research articles. (See Learning from the Literature, below.) However, include enough open-ended questions to uncover new ideas that may surprise you.

Learning from the Literature
Teachers and researchers have examined many issues of student concepts in science for over two decades. You can tap into the resulting large body of literature to plan lessons based on the students' most likely ideas. The most heartening message from the research is that there is a limited number of ideas students are likely to hold about any particular science topic. While it is always important to keep yourself aware of your students' ideas as they develop, starting by teaching to the ideas that you find in the research literature is a good initial strategy.

Student Predictions: Journals and Essays
Before presenting a phenomenon in class or in a hands-on student experience, have the students write down their predictions of what they expect to happen and their reasons for their predictions. When, as often happens, the phenomenon behaves completely differently from many of the students' predictions, the students will feel startled, helping them to remember and begin to understand the ideas. If you get the students to discuss their predictions and their explanations before the lesson, you may uncover several interesting alternative ideas.

Learning Logs
Having students keep notebook diaries or logs of their ideas as they learn can serve at least two purposes. First, when you regularly collect and read the notebooks, you get a detailed picture of the students' developing ideas, both individually and as a class. Second, developing the habit of regularly reflecting on their own learning process helps stimulate students to take more responsibility for their own learning. For instance, by writing down new ideas, students may see that some of their old assumptions no longer explain their observations or experiences.
Student Discussions and Debates
Sometimes students are more likely to express their science concepts when discussing or debating their ideas in small groups of their peers. Assign provocative questions to groups of two to four students. By circulating among the groups and by asking representatives from each group to report on the discussion to the class as a whole, you can often obtain a vivid picture of the range of student understanding about the topic. Sharing these ideas with the class also motivates students to search for an explanation that makes the best sense.

Posters
Individually or group created posters, on which students display their science ideas in words and in graphics, combine some of the most useful aspects of several other probing techniques. Students can work in small teams (2-4) to illustrate their ideas in response to a specific problem defined by their teachers. Each group can report its ideas to the class, using the poster as a guide. Posters can include words, diagrams, drawings, pictures from magazines, and any other items that can clarify the students’ ideas. Posters allow students to make a concrete commitment to their ideas and stimulate students to further learning.

Student Drawings and Diagrams
Pictures can certainly be worth many words when it comes to revealing some of the details and subtleties of students’ ideas. Asking students to include drawings and diagrams along with the verbal descriptions of their ideas in interviews, learning logs, and class discussions can provide excellent insights to student understanding.

Planning Effective Science Lessons
Teaching for understanding requires flexibility and patience. Each class of students will hold somewhat different ideas and present varying challenges and opportunities for teaching. Since paying attention to students’ prior ideas and the ideas they construct during the lesson is important in this teaching approach, you should plan lessons that include opportunities to probe for these ideas. You need not abandon traditional science teaching goals, whether they include content knowledge or experience with scientific processes. When you uncover the students’ ideas, the most effective path to achieve your teaching goals will become clearer. Minds of Our Own includes several approaches to lesson planning and execution. Some of the most effective, teacher-tested approaches are described below.
Creating a Safe Place for Learning
From the very beginning, students will learn faster and more effectively in a classroom that you have made a safe place for learning. When you honor each student's ideas and treat student errors not as failures but as interesting problems for exploration, students will be more willing to reveal their ideas to the class and take bold steps toward understanding. This does not mean that all ideas should be treated as equally valid from a scientific point of view. It does mean, however, that all ideas are important steps toward a deeper understanding of science.

Negotiating Learning Goals With Students
Your students will be more willing to invest their time and effort into the process of learning if they have had a hand in setting the learning goals for themselves. There are many ways to negotiate learning goals with students, ranging from individual conferences to whole-class discussions. In Minds of Our Own, a fourth-grade teacher starts the lesson on decomposition by listing what the class members already know and what they want to know about the subject. The students in this class may not realize that "negotiation" is the name for the process, but they clearly display a deep engagement throughout the weeks of the lesson, as we witness in the videotape.

Bridging Between Ideas
Starting from the students' initial ideas and working toward the science ideas, you may encounter a wide gap in student understanding. It is up to the teacher to help bridge this gap by providing rich learning experiences. These experiences can be direct "hands on" encounters with natural phenomena, but you must probe the students' ideas as they develop. Without guidance, hands-on activities can produce just as many non-scientific ideas as can other sources. One approach to bridging the gap between students' and scientists' ideas is to provide a series of "bridging analogies" — ideas, demonstrations, and activities that link the original students' ideas with the scientists' ideas through intermediate examples.
Guiding Student Learning vs. Dispensing Information

A common (and witty) statement heard when teachers change is, "I went from being the sage on the stage to the guide at the side." Teachers who identify with this statement are talking about their image or metaphor for what it means to be a teacher. In the old view, teachers are those who dispense "facts" that are taken in by students; the successful students are those who can consume and remember the greatest amount of information. In the newer view, teachers act as "tour guides" for students on the journey of learning; students are active learners, responsible for their own learning under the watchful eye and occasional intervention of the teacher. Like a tour guide, the teacher is one who has "been there before" and can help the student identify some of the most productive paths and some of the pitfalls. It is still up to the student to choose paths and make the journey.

Science Content and Science Process

Should a science teacher focus on students' grasp of the content of science (the theories, formulas, and "facts"), or should the teacher guide students to an understanding of the process of science (the methods by which scientists develop their theories and make their discoveries)? A good science education can achieve both goals: teaching science content and teaching the process of science. In one video, we watch as the experienced teacher guides her fourth-grade students through an exploration of decomposition. In this lesson, the students learn about several science ideas. More important, they develop a deeper understanding of the processes of science, including careful observation, hypothesis testing, experiment design, and interpreting results. At one point in the program, we witness one fourth-grader discover for herself the crucial scientific concept of the controlled experiment. In another program we see a newer teacher focus on teaching students the content of a lesson on friction. During the lesson, however, students also discuss and evaluate their ideas in a way that introduces them to some of the methods used by scientists. Many lessons will necessarily stress either content or process, but over the long run, you should ensure that students have opportunities to learn both.
Section 4 Advice for Administrators

Encouraging Classroom Change

Science education reform cannot work without your leadership and cooperation. Teachers may implement new ways of guiding students, but unless administrators support teacher change, reform efforts will most likely fail. In order for science education to improve, teachers must be encouraged to be flexible with regard to curriculum and time. Just as teachers must make the classroom a safe place for children to explore and to learn, administrators must make the school a safe place for teachers to try new approaches. Here are just a few of the things administrators can do to promote science education reform.

Create Partnerships

No single segment of the educational community can effectively improve the way science is taught. Teachers, parents, and administrators must work together to explore and evaluate new methods of guiding students to a better understanding of science. If you try to control the process with too heavy a hand, you risk stifling the enthusiasm and creativity of teachers.

Supporting Changing Teachers

Support Professional Development Opportunities

The profession of teaching is changing at a rapid pace. This is due not only to technological developments but to new ways of looking at the process of learning. Keeping your teaching staff up to date on these changes requires a vigorous program of workshops and teacher institutes. You can enrich this process by helping to establish support networks of educators both within the school system and across greater distances.

Promote and Support Flexible Approaches

Most teachers face the difficult task of promoting learning while suffering the tyranny of the clock and the limitations of the curriculum. You can help teachers explore new approaches to practicing their craft by creating a flexible atmosphere. Some new methods illustrated in Minds of Our Own may require more initial time than outdated approaches. If you help relieve teachers of the constant pressure to "cover the curriculum," you may contribute to a greater understanding of science by students.
Advocate Educational Reform Efforts

Many members of the public are skeptical about new approaches to teaching and learning. You can help create a positive climate for change by pointing out problems with present teaching methods and illustrating the promise of new methods. Using Minds of Our Own in public presentations is one method of helping to convince parents and other stakeholders of the need for science education reform.
Section 5 An Appeal to Parents

Establishing Partnerships

Not only teachers, but parents, other relatives, and friends play important roles in a child’s learning. As we approach a new century, computers and interactive games join books, magazines, comic books, films, television, toys, playground games, and everyday experiences in affecting how children understand the world around them. Children make sense of the world, including constructing their ideas about science, both in and out of the classroom. As a parent, you influence a child’s non-classroom learning more deeply than any other factor, both through your direct contact and in the way you limit and monitor the child’s experiences. Parents and teachers can be powerful partners in educating children, maintaining strong connections between classroom and non-classroom learning.

Given the enormous stresses on the modern family, how can you find the time or energy to contribute to your child’s learning? Nothing could be more important for your children than their education, but fostering a high quality of learning need not become a “second job.” Most of your efforts can be blended in with everyday activities such as mealtime conversations, household chores, and recreational activities. Here are a few ideas that may help you.

Partnership with Teachers

Your relationship with your children’s teachers can go well beyond demanding “results” in the form of higher grades or test scores. Teachers are often delighted to share with parents information about the curriculum and learning goals of the class. Parents and teachers can cooperate to set goals and to identify the unique learning abilities of each child. You can plan home activities that reinforce your children’s classroom learning. At regular parent-teacher conferences, you can then compare notes rather than only listen to the teacher’s evaluation and advice.

Some parents may also have the time or expertise to visit the classroom and lead or participate in learning activities for the class as a whole. At the least, an occasional observation visit to the classroom will help you to understand your child’s learning environment. Always plan such visits in cooperation with the teacher.
Partnership with Schools
The necessary process of educational reform often happens in a climate of conflicting goals. Time and money are usually scarce commodities. Political decisions often dictate much of the shape of the curriculum. Teachers, administrators, and policymakers need the special insights of parents in order to set and achieve educational priorities. By informing yourself about the latest issues affecting education and participating in parent-teacher organizations, you can make a positive contribution to the education of your children and their classmates. Whether you participate at the level of the classroom, the school, the community, or beyond, your voice will be heard.

Helping Children Learn
Finding Out What Your Child Really Knows
Children have their own ideas about the natural world even before they are taught classroom science. Many of the techniques used by teachers to uncover children's ideas can also be used by parents. These techniques are described in Section 3. One purpose for finding out what a child believes is to be able to guide the child to the next level of understanding. Provocative questioning works better than doling out facts in helping children to learn.

Some of the best opportunities to talk with children about their ideas come during mealtime conversations, while traveling to school, or while shopping.

Providing Rich Educational Experiences
Opportunities to learn science go well beyond obviously “scientific” experiences. Of course, trips to a science museum, a planetarium, a zoo, or an aquarium can both stimulate a child’s interest in science and provide occasions for science learning. The same can be said for viewing television programs and films about science, even science fiction. Nearly any experience, however, can be gently turned to a new understanding of science. Ball games involve physics; cooking involves chemistry; fishing, hiking, and camping provide interaction with biological and environmental phenomena. One of the best way to stimulate your child’s learning is to ask questions. How does this vacuum cleaner work? Why does bread dough rise? Who can explain the movement of a curved ball?
Section 6 Guide to the Programs

Hour 1: Can We Believe Our Eyes?

Program A
Graduates of Harvard and MIT, still in their caps and gowns, cannot light a bulb when handed a wire, battery, and bulb. A high school honors physics student believes that without a socket, a bulb cannot light.

Perhaps light bulbs and sockets are not embedded in real life to the extent that every student can understand how a bulb works. Consider then, the relationship between the distance from a mirror mounted on a flat surface and the image reflected. A barber, whose livelihood takes place in front of a mirror, believes, erroneously, that there is a relationship between distance and image. Does the reflection in a mirror defy our intuition?

Young Conor has a well-researched and convincing argument for his belief that our eyes emit light to help us see. A seventh-grade science student remains convinced that she will eventually see in a darkened room, even after she sits in one for more than six minutes, unable to see anything. Could it be that, when we see something that we do not believe, our minds simply reject what we see?

These examples tell us something about effective science teaching and learning—about how our minds work. This first program in the Minds of Our Own series presents these and other examples that encourage viewers to reflect on their own thinking and to inform science teaching and learning.

Program B
Conor, like many of us, believes that our eyes are like flashlights that send out beams of light, allowing us to see—just like the glowing eyes of his grandmother’s cat, or bats that see in the dark. Like us, Conor believes the ideas that he’s constructed from his experiences. What can we do when our ideas and constructed understandings don’t match what scientific research and evidence shows?

Moved by the need to teach for understanding, a pioneering group of teachers in Seattle devise a new approach to teaching science. High school students are given a wire, a battery, and a bulb, and are then challenged to make four different configurations that each light the bulb. Students find the problem difficult, but frustration gives way to revised thinking. Teachers hold back ready answers and allow their students to do the thinking. Can other teachers adapt and apply these innovative techniques?
Hour 2: Lessons From Thin Air

Program A
Photosynthesis is thought by many to be one of the most basic, fundamental scientific concepts taught in elementary grades and middle school years. Yet, ask most any middle grades student or university graduate "What are trees made from that makes them so heavy?" and you're likely to be told soil, water, sunlight. Carbon dioxide, the ingredient in wood accounting for over three-quarters of its weight, is left out. "Why is this so," we ask? Because air has no weight, we are told. How do such misconceptions and breakdowns in our chain of understanding occur in science teaching and learning in America's schools and universities?

Program B
Making the grade. Scoring high on the test. That is the goal of many of America's students and teachers. In science, teachers are expected to cover chapters in text books and are evaluated on that expectation. Students are expected to memorize many concepts and facts, hoping to score well on standardized tests. Expectations and experiences affect and inform our understandings, beginning at a very young age. If more teachers become aware of this, then how can our expectations for our students change? Will they change?

Hour 3: Under Construction

Program A
The reform of science education will require support and leadership from educators throughout our school systems. But in the end, change must take place in the classroom. How do teachers go about the job of changing how science is taught?

Dotty was burned out and was ready to leave the profession. Instead, thanks to a program connecting classrooms through the Internet, she gains renewed enthusiasm and dramatically changes her approach to teaching.

Program B
Can a teacher who has no science background teach science to middle to their daily lives, and in so doing, transmit a passion for learning?

Can a community's cultural heritage serve as a stepping stone toward science by its young members? Donna finds ways to nurture her students' culture and elucidate the underpinnings of modern science at the same time.
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