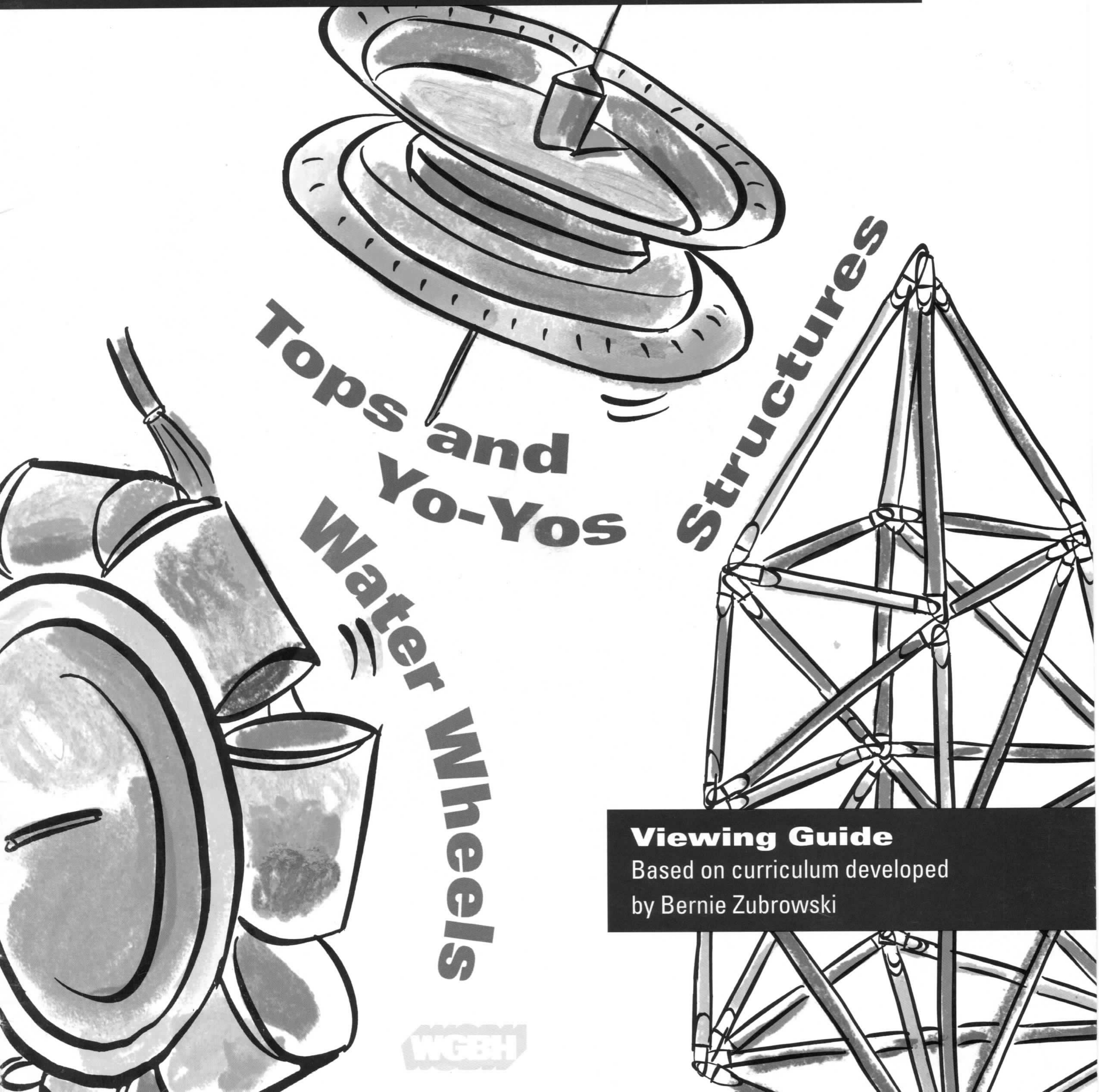
Science First Hand

Models in Physical Science



Viewing Guide

Based on curriculum developed by Bernie Zubrowski

To teachers and teacher trainers,

Over the past few years, we at WGBH have rededicated ourselves to making videotapes for classroom and staff development use. We made *Science First Hand* to fulfill two particular goals.

First, we knew of Bernie Zubrowski's work with The Children's Museum staff and Boston area teachers to develop this curriculum, and we thought its long-term investigations offered an unusually rich opportunity for documenting classroom activities.

Second, we wanted to put our video production experience to use in this important area. Viewers will clearly see and hear what happens in real, unscripted classrooms when teachers start to use new methods. The energy, exuberance, and fun inherent in a room full of middle school students are here, as are the occasional problems.

Here we have shown many general science teaching issues in the context of physical science topics. The tapes are intended to be a jumping off point for discussion in both teaching methods and science content. Review this guide first to think about how you might use the tapes.

We hope you enjoy *Science First Hand*.

WGBH Instructional Programming Group

Introduction

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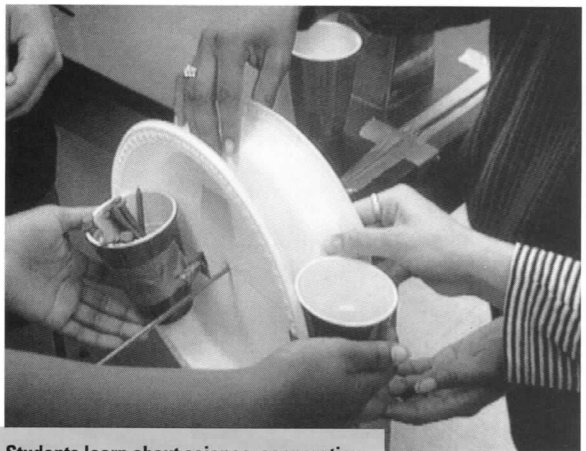
Science First Hand presents three public school teachers, each at a different level of teaching experience, in real-life classrooms. The classrooms featured in these videotapes were not chosen for their ideal conditions, gifted students, superstar teachers, or elaborate resources. Instead, they were chosen to represent teachers and situations common to many classrooms nationwide.

This series of three 30-minute tapes is designed to assist middle school teachers and teacher trainers interested in engaging students in projects in which the students investigate, experiment, cooperate, solve problems, and think about what they are observing. The activities shown are based on a curriculum created by Bernie Zubrowski, long-time developer of science exhibits and curricula at The Children's Museum in Boston, Massachusetts. The purpose of the tapes, however, is not to promote a single program or curriculum but to give a realistic view of how hands-on science works and how students respond to it.

Using simple materials—drinking straws, paper clips, plastic cups and plates, rubber stoppers, wooden dowels, tape and string—students begin to understand the hows and whys of physical science.

To gain the most from the tapes, view them for general strategies and observe student responses to instructions and assignments. Think about your own circumstances and consider how you might directly apply the techniques or modify them to fit the special requirements of your teaching style, students, and conditions.

A time clock has been added to the upper right-hand corner of the videotapes to help you locate examples of hands-on science throughout the tape. You'll find tape location times listed throughout the guide to help you locate these examples.



Students learn about science, cooperation, and teamwork when actively engaged in science investigations.

What Is Hands-on Science?

Hands-on science has become a popular term in the parlance of science educators. It has been applied to almost any situation in which students engage in tasks rather than listening to the teacher or watching the teacher demonstrate an experiment. In this series of tapes, students are participating in hands-on activities.

The approach, however, is more specific than merely involving students in some type of activity. The investigations shown in these videotapes are aimed at giving the students materials with which to explore and examine natural phenomena on their own for an extended period of time before they are formally instructed in vocabulary and classic theory. The activities present a context for concepts that are tied directly to what the students observe.

Here are some key elements of the hands-on experiential method of teaching science that may be seen in various segments of these tapes.

▶ The teacher as a facilitator

- provides materials
- reviews approach and assesses progress in individuals and groups
- supports group interaction
- encourages discussion and verbalization of observations, approaches, and conclusions

▶ The teacher as a problem poser

- defines an initial problem
- responds to questions with clarifying questions that help students find answers for themselves
- asks leading questions to stimulate thinking
- challenges the reasoning and conclusions arrived at by individuals and groups
- helps students focus attention on potential problems (for example, experimental design problems, errors in reasoning, unequal participation by group members)
- encourages further explorations
- relates subsequent challenges to prior explorations

▶ Cooperative learning groups

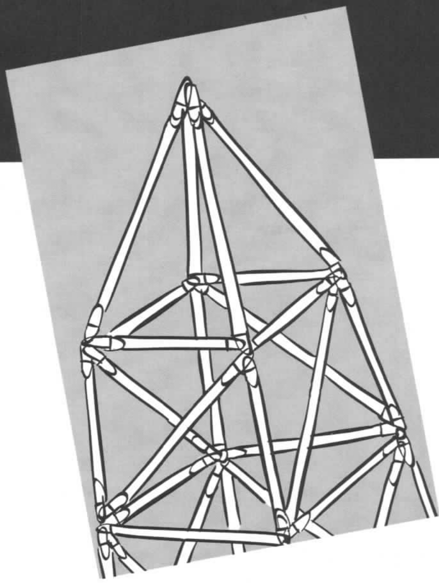
- may be self-selected or teacher-assigned
- may vary in size within the same class (individual work may also be permitted)
- can bring together students with mixed but complementary abilities
- may have roles formally assigned or determined by the group

▶ Content coverage

- focus is on key concepts (such as forces, tension, and compression)
- generous time and opportunity is given to explore and manipulate variables related to fundamental concepts
- depth of understanding is valued
- discussion among students reveals intuitive knowledge and practical application of underlying content
- experimentation and laboratory work precedes development of vocabulary and technical terminology

The classrooms featured using this approach differ in many ways, but one observation can be made about all three classrooms in this series. The student conversation, both in formal interview-style settings and informally while working in the classroom, reflects a depth, a seriousness, and an analytical level that are quite unlike the usual terse answers one hears from middle school students responding to questions found in a more traditional, teacher-directed discussion. Throughout the tapes, you'll see examples of how to create such an environment in your own classroom.

Structures



Video Overview

This investigation takes place over a three-week period at the Frank V. Thompson Middle School in Boston, Massachusetts. Joseph Johnson's seventh-grade students use plastic drinking straws and paper clips to build and test houses, bridges, and towers.

First the students are challenged to construct a house that is three straws high and three straws wide and that will support the weight of 100 nails suspended in a paper cup. Students calculate the ratio of straws in their structure to the maximum number of nails supported.

Then students construct a bridge that spans 50 centimeters and supports at least 100 nails. The bridge's strength is tested by loading a cup with nails and hanging it from what students believe is the strongest point. In the final challenge students build a tower that can resist simulated hurricane-force winds.

This videotape makes a compelling case for using an approach that encourages personal exploration and experimentation by middle school students employing this method for the first time. A year before the taping, Mr. Johnson was quite skeptical of this method. Yet throughout the videotape discussions among his students reveal that they are engaged and take personal responsibility for their work.

Discussions among the students as they work also suggest thoughtfulness and commitment to theories based on observation and experimentation. In some cases, the camera captures students engaged in intense debate even when the teacher is not nearby.

Key Points in the Investigation

During each construction activity, students must judge where to place lengths of drinking straws to make a structure strong and rigid. For this, they must imagine and test how a structure will resist forces. The video shows some students pressing on one part of their house. By noticing how much and where a section bends students discover the strength or weakness of a section. Students must then determine the best place to add another reinforcing straw. One approach is to add segments. Another is to consider how a force acts on the segments of that particular section and to add just a few extra straws to reinforce the weakest point.

Partway through the activity, students begin to recognize the importance of a diagonal support in their construction. One or two groups eventually discover that diagonals at the corners of a house provide rigidity and strength, an idea that spreads to other groups. The students then apply this knowledge to their subsequent tasks.

However, this does not necessarily mean that students understand how the diagonal support functions. Although they realize that a diagonal placed at a corner stops the movement of other straws around it, they may not yet understand how a row of triangular arrangements distributes the force of a cup of nails. You may notice this and other aspects of the students' understanding as you view the tape.

By encouraging students to explore and experiment with materials, Joseph Johnson (right) creates a dynamic classroom learning environment.

Topics for Discussion

▶ Teacher Interaction

Identify instances of teacher interaction and intervention with individuals and groups of students in the tape. [See tape locations 00:28, 01:08, 02:51, 03:13, 04:44, 05:59, 09:53, 10:57, 12:50, 14:37, 19:04, 25:00, and 25:55.]

- Classify the interactions into categories, such as explicit content instruction, procedural instructions, open-ended questioning, admonition, and housekeeping. Analyze students' responses to the various types of intervention.
- When in the design process would you intervene with questions? When would you hold back from intervening?

▶ Subject Knowledge

Mr. Johnson, who also teaches social studies, has for a number of years been using more traditional approaches to teaching science. This is the second year he has used the curriculum materials shown on this videotape. Although Mr. Johnson's class has studied gravity and forces through a textbook-based curriculum, this is its first journey into an inquiry-based method of science instruction. At the beginning of the unit, Mr. Johnson explained to students that he had little experience with the materials they would be using but that he thought the investigation would be fun and educational for both him and them.

- What are the advantages and disadvantages of letting students know that the program is new and challenging for the teacher?
- What kind of relationships between the teacher and the students are evident on this tape?
- What steps would you take to use this method?

▶ Group Assignments

Group dynamics can dramatically influence student-led learning environments. In this unit, Mr. Johnson began by assigning students to groups that he thought would function well together. Each group included three or four students with mixed ability and skill levels. Groupings changed for different activities within the unit, and Mr. Johnson allowed students to form their own groups. As a result, many of the students segregated into groups by gender. Mr. Johnson chose not to assign specific roles to the students in each group, leaving planning, construction, and decision-making roles up to the students.

- What kind of interactions occur within groups when the teacher is not present? [See tape locations 00:46, 01:45–02:50, 04:19, 06:10–07:50, 13:05, 14:10, 15:39–16:58, 17:40, 21:40, and 24:32.]
- When he is present? [See tape locations 00:28, 01:08, 02:51, 03:13, 04:44, 05:59, 09:53, 10:57, 12:50, 14:37, 19:04, 25:00, and 25:55.]
- What effects, if any, do you think same-gender grouping has on the groups and the individual students? What are the advantages and disadvantages of different kinds of groupings?

▶ Student Discussions

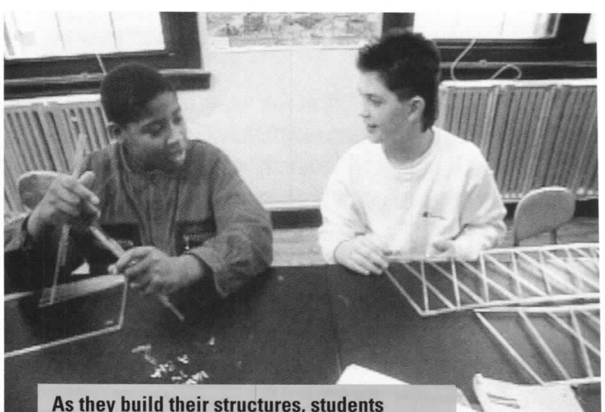
Student discussions play a key role in the acquisition of knowledge. The videotape shows students thinking about cause and effect as they consider their drinking-straw structures. They propose theories, right and wrong, to explain their observations and are able to describe how they arrived at the theories they have proposed.

- How does Mr. Johnson get students to explain how they strengthened their structures and to describe why they believed their designs were or were not working?
- How would you tailor your questions to address the different skill levels represented in the classroom?

Viewing Highlights

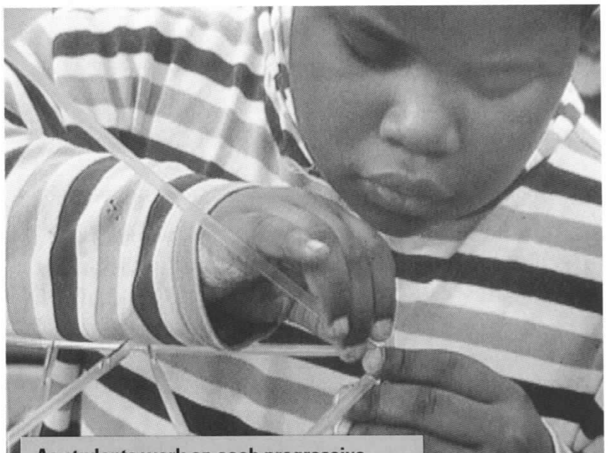
As you view the videotape, watch for:

- how the teacher interacts with the students
- how the students interact with each other
- how the students apply what they learn as the lesson progresses



As they build their structures, students reflect on their designs, test ideas with other class members, and engage in lively group discussions.

- Some students are more verbal than others. How can a teacher facilitate discussions to encourage all students to participate?
- To analyze students' thinking levels, use the segment in which three students discuss the strength of their bridge [see tape location 17:40]. Identify areas in which their comments demonstrate competence and understanding and areas in which the students' comprehension is still deficient.



As students work on each progressive building task in this investigation—a house, a bridge, and a tower—they learn what makes a structure rigid and strong.

▶ Student Understanding

The content embedded in this unit is drawn from physics.

- Which definitions, concepts, and theories are most closely related to and supported by the students' activities? What, if any, evidence is there that students improved their understanding of these during the three weeks of this unit?
- What alternative or additional steps might be used with this approach to enhance students' gains in the content area?
- Students were asked to calculate a mathematical ratio of straws to nails. How might collaboration with a mathematics teacher provide instruction on ratios and help develop the use of ratios in this unit?

▶ Real-World Connections

To relate the bridges constructed in the second segment of this unit to real bridges, the teacher took his students on a field trip in which the students could observe a number of large structures such as railroad bridges.

- What aspects of the bridges would be important to highlight and why?
- Identify other real bridges of various scales that can be related to the straw-and-paper-clip models.

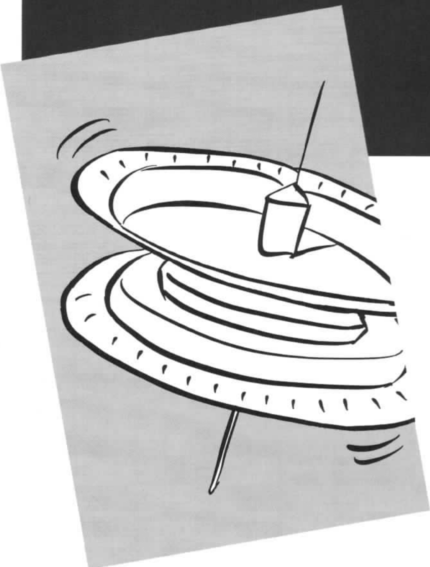
Assessment

In assessing student achievement in any program, teachers need to look for change and progress in knowledge and understanding. In Mr. Johnson's class, students attempt to apply intuition and, as they learn more, practical experience in the assembly of their structures. With each successive activity, students should further develop their manual skills and refine their understanding of what is happening with the structures. Student progress can be gauged by:

- *Listening to students' comments.* A great deal of emphasis in any evaluation of this activity is on verbal explanation. If students can verbalize in some manner what they think occurs with weight on a structure, they may appear to understand what is happening. This may or may not be true. Careful questioning by the teacher to follow up on students' comments will help determine whether students understand key concepts. Comprehension also can be measured by noting the kinds of comments students initially make as they describe their structures and by comparing them to later comments.
- *Taking notes.* Record how each group performs during the first activity and compare this with how each group performs in later activities.
- *Noticing how a structure looks.* Progress can also be assessed by looking at students' structures. If a house has many straw segments added to the corners in certain parts, this indicates that students have worked on an approach of brute counterforce. They believe the more straws used, the stronger the model will be. Students who do not use many straws, however, may have built a very strong structure and have a better understanding of the physical science concepts involved.

  As the activities progress, notice whether students incorporate lessons learned from previous structures or seem to devise their structure randomly. Some students might spend time making the structure attractive instead of attempting to make it strong. Others may build a model quickly and test it. If there are failures, then rebuilding and testing can be done right away. As they add and subtract from the structure or rebuild whole sections, students can quickly compare how these new arrangements react to the weight of nails.

Tops and Yo-Yos



Video Overview

In this unit, which spans two-months, students make use of common household disk-shaped objects such as paper, plastic, and aluminum plates; pie pans; platters; and covers. These items are mounted on wooden dowels with rubber stoppers, tape, and string to create large tops and yo-yos.

This tape features two seventh-grade classes at the Andrew Peabody Elementary School in Cambridge, Massachusetts. The science classes meet five times a week for 45-minute periods. Kathy Brown has been teaching science for more than 20 years. Although she has always tried to involve her K–8 students in direct investigations and explorations, teaching physical science is new to her. Until two years ago, most of Ms. Brown's teaching was in environmental sciences and outdoor education.

Without formal introductory instruction about the physics of the objects, Ms. Brown encourages her students to observe her homemade tops, to spin them, and to compare them. Students guess which designs will spin the longest and work in groups of four or five to test the tops for length of spin. The students use three different launching methods: rubber-band launchers, ribbon launchers, and electric mixer launchers.

After designing, building, and testing their own tops, the students face a new challenge. Based on their experiences, they design and test yo-yos that must remain in motion for as long as possible. In a final segment, two working research scientists from a nearby corporation visit the class.

This videotape strongly supports the process of finding out, which often is neglected or ignored in the common thinking that science is a body of knowledge passed from those who know to those who don't know. Ms. Brown greatly values the process of finding out and puts students in the role of those who find out.

Key Points in the Investigation

In the first few minutes of the tape, students guess how long a set of tops made by the teacher will spin. The students come up with explanations of why they decided that a certain top would spin the longest. They then test the tops to see if their predictions and explanations are true.

Kathy Brown demonstrates a homemade yo-yo. Students make predictions about Ms. Brown's homemade tops before designing, building, and testing their own.

Approximately 20 minutes into the videotape, the students discuss the effect of adding more plates, and consequently more weight, to their tops. They observe that with electric mixer launchers more weight seems to make the tops spin longer. However, the data for the rubber-band launchers shows a different pattern. Tops with more plates turned out to be a problem because the rubber-band launchers could not get the heavier tops to spin. Here students realize the real meaning of inertia.

In several places throughout the tape students attempt to explain why some tops spin longer than others or why one particular design does not spin as long as another [see tape locations 05:40 and 08:11]. Listen carefully to what the students say. Several express the theory that the disturbed air around the spinning top seems to be holding up the top or somehow to be giving it stability. The way students use this theory to describe the tops' motion may be applied incorrectly, but air resistance is a real factor that affects the spinning of tops.

Finally, the process of scientific investigation is an essential feature of this project; it provides a valuable context in which students can better grasp and remember what this process involves.

Topics for Discussion

▶ Teacher Comments

Throughout the videotape, Ms. Brown makes comments designed to encourage the students to explore further, to return to their data, and to work at understanding their findings. For example, she says, "This is what you did; this is not something from a book," to reinforce the importance of the students' own data and to authenticate the notion of students as scientists.

- Find instances of such comments and analyze their effect by observing the students' responses.
- Classify teacher comments by using such categories as supportive, directive, and evaluative. How do timing and context play a role in determining the effectiveness of teacher intervention and commentary?
- Ms. Brown frequently reminds her students to work with each other first to solve problems and find answers. Is there any evidence that the students are responding to Ms. Brown's instructions to work things out among themselves? What benefits or problems arise from such an approach?
- When one student expressed exasperation because the tape on his yo-yo kept failing [see 28:30], the videotape recorded an exchange between him and Ms. Brown but did not show the outcome. Analyze the exchange and suggest possible outcomes. How would you have handled the situation?

Viewing Highlights

As you view the videotape, watch for:

- how Ms. Brown encourages the students to learn from one another
- ways in which the scientific process and content are interwoven
- how the students develop concepts

Testing tops in different ways helps students to understand the process of investigation. Once the tests are done, students learn ways to present and interpret the data they've collected.

▶ Data Presentation

The students work in small groups to construct tops and to test them. But the class needs everyone's data to draw meaningful conclusions. To share data and discuss results, representatives from each group post results on a large chart for all to see and copy. Sometimes the posted data are averages, and sometimes they are individual trial results. Often the results from individual groups are plotted on large-scale graphs that can be displayed as group members explain their conclusions to the rest of the class.

- The teacher designed and provided the structure of the charts and graphs that students used for recording and displaying their data. What other methods might be used to share data?
- What might happen if individual students or groups were asked to design their own charts and graphs? How might such individual designs affect what and how the students learn about displaying data? What determines the amount of structure to provide for students in collecting and analyzing data?

▶ Concept Development

Replay the class discussion that begins at tape location 20:00, and watch for the development of the concept of inertia.

- How is the concept emerging from the hands-on experience that the students have been acquiring?
- What evidence is there that the students are gaining an understanding of inertia?
- What was the effect of Ms. Brown's comments and intervention in the discussion?
- What follow-up steps can be taken to ensure that the concept of inertia is well established?

▶ Process and Content

In an interview segment, Ms. Brown describes science as "finding things out" and talks about assessing the processing skills the students develop. But she also is concerned about teaching process at the expense of content.

- How should process and content be balanced in a science curriculum?
- Does the type of science program shown on this videotape preclude content instruction in order to be effective? If not, how can the conveyance of content knowledge be ensured within this style of teaching science?

▶ Students' Learning Abilities

At the Peabody School, classes are ethnically diverse and heterogeneously grouped; they include students with special needs and some students for whom English is a second language. Students of widely-differing abilities and experiences work together in this activity.

- Watch the debates and discussions within the small work groups. Can you distinguish the students with learning disabilities from their highest-achieving classmates?
- Look for the firmness and confidence with which students put forth their arguments, especially in those segments where Ms. Brown is not present and directing the debate. Can you differentiate the top readers from the lower level readers?

Assessment

The beginning activity, in which students guess which tops will spin the longest and then test their hypotheses, can act as a type of embedded assessment, helping the teacher gain a sense of where students start from in their understanding of rotational motion. [See tape locations 02:08, 02:12, 02:30, and 03:25.] Some questions to consider include:

- What properties of the tops do students focus on?
- What kind of intuitive theories do they bring to this investigation?
- What indication, if any, is there that students have a sense of what determines how long a top will spin?

At the unit's start, the teacher should record students' comments. Later on in the investigation or at the end of all the investigations, the teacher can return to these comments and compare them with how students talk and think about spinning objects.

At several points in the videotape, Ms. Brown asks students to report on what they have been doing and to interpret their results [see tape locations 08:58, 11:10, 12:30, 15:38–23:00, and 25:15]. This is an essential part of the teaching process. The manner of reporting and the way the results are discussed will depend on such issues as students' experiences in school, the nature of the investigation, and the teacher's individual style.

The videotape illustrates ways in which the teacher asks the students to report on their results. After making different kinds of designs, the students stand in front of the whole class to show what they have assembled and to explain what happened. This practice does more than provide information. It gives students practice at verbalizing what they have experienced.

Students need help in deciding what to talk about. Their presentations should be more than a recitation of data. They should add observations about the performance of the top or device they used. These observations can be a fruitful starting point for a meaningful discussion, which can help students assimilate and make sense of their explorations.

During these presentations the teacher can help students by asking questions. Sometimes students need to be reminded about some surprising result that occurred while they were manipulating the materials. The students may feel that the result is not significant. The teacher can point out the result and generate a discussion on how it occurred.

Ms. Brown measures students' levels of understanding by recording their comments, watching how they work with materials, and listening to how they explain their thinking.

Water Wheels

Video Overview

This investigation, which spans six weeks, challenges students to use plates, cups, string, duct tape, metal rods, nails, and other commonly available items to make and test waterwheels that lift nails. By using simple materials and an open-ended challenge, students are required to be resourceful in constructing the waterwheels.

The tape features a group of eighth-graders at the K–8 William H. Lincoln School in Brookline, Massachusetts. Chris Whitbeck, a science specialist with seven years of experience, teaches this science class five times a week in 50-minute periods.

Mr. Whitbeck introduces his class to the unit by asking students to talk about what they already know or have heard about waterwheels and what waterwheels can be used for. He then divides the class into groups of four or five. Each group must design, construct, and test a waterwheel that can lift 10 nails. Half of the groups design their waterwheels to lift as many nails as possible, while the other half design their waterwheels to lift the nails as quickly as possible.

After the experimentation period, discussion focuses on identifying the variables that make the strongest or fastest waterwheels. The challenge is to build new waterwheels that test the students' hypotheses about the variables in waterwheel strength and speed. Mr. Whitbeck later introduces two waterwheels of differing sizes. Again working in small groups, students experiment with the diameter variable.

This videotape illustrates a strong emphasis on the development of key science-process skills. Mr. Whitbeck constantly presses his students to identify and control variables in each waterwheel model they develop and test. He urges students to look for patterns in their data and to interpret the patterns when forming hypotheses about cause and effect.

Key Points in the Investigation

Before handing out materials for students to explore, Chris Whitbeck finds out what students already know or have heard about waterwheels.

This videotape follows students as they learn several basic physical science concepts about forces, simple machines, and mechanical advantage. The teacher helps students isolate the essential variables involved in these concepts. For instance, the manner in which the water is siphoned from the bucket can determine the kind of results that are obtained. If the water level in the bucket is low, the flow out of the tubing will be slower than when the water level is higher. Keeping the end of the tubing in one spot as the water falls into the cups on the wheel instead of moving the tubing back and forth over the wheel also makes a difference. Details such as these have to be continually attended to if students are to obtain valid and consistent results.

Groups focus on different tasks. Some groups look at the lifting capacity of the waterwheels and examine one variable at a time, while others study variables that affect the speed of the waterwheels. Students first master the construction and operation of the wheel and then get a good sense of the key variables in its operation.

At several points in the video the teacher and students discuss the results of their investigations. At times students come up with their own analogies to help explain their understanding of the problem. It's important to pay attention to these student descriptions because they provide an excellent opportunity to gain insights into how students are thinking about and understanding their discoveries.

Topics for Discussion

Viewing Highlights

As you view the videotape, watch for:

- ways in which the teacher interacts with the students
- how the students develop concepts following exploration
- what variables are involved in the investigation

▶ Questioning Strategies

Throughout the tape, you will hear Mr. Whitbeck asking questions more than giving answers. Some questions elicit data, and others encourage the students to continue thinking aloud. Some challenge students to provide evidence to support a theory. In some cases, a student's incorrect theory or explanation is allowed to stand until conflicting evidence is presented. You will see and hear students challenging and supporting each other and challenging and supporting Mr. Whitbeck's claims and explanations.

- What additional questions might you ask in this investigation?
- Replay segments of the videotape during which Mr. Whitbeck leaves response time for students to discuss ideas and explain their theories [see tape locations 18:05, 27:30, and 32:00]. See if you can find examples supporting the theory that if you allow a student a longer period of time in which to respond, the student's response will show more analysis and greater understanding.

▶ Student Exploration

Practical experience and personal exploration precede and lay the foundation for building concepts, which comes at the end of the unit rather than the beginning. The experiments give students firsthand experience with some fundamental ideas of physics such as force, simple machines, and mechanical advantage.

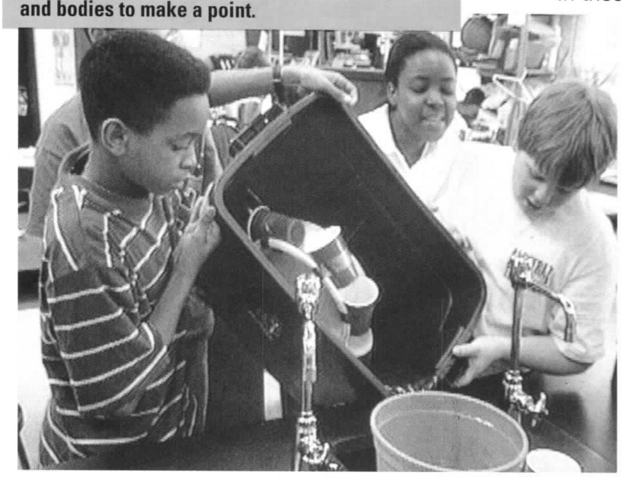
- How well do students make the connection between their waterwheel tests and formal physical concepts?
- At the end of the tape Mr. Whitbeck says, "I don't think that introducing a topic without having some experience or something to relate it to makes a lot of sense for middle school kids." What does his statement imply for how science programs should be structured for middle school students? What do you think about his statement?

▶ Role of Analogies

Several times in this videotape, students draw on analogies to explain their understanding. Replay the segments in which a girl and then a boy try to explain why a longer hose would make the wheel go faster [see tape locations 22:13–23:45].

In these instances, you'll find that the girl compares the water going through the tube to a roller coaster going downhill, seeming to believe that the longer something takes to fall, the more force it will have by the fall's end. The boy who follows compares the water going down the tube to a long slide and the free fall of an object. He develops his analogy by enclosing the slide and saying that a body going down would bump against the side and experience more friction (as would water in a smaller tube). Water in free fall, he speculates, would have less friction and fall faster.

As they investigate, students learn to think about the variables involved in a working waterwheel. When they explain what they've learned, some draw on analogies and others use their hands and bodies to make a point.



- The girl's thinking was not immediately apparent in her comments. What questions could have been asked to help clarify her thinking and the way she was expressing herself?
- Both students used their entire bodies to illustrate and better articulate what they were trying to express verbally. In what ways can students be encouraged to feel that this is a legitimate way of expressing a scientific idea?
- Each student's analogy addressed principles such as momentum, force, and acceleration due to gravity. How can you help students make connections between their analogies and the principles embedded in them?

▶ Scientific Variables

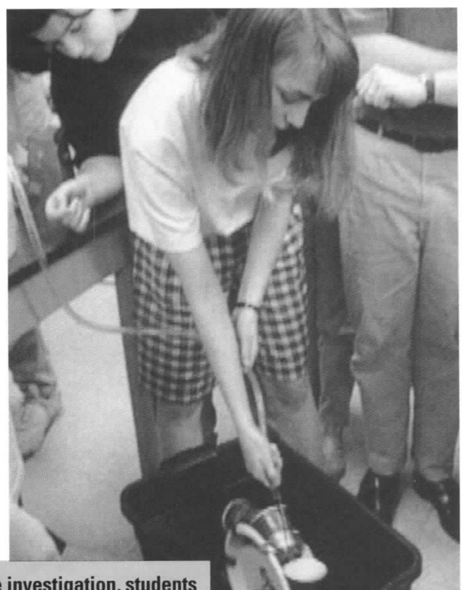
Mr. Whitbeck frequently refers his students to variables that are present in their experiments. It can be a challenge to bring out in discussions the underlying concepts applicable to the waterwheel. The concepts of force, work, power, levers, torque, and rotational momentum are interrelated and need to be carefully developed and distinguished from each other.

- What variables affect the waterwheel models that students are constructing and testing?
- How well has Mr. Whitbeck helped students isolate and control their variables?
- How well have students demonstrated an understanding of the need to isolate and control variables in an experiment?

▶ Multicultural Classrooms

The eighth-grade science class is a heterogeneous group that includes numerous non–native English speakers and recent arrivals from schools and countries that approach science instruction differently.

- Can you identify the non–native English speakers and new students?
- What are the advantages and disadvantages of using this style of science program with these students as opposed to a more traditional science program?



Throughout the investigation, students record their work in journals. Mr. Whitbeck uses the journals to gauge student understanding.

Assessment

Individual journals play a key role in Mr. Whitbeck's science program. Students must plan all their explorations and record their plans in journals prior to experimentation. They must also record all observations and data directly in their journals as they are working in class. Most homework assignments require students to review their journal entries and analyze the data they have recorded. Mr. Whitbeck reviews each journal regularly. He writes individual notes in the journals and uses them to assess progress as well as to communicate with his students.

Because Mr. Whitbeck's nontraditional homework assignments are neither practice problems nor completed papers that are to be handed in as a project, students are less inhibited because they will not be graded on grammar and the rules of formal presentation. Accordingly, the assignments allow and encourage students to put down half-formed thoughts. This practice tells the students that part of the learning process is reflecting on what they have done in class and sets the stage for further class discussion based on information students have already had time to think about. In addition, it is a way of helping them continue to record what they have experienced.

These comments enable Mr. Whitbeck to evaluate students' thinking about the investigation. By scanning their comments, he can quickly see where students are confused and need help, or he can determine how to start a discussion and where to take it.

To help you better understand how journals might be used, review the homework assignments that are mentioned in this videotape and evaluate their appropriateness and effectiveness. What other homework could be assigned in conjunction with the activities in this unit, and how might these assignments be used as an assessment tool?

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Credits

This guide was produced by the Educational Print and Outreach department of the Special Telecommunications Services division, WGBH Educational Foundation.

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Special thanks to
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Andrew Peabody Elementary School, Cambridge, Massachusetts
William H. Lincoln School, Brookline, Massachusetts

Funding for *Science First Hand* is provided by the National Science Foundation. This material is based upon work supported by the National Science Foundation under Grant No. TPE-9153809. The government has certain rights in this material. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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