Teacher's
Guide For

WHISTLES AND STRINGS

Elementary
Science Study

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THE WHISTLES AND STRINGS UNIT

Teacher's Guide for Whistles and Strings
Class Kit for Whistles and Strings

RELATED UNIT

The Musical Instrument Recipe Book

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PREFACE

The Elementary Science Study is one of many curriculum development programs in the fields of science, social studies, and mathematics under preparation at Education Development Center, Inc. EDC (a private nonprofit organization, incorporating the Institute for Educational Innovation and Educational Services Incorporated) began in 1958 to develop new ideas and methods for improving the content and process of education.

ESS has been supported primarily by grants from the National Science Foundation. Development of materials for teaching science from kindergarten through eighth grade started on a small scale in 1960. The work of the project has since involved more than a hundred educators in the conception and design of its units of study. Among the staff have been scientists, engineers, mathematicians, and teachers experienced in working with students of all ages from kindergarten through college.

Equipment, films, and printed materials are produced with the help of staff specialists, as well as of the film and photography studios, the design laboratory, and the production shops of EDC. At every stage of development, ideas and materials are taken into actual classrooms, where children help shape the form and content of each unit before it is released to schools everywhere.

ACKNOWLEDGMENTS

There have been two major sources of inspiration for this unit on musical sounds. The first was some preliminary work involving the science of sounds that was done at the 1963 Summer Conference of the Elementary Science Study. The second was the report of the Entebbe Conference of the African Primary Science Program, held in the summer of 1965. At that conference, African musical instruments provided the jumping-off point for a study of musical sounds.

Development work on *Whistles and Strings* began in the spring of 1967. Emily Romney, Dan Watt, and Rosly Walter taught and observed the development classes. Over the course of about a year, the two sections of the unit evolved to their present form.

We would like to extend our thanks to those teachers in whose classrooms the development of this material took place. They are Margherita Duffy, Arlington, Massachusetts; Paul O'Connell, Watertown, Massachusetts; and June Amsterdam, Margot Wygant, Barbara Reynolds, and Helen Leverett of Brookline, Massachusetts. Mrs. Reynolds was especially helpful to us in doing some "instant trial teaching" of an early draft of the "Whistles" manuscript.

We are grateful for the assistance of Adeline Naiman and Nancy Weston in the preparation of this manuscript for publication. A special debt of gratitude is owed to Joan Hamblin and Major Morris of the EDC Photography Studio. Their photographs are an integral part of our attempt to provide a record of the activities and the spirit of the development classes.

Emily Romney

Dan Watt

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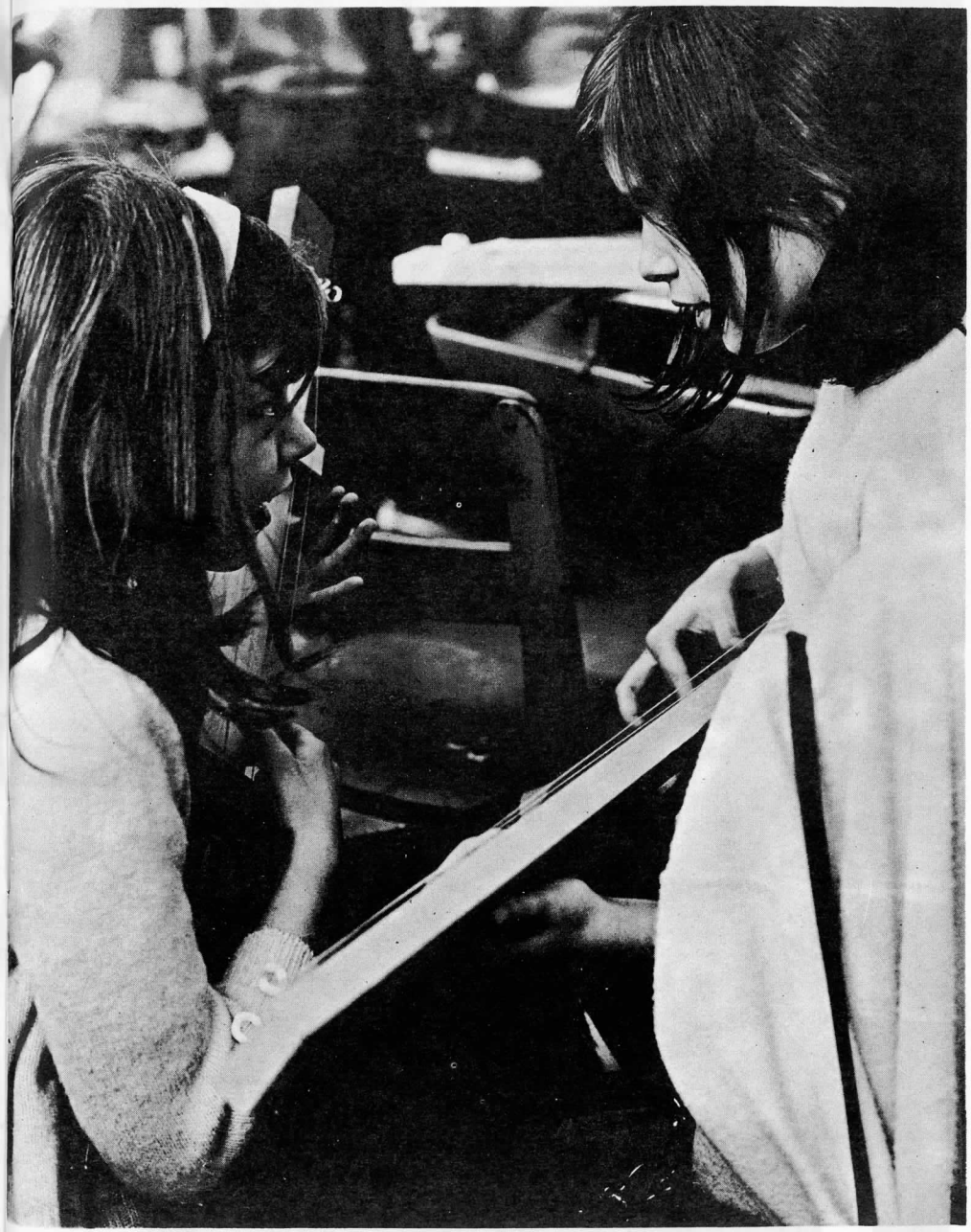


INTRODUCTION

Musical instruments are fascinating to children. Most children like to play instruments and hear them played. They enjoy finding out how the instruments are put together and are eager to make instruments of their own.

Many instruments, especially ones that play definite pitches, are so complicated and so difficult to play that it is hard to figure out how their sounds are produced. The elaborate structure of the clarinet, for example, makes it difficult to see just how the parts of the instrument work together to make different sounds. Using simple materials, however, children can investigate many of the basic sound-making elements of more complex musical instruments.

Sound is as natural a part of our lives as the air we breathe. We can make all sorts of sounds, but without complex scientific apparatus, it is impossible to understand the precise and intricate relationships between the sounds that we hear and the forces that produce them. With simple instruments, however, a child can begin to find out for himself the relations between objects, the sounds they produce, and the actions necessary to produce and change those sounds.

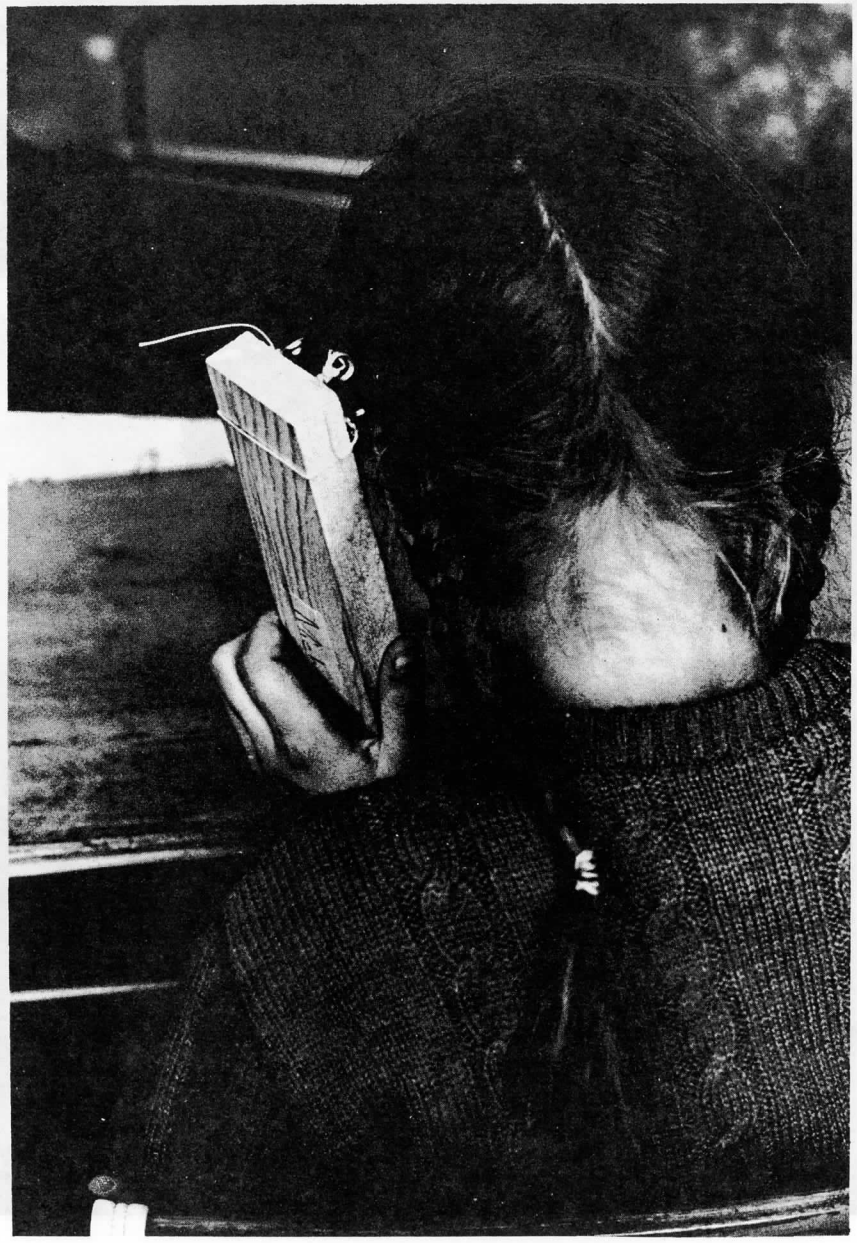
Some of the materials for this unit--the plastic tubes, straws, and strings--are themselves simple instruments. Through trial, children find out about the conditions that are necessary to produce sounds with the materials. They can explore the ways in which the pitch, the tone quality, and the loudness of sounds can be affected by the physical characteristics of the materials and the way they are manipulated. In combining materials, children can investigate the ways in which various parts of an instrument influence one another to affect the sounds that are produced.

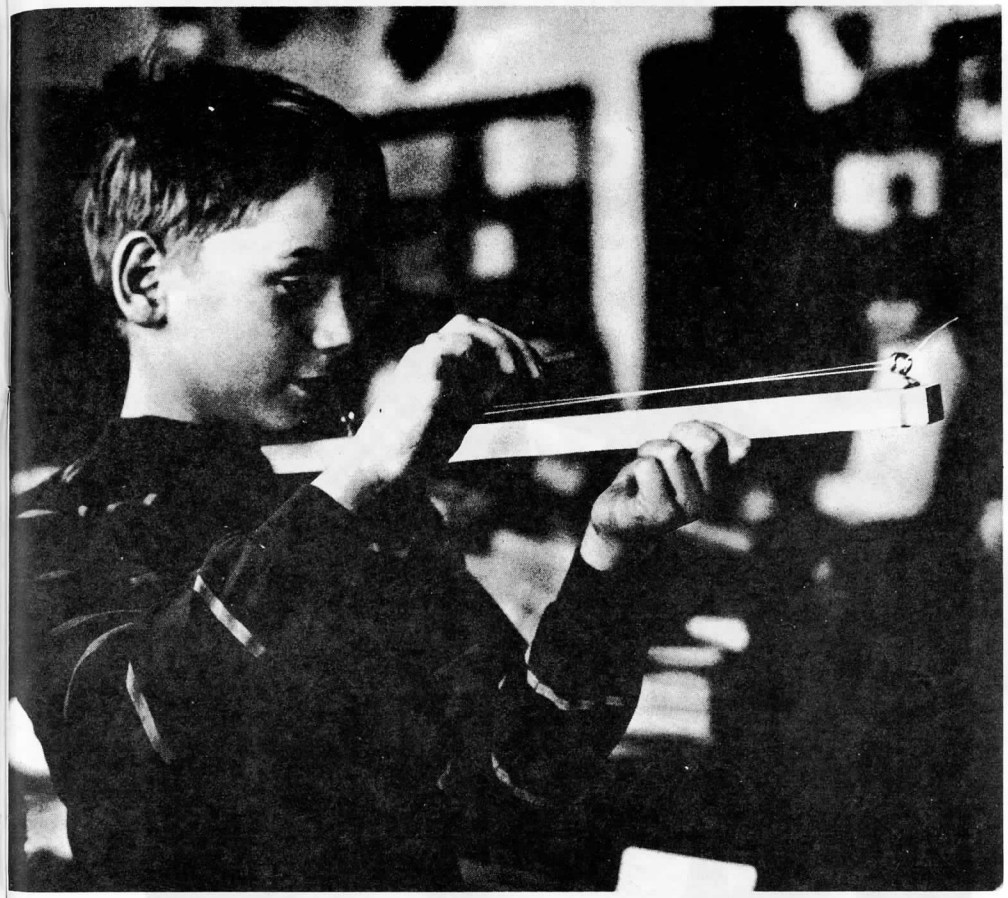
Many children have also used these materials for experiments unrelated to sound. The capped plastic tubes, for example, have enabled many children to investigate such things as the behavior of air bubbles in a tube of water or to observe the motions of various materials as they fall through a tube filled with water. Other activities appear throughout this *Guide*.

The richness of the materials allows each child to find something fascinating to explore, if he is given the opportunity to choose his own problems and his own way of working on them. The most fruitful investigations and projects have been consistently those which children themselves have initiated and on which they have worked in rather informal and individual ways. This has meant that, at times, several activities were going on simultaneously in a single class. Children worked with different materials in different ways, often alone, in pairs, or in small groups. Occasionally the students discussed as a class the work that they were doing, or all worked on the same problem. More often, children did different things and shared their findings in informal ways.

For some children, it is the process of constructing instruments that has been particularly absorbing. Not only have they had to be concerned with how they wanted their instruments to sound, but also they have become involved with the possibilities of tubes, strings, and boards as building materials. Other children have been mainly interested in making music with the instruments that they constructed. Tuning their instruments, playing songs, and composing music, they have encountered many of the same problems and questions about sounds which other children have encountered in instrument building or other kinds of investigations.

Before teaching *Whistles and Strings*, try some of the activities yourself. After seeing the kinds of questions, problems, and further activities they lead to for you, you will be better able to share in the experiences of the children and to work with them on the problems which they find for themselves.





AGES AND SCHEDULING

Whistles and Strings has been taught in classes ranging from third to eighth grade. The activities seem to fit in naturally with the inclinations of fourth and fifth graders. Many of the activities have proved interesting to third graders and sixth graders as well.

Teachers have used *Whistles and Strings* as a single unit or as two separate ones and have taught it in several ways. In one school, a classroom teacher and a music specialist collaborated on the unit with great success. "Whistles" activities tend to be noisier than "Strings" and, at times, the noise level can be high. Although noise has not been a problem in every class, it was troublesome in a few classes that were poorly insulated against noise transmission and in large classroom areas that were shared by more than one group. Some teachers solved the problem by rescheduling the time or the location of "Whistles" to avoid disturbing other classes. A few teachers took their classes outdoors when the weather permitted. "Whistles" noise was invariably more disturbing to adults than to children, and teachers considered the activities interesting enough to make special arrangements when necessary. Used as a whole-class activity for two or three one-hour periods per week, "Whistles" has lasted from three to five weeks or longer, depending on the interest of the students.

"Strings," on the other hand, has been found suitable either for an entire class or for a small group to engage in while others are working on something else. If an entire class works on "Strings" three times a week, you should expect the activities to last from three to four weeks.

The two parts of the unit are rather different in one other respect. In "Whistles," children explore sound by manipulating, observing, testing, combining, and rearranging many kinds of materials in different ways. In "Strings," they are primarily engaged in instrument making. Although there is always some instrument making in "Whistles" and considerable testing and rearranging in "Strings," this difference in emphasis seems to hold true from class to class. In "Strings," many children have especially enjoyed the opportunity to make something that is their own, both in design and construction.

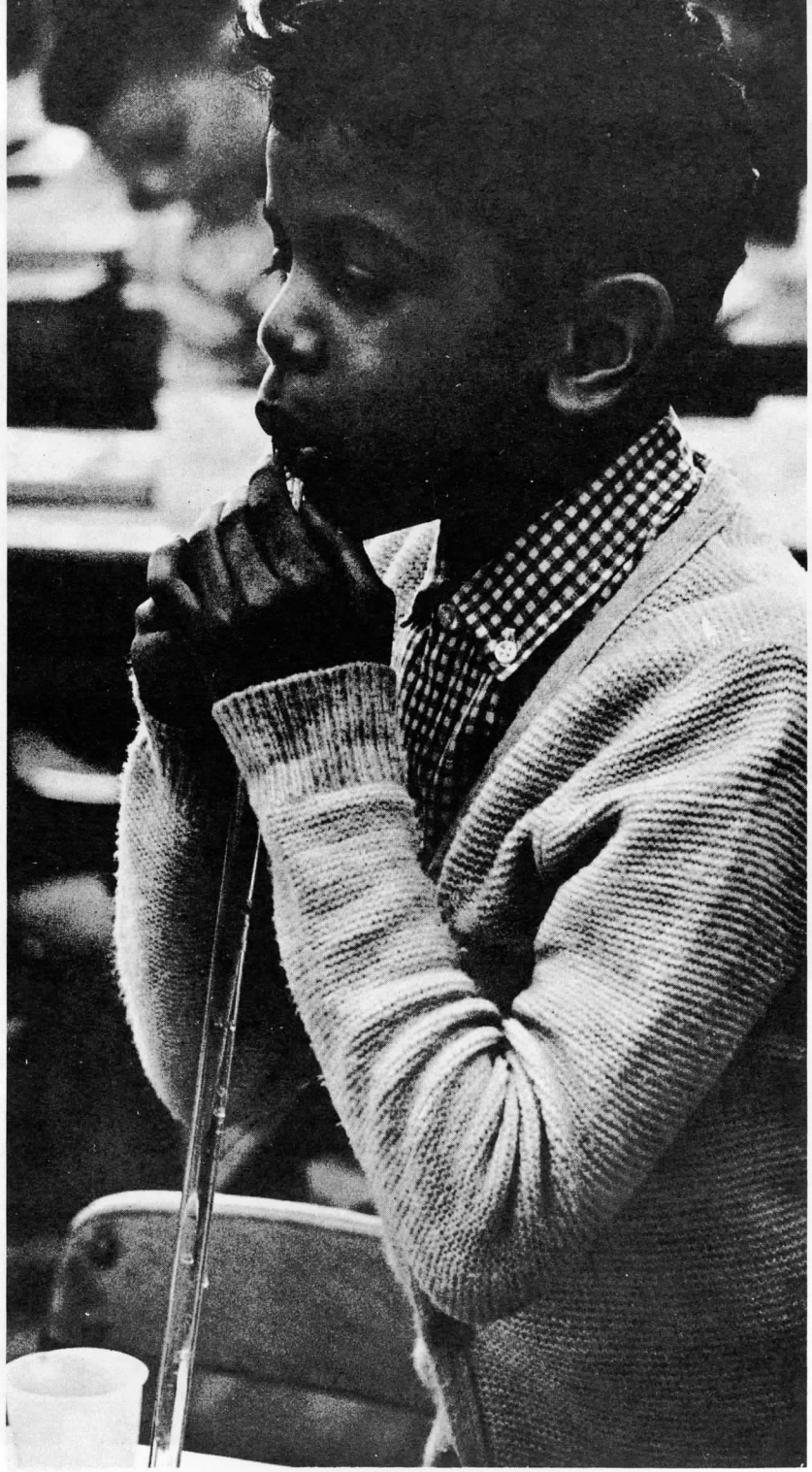
Whether you choose to teach both sections of the unit or just one is up to you. You may choose to teach the two sections one after the other, or to allow months to pass between sections. The two sections seem to complement each other best when "Whistles" is taught first and "Strings" second.

USING THIS GUIDE

In the descriptive account that follows, the activities have been grouped into sections according to the materials used. The materials are listed together with the reasons for introducing them to a class. Then follows a detailed description of some of the things that children have done with each set of materials, together with some indication of the amount of time that children have spent on each set of activities. The time factor has varied from class to class, depending on the interests of the children. In some cases, the starting point for a new set of activities has been the introduction of new materials. In most cases, however, teachers have tried to introduce new materials in such a way that children could use them to further the activities and investigations they had already begun. In any case, if a child was so deeply involved in what he was doing as to ignore the new materials, he was encouraged to continue on the path he had been following.

The order in which the materials are presented in the *Guide* is only one of the possible ways that they can be used. The actual sequence has varied from class to class. In one class, for example, the children began using plastic tubes. In another, water was not used until the fourth class period. As your class works through the activities, you should feel free to change the order to suit the particular needs of your students.

The questions included in the description of the activities arose naturally in trial classes. Sometimes a teacher asked a question to help a child see his work in broader perspective or follow through on something he had begun. Sometimes children questioned classmates or the teacher. Often the teacher could help by opening the question for discussion. When two children were working in the same general area or when one had found a way of attacking a problem that was stumping another, the teacher encouraged them to share their ideas and experiences. Occasionally, when many children happened to be working on the same problem or were concerned with similar questions, the whole class would be brought together for discussion.



USING THE APPENDIX

Certain techniques involved in making sounds with tubes can be a bit tricky for adults as well as children. Many people have no difficulties at all, while others can benefit from a little help at the right time. The *Appendix: On Making Sounds from Tubes* has been included so that teachers can help those children who have trouble with some of the sound-making techniques.

THE MUSICAL INSTRUMENT RECIPE BOOK

During the course of the development of *Whistles and Strings*, many designs were accumulated for simple musical instruments that could be made by adults or by children with simple tools and materials. Instructions for building these instruments have been assembled into *The Musical Instrument Recipe Book*, which is available from Webster Division, McGraw-Hill Book Company, Manchester Road, Manchester, Missouri 63011. It can be used as a supplement to *Whistles and Strings* or as a resource book apart from this unit.

MATERIALS

CLASS KIT*

30 waterproof cardboard trays
50 6-oz coffee cups
1 ball string
15 cardboard paint buckets
6 funnels
1 roll vinyl tubing, 3/8" inside diameter, 25' long
1 roll vinyl tubing, 1/4" inside diameter, 50' long
1 spool squidding line
1 spool monofilament fishing line
15 pouring cups, 1-oz capacity
70 plastic caps, 7/8" diameter
250 plastic caps, approximately 1/2" diameter
20 plastic tubes, 7/8" diameter
130 plastic tubes, 1/2" diameter
1 box plastic straws, 5/16" diameter
1 box plastic straws, 1/4" diameter
1 package elastic cord
30 nails
400 screw eyes, 1/4" diameter
15 droppers
1 lb dried peas
1 box cotton
4 rolls masking tape, 3/4" wide

* Available from Delta Education
Box M, Nashua, N.H. 03061

Note You will have to supply (or ask the children to bring in) pieces of wooden board in a variety of sizes, from long and thin to short and wide. Any kind of wood can be used, but it is easier to saw and to insert screw eyes and nails into soft woods, such as pine and balsa. Boards to which the strings are attached can help to amplify (increase the volume of) the sound that the strings make. The thickness of the board, however, affects how well it resonates. Board that is 1/2-inch thick is sturdy enough to support a number of strings, but not so thick that it absorbs the sound. Children have also used thinner and more flexible boards very successfully. In some cases, they designed their instruments to take advantage of the wood's flexibility to change pitch. The greater the variety of shape, size, and thickness of board you and your students can obtain, the more possibilities there will be for making different kinds of instruments.

You will also need small pieces of wood to be used as bridges--thin strips or narrow blocks will do.

You should begin to collect scraps of wood about two weeks before you intend to begin work with "Strings." Children can bring them from home, or they can be obtained from carpentry shops, school shops, lumberyards, or construction projects.

In addition to the wood, you will need two or three hammers and blankets or pieces of felt to place on desks to deaden the sound of hammering.

Saws are optional but would be very useful if there is enough room to work with them.

BOOKS FOR CHILDREN ABOUT SOUND AND MUSICAL INSTRUMENTS

Baer, Marion E., *Sound: An Experiment Book*, Holiday House, Inc., New York, 1952. This book of experiments can help children investigate sound, using simple devices and commonly available materials. Attractive and informal narrative and clear discussion of phenomena.

Dietz, Betty W., and M. B. Olatunji, *Musical Instruments of Africa*, John Day Co., New York, 1965. This generously illustrated book conveys a sense of the importance of music in African life as well as information about the ways in which many traditional instruments are made and played. Several of the photographic illustrations show instruments being played for dancing, ceremonials, and so on, by both children and adults. The book also contains rhythmic patterns for body movement and for accompanying songs and a field recording of traditional music played on authentic instruments.

Hofsinde, Robert, *Indian Music Makers*, William Morrow & Co., Inc., New York, 1967. The author describes many traditional American Indian instruments, their history, and their use in the Indian life. The illustrated descriptions of some of the instruments are in sufficient detail to serve as directions for making the instruments. A number of traditional Chippewa songs are also included.

Kettelkamp, Larry, *Drums, Rattles, and Bells*, William Morrow & Co., Inc., New York, 1960. This book--one of a series--offers historical background and information about the construction and musical use of many kinds of percussion instruments from different parts of the world. Illustrated instructions for making drums, a xylophone, and water-glass bells are also included.

Kettelkamp, Larry, *Flutes, Whistles, and Reeds*, William Morrow & Co., Inc., New York, 1962. This account of the development of woodwind instruments has instructions for making simple instruments, such as the elderberry whistle and the shepherd's pipe, and illustrated descriptions of some of the sound-producing mechanisms in more complex woodwind instruments.

____, *Horns*, William Morrow & Co., Inc., New York 1964. Here is a brief history of the development of brass instruments, with information about how ancient and modern instruments were and are made and played. This attractive book also contains suggestions for experimenting with shower hoses, water pipes, and the like, as well as a detailed description of the process by which a modern French horn is made.

____, *Singing Strings*, William Morrow & Co., Inc. New York, 1958. Mr. Kettelkamp combines suggestions for making simple instruments with information about the history and construction of various traditional instruments. This volume deals with the violin, guitar, and keyboard families of stringed instruments. It conveys the information in a clear and unpretentious manner, is helpfully illustrated, and is interesting to read.

Windle, Eric, *Sounds You Cannot Hear*, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1963. A book about sounds which are beyond the range of human hearing, animals that navigate and find their prey by means of ultrasonic sound, and some of the ways in which men have learned to put these sounds to use. There are many bits of interesting information about a world beyond human sense perception.

ACTIVITIES WITH WHISTLES

In this section are descriptions of some of the things children have done that related to whistles. The particular materials that are available encourage a rich variety of activities so that each child can find many things to interest him, and different children may find different experiences valuable. Also included are some of the questions that have occurred to teachers and to children while they were working.

Making Sounds with Tubes and Caps
(2-3 periods)

Children compare the sounds made by tubes of different lengths. In comparing their tubes with those of their neighbors, they find some tubes that make the same sounds. They cut and combine extra tubes in ways that seem useful to them.

MATERIALS

Start with:

3 1/2" diameter plastic tubes of different lengths for each child

1 cap for each tube

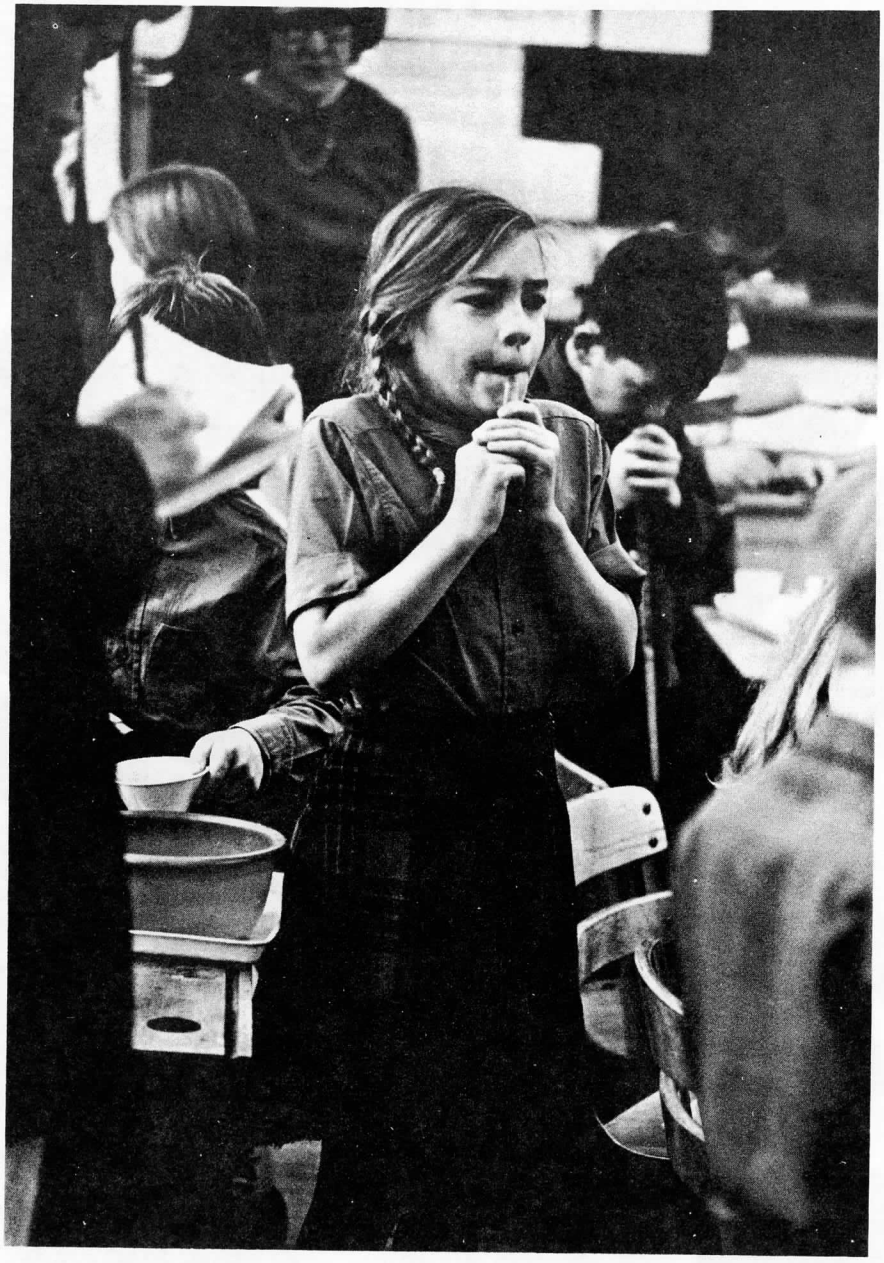
Have available:

uncut tubes and extra caps

scissors

masking tape

Before the first class, you will need to cut some of the 1/2-inch diameter tubes into five smaller lengths. The tubes can be cut neatly with sharp scissors or a paper cutter.

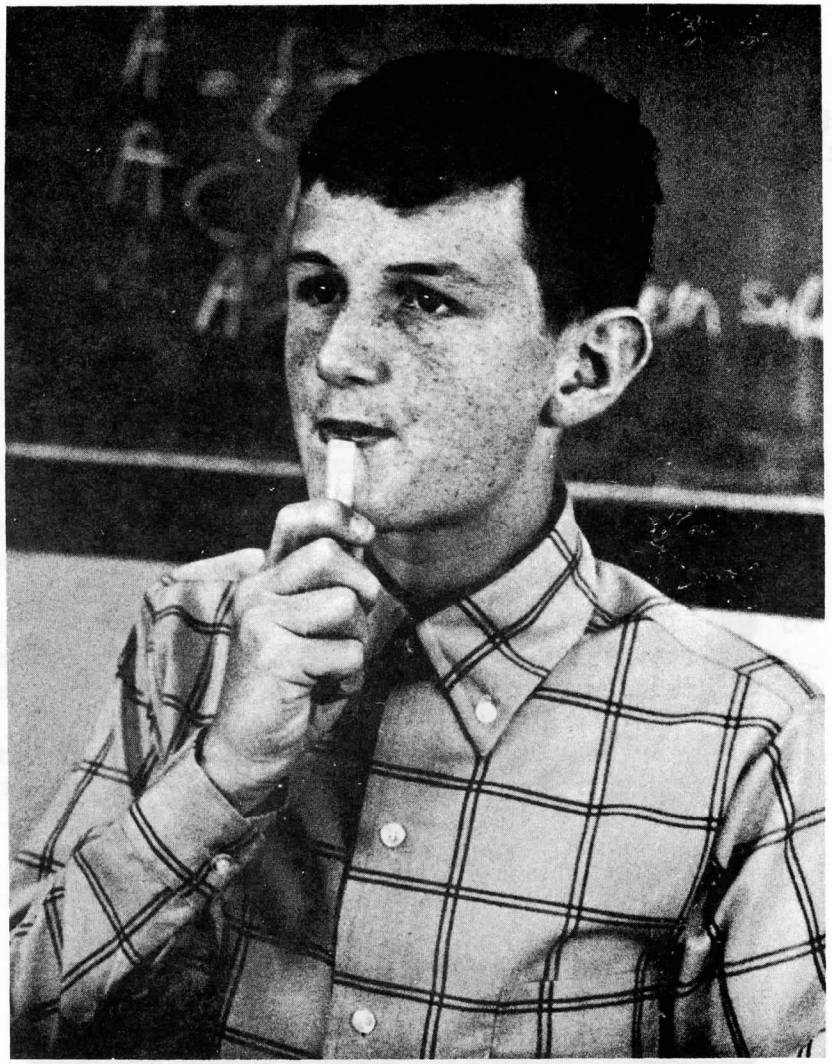


Cut 2½ inches from 20 ½-inch diameter tubes and set all the 2½-inch pieces aside. Cut 4 inches from the remainder of each tube and set the 4-inch pieces aside. Then cut 5 inches from the remaining part of each tube. You now have 80 small tubes--20 each of four sizes: 2½, 4, 5, and 6½ inches. Then to make 20 9-inch pieces for the fifth size, cut 10 uncut ½-inch diameter tubes in half.

There are many ways to begin working with sounds and tubes. A discussion about the ways in which musical instruments make sounds could be a starting point. In one class, the teacher simply held up one of the plastic tubes and asked the children how they could get the tube to make a sound. Several children volunteered and tried different ways of blowing into and across the tube. When at least one child had been successful in making a clear sound, the teacher gave each child his own set of plastic tubes.

The children were asked to see what they could find out about the sounds made by their tubes. The first problem was to be able to blow across the open ends of the tubes to get consistent sounds. Several children had difficulty with this at first (see Appendix). Some were helped by friends who had more skill than they did at blowing on tubes. Others were helped by the teacher. They were shown how they could vary the way they blew and the position in which they held the tube in order to make a clear sound.*

*A few children may become dizzy if they blow too hard on the tubes or for too long a time. This is not dangerous. Ordinarily, as the children become more skillful at blowing, the problem disappears. You may wish to caution your class ahead of time about this. Encourage them to stop for a while if they begin to feel uncomfortable.



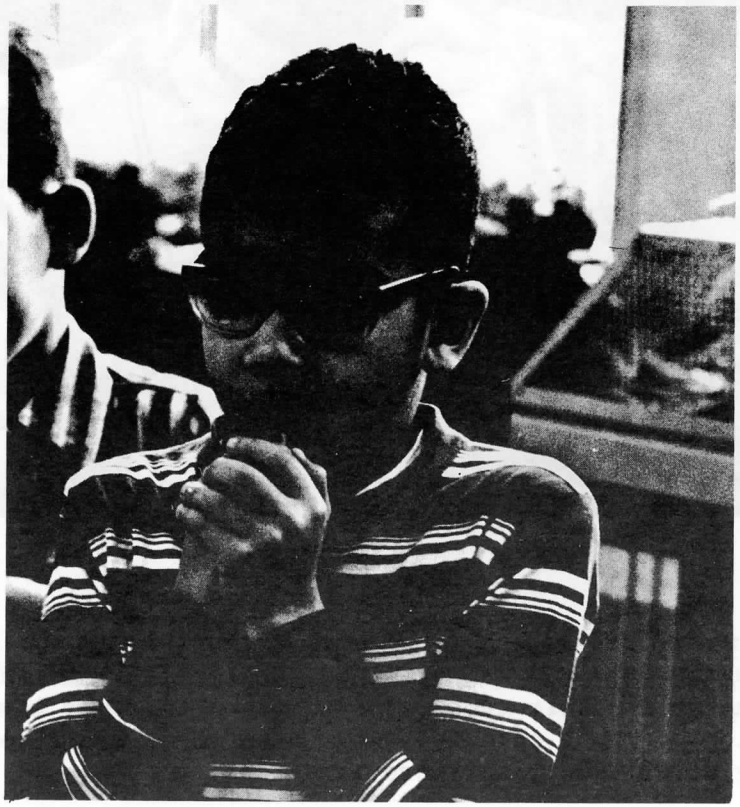
Once the children had attained some skill in making sounds with their tubes, they went on to other investigations. Those children who wanted them were given long uncut tubes, scissors, and tape.

Here are some of the things that children did in the first couple of class periods:

removed the caps from their tubes and tried to make sounds

covered the ends of tubes with tape, fingers, pencils, and pieces of wood, and tried to make sounds

cut very short pieces of tube to make high shrill sounds



tapped tubes of different lengths with pencils, or against their desks, or against their hands

cut "finger holes" in the sides of their tubes

tried to make a "flute" by cutting a hole in the side of a tube and blowing across it

made "flutes" with and without finger holes, with the ends of their tubes open or closed

made "slides" for their tubes, using pencils and tape

stuck a finger into a tube and pulled it out suddenly to make a popping sound

tried to make sounds using long tubes with both open and closed ends

taped different tubes together to make "panpipes"

Through repetitious and seemingly random investigations, the children explored the complicated factors involved in making and not making sounds with tubes. *Sometimes those activities which were least successful in producing sounds were among the most useful for isolating the conditions needed for producing sounds.*

COMPARING THE SOUNDS OF DIFFERENT TUBES

Children make comparisons between tubes at many stages of their work. It is sometimes helpful to suggest that children work in pairs or small groups on this kind of activity.

One of the first things that some children did was to compare the sounds made by their own different tubes. Then they began to compare their tubes with others.

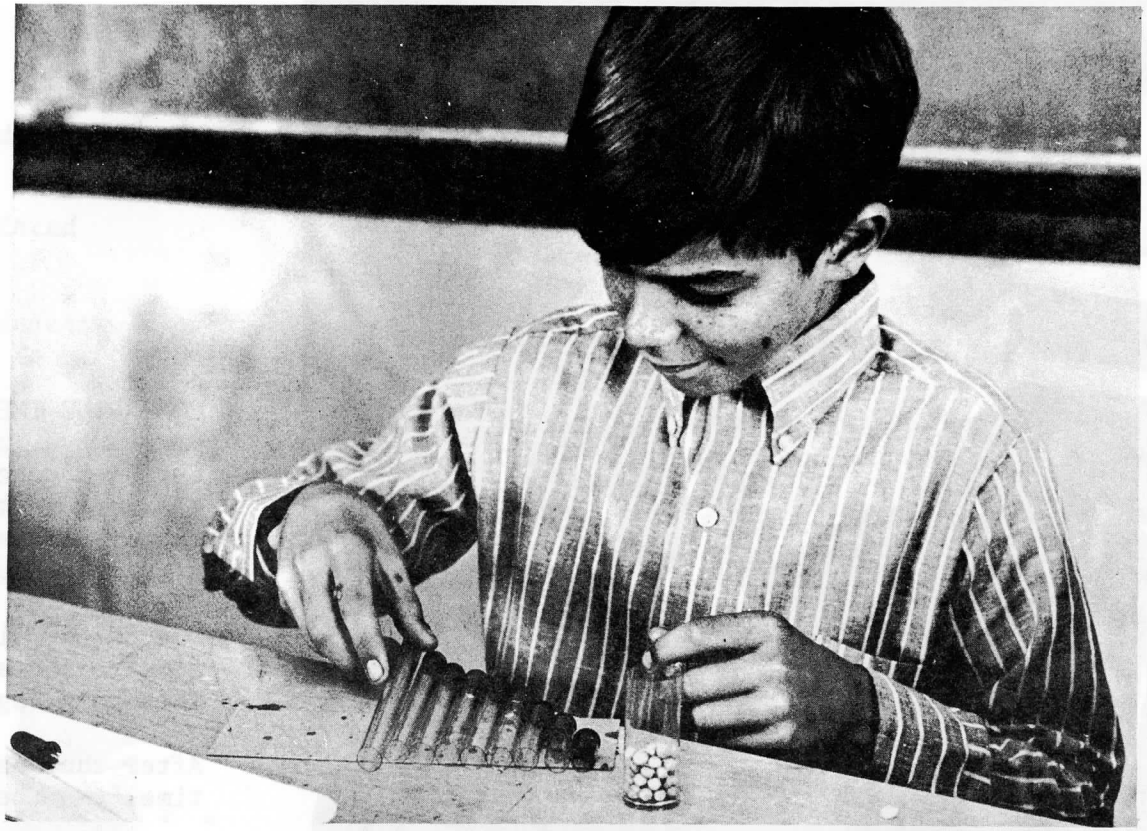
After they had been working with the tubes for some time, they began to consider problems like these:

Are there any tubes which made the same sound?

How are the sounds of tubes different from one another?

How many sounds can one tube make?

They compared the lengths of tubes which made the same sounds and of tubes that made different sounds. Most of the children recognized that a shorter tube made a higher sound than a longer tube did. Some of them began to notice that it was possible to get more than one sound from a tube by blowing harder or softer. This became more obvious when children began working with longer tubes.



It is not always easy to blow softly enough to get the lowest note possible on a long tube (see Appendix). Some children were able to produce a high note from a long tube but where unable to produce the low note others had made with that particular tube. They were very much confused by this seeming inconsistency in the way that the tubes behaved. After a great deal of blowing on different-sized tubes, they could begin to understand how both the length of a tube and the way it is blown influence the sound.

As they gained skills in making different sounds with the tubes, children became interested in combining their tubes in various ways. Some taped their tubes together lengthwise to make a long tube. Others taped several tubes into a long row, so that they could make a sequence of sounds with them. Most arranged their tubes in order of length to make a sort of panpipe.

One boy made a xylophone-like instrument by arranging empty tubes of different lengths on a board. He played his instrument by hitting the tubes to get different pitches.

A group of children in one class recorded the sounds they could make with various tubes on a tape recorder.

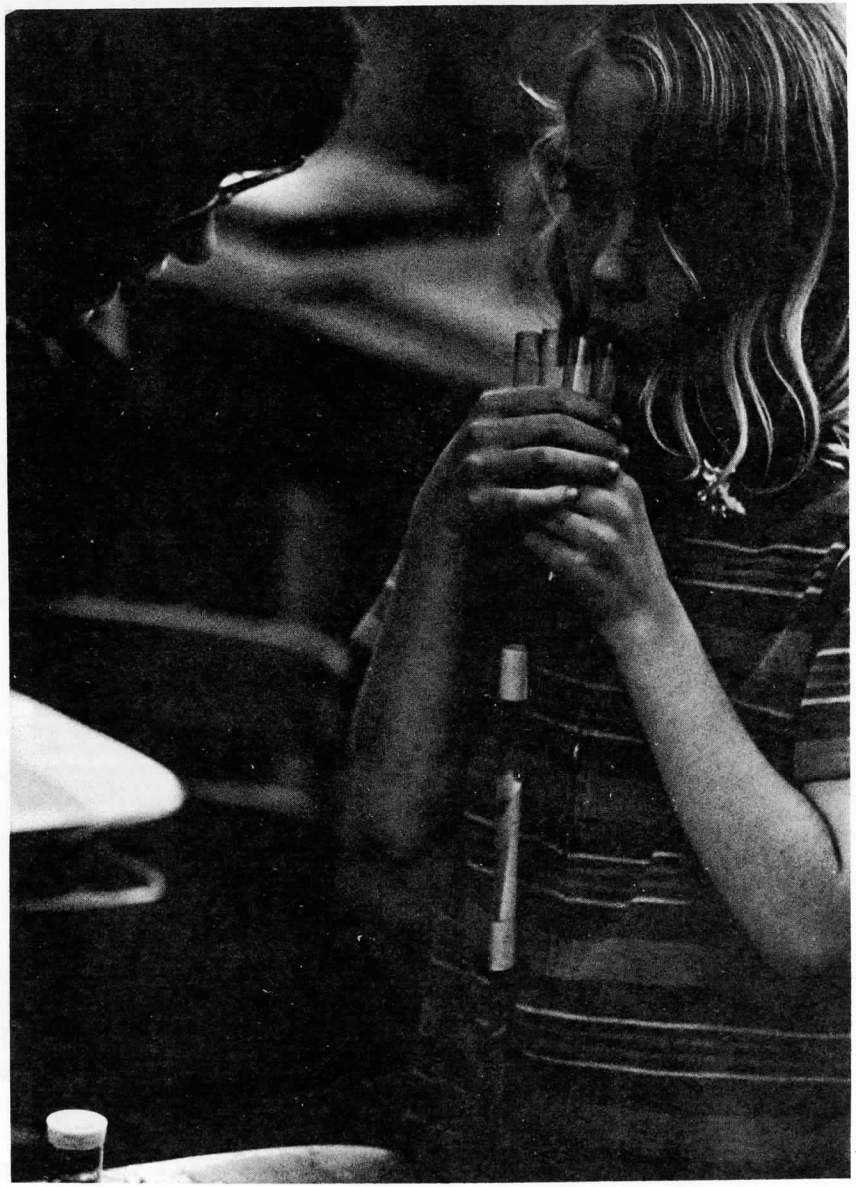
PLAYING SONGS WITH TUBES

Some children enjoy playing tunes and making music with their tubes. By trying to make a set of tubes which will play certain notes, children can gain a great deal of insight into the precise relationship between the lengths of tubes and the pitches of the sounds they make.

A few children in trial classes were very concerned with playing tunes, such as "Mary Had a Little Lamb" or "Jingle Bells." Others were content simply to blow sequences of notes. Among the tune players, some children did not seem to be concerned if all the notes they used were exactly in tune for the songs they were trying to play. Others were acutely critical of the notes that they were playing and were anxious to make a set of tubes that would play the notes of their tunes accurately.

When a child who had the tune obviously wrong asked the teacher to listen to his playing, she would point out to him that though the rhythm was clear, the tune did not sound right to her. Some children understood what she meant and wanted to try to alter their tube lengths to get the notes right. With those children, the teacher discussed how to go about pursuing the problem further. On the other hand, it did not seem useful to guide a child to exact tuning if he himself could not *hear* that it was wrong, since tuning often involved a fine discrimination between pitches, as well as much careful work.

Sarah, a fourth grader, invented a kind of musical notation to help her remember how to play "Mary Had a Little Lamb." She was using three tubes to play the tune, and she named them "*s*mall," "*n*ext," and "*l*arge." She then wrote the tune as "s, n, l, n, s, s, s. . . ." This system caught on briefly in her corner of the room. She passed her sheet of music to her neighbor, Pushpa, who chose small, medium, and large tubes of her own to play the tune. Pushpa did not realize that the notation would work only for the three particular tubes for which it had been written. When Pushpa used Sarah's music sheet to play the tune on her own tubes, the tune didn't sound right. Sarah was able to explain to her that the reason it didn't work was because the two sets of tubes were not of the same lengths.



Susan, another girl in the same class, labored long and hard to get a set of tubes which would play the first line of "Jingle Bells." After working on this for about two class periods, she finally succeeded. By the next class, however, Susan had to repeat the same laborious process in order to play the tune again. This was an occasion when the teacher could have suggested that Susan, with her tubes for "Jingle Bells," and Sarah, with her notation for "Mary Had a Little Lamb," work together to invent a notation for "Jingle Bells." Both children might have then seen the implications of their work more clearly and could have pursued problems of tunes, notations, and lengths much further than they did.

AN UNUSUAL EXPERIMENT WHICH LED TO FURTHER EXPLORATION

Laurie took a tube home with her and asked her older brother to blow some cigarette smoke into it. She then capped both ends of the tube. When she brought her tube to class the next day, the smoke had disappeared, and she wondered why. By chance, her tube had a small hole in it, which she had covered with cellophane tape. There was a dark brown stain on the tape covering the hole. Neither Laurie nor any of the other children could offer any explanation as to how the stain had gotten on the tape or, for that matter, what had caused the smoke to disappear. No one associated the stain with the cigarette smoke. They were, however, interested in trying similar "smoke" experiments with their tubes. Several children went about this by breathing into their tubes, quickly capping both ends, and watching what happened to the mist that formed on the inside surface of the tubes. Another child suggested that water be put into the tube to see what smoke would do to the water or what water would do to the smoke. At this point, activities with water and tubes were under way.

Tubes, Caps, and Water
(2-4 periods)

*By adding water to tubes, children can easily change the pitch of the sounds that the tubes make. They investigate further the relation between the length of a tube and the sound that it produces.**

MATERIALS

For the class: a central supply of water in a bucket or other large container (In one class a large watering can worked well.)

For each child: cardboard tray to minimize spilling

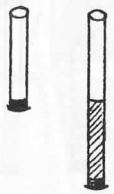
small plastic cup for individual water supply

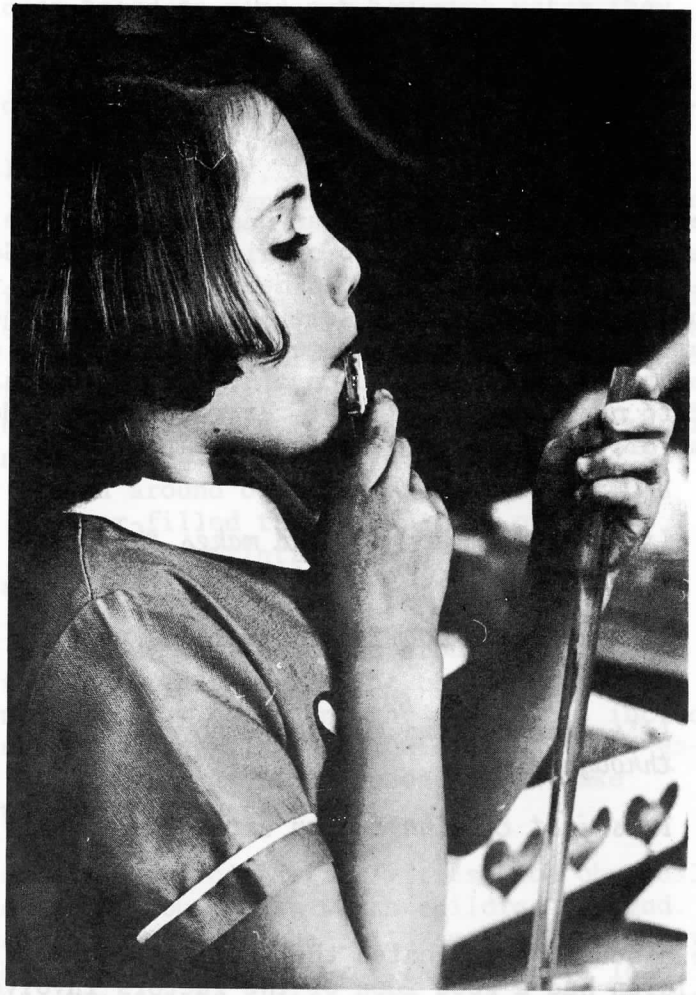
eyedropper for making fine adjustments to the water level in tubes

*Activities with water and tubes have usually been initiated by the children. If using water does not come up spontaneously in your class, plan to introduce it when it seems appropriate.

With the addition of water to the tubes, a new stage of exploration was reached. The children made many experiments with changing the pitch of their tubes. They soon realized that the addition of water made the note higher, but some children didn't know why. Was it the amount of water or air space in a tube that determined the note that the tube would play?

After the children had worked with water for some time, the teacher talked with the class about changing the sound of a tube. What could be done to make two tubes of different lengths play the same sound? Someone suggested filling the longer tube with water to the same level as the cap of the shorter tube. When the teacher did this and blew across the tube, they sounded the same.





The class agreed that if the water was taken out, the tubes would not sound the same. The longer tube was emptied, and both tubes were blown again. The longer one sounded definitely lower.*

*At this point some children might want to make sounds with materials other than water in their tubes. See "Tubes, Caps, Water, and Other Materials," page 22.

Then the teacher asked if anyone had been able to get the same sound on any two of his own tubes. Several children said that they had been able to make the same sound with tubes of the same length. Laurie mentioned that she had gotten the same sound by putting equal amounts of water into tubes of the same length. This led to questions about what the water does. Here were some of the children's explanations.

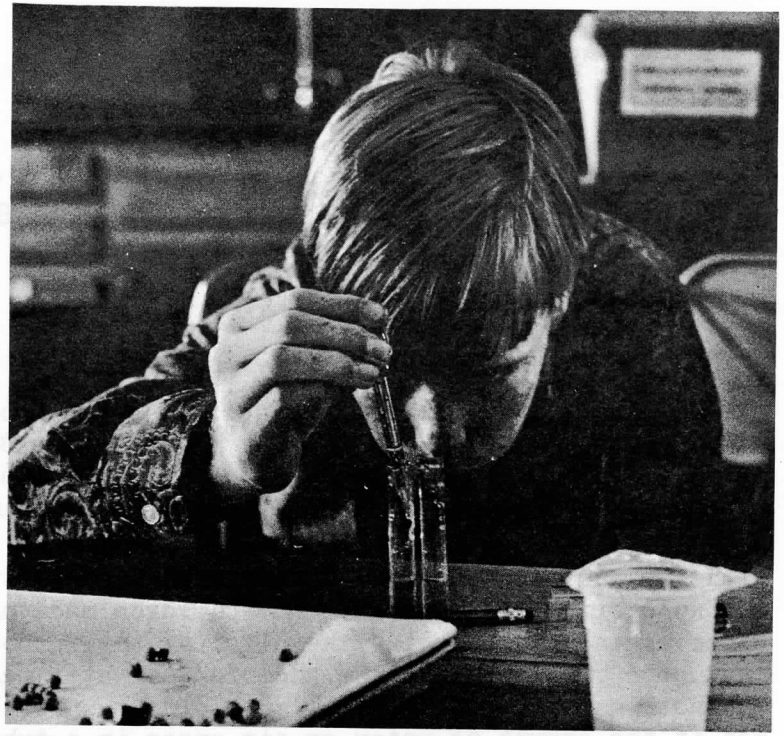
It fills them up more and makes them the same size. (different sized tubes)

It makes less room for the air to go through.

It's like cutting the tube--no air goes through.

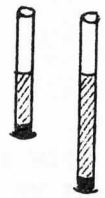
It's just like having an extra cap.

The discussion indicated that at least some of the children had a good idea of the factors involved in changing sounds with water in the tubes. However, when the children continued to pursue these questions, many of them still had difficulty in getting two tubes of different lengths to play the same notes. Some children lined up the *tops* of their tubes (Figure 1) and poured water to the same level in both tubes. These children had the same *air space* in both tubes, and both tubes played the same note. Other children lined up the *bottoms* of their tubes (Figure 2) and poured water to the same level in both tubes. These children had the same *amount of water* in each tube, and



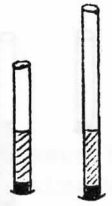
the tubes did *not* play the same note. It was clear that these children needed more time to experiment with the effects of adding water to tubes before they could solve the problem.

Figure 1



same note

Figure 2



different note

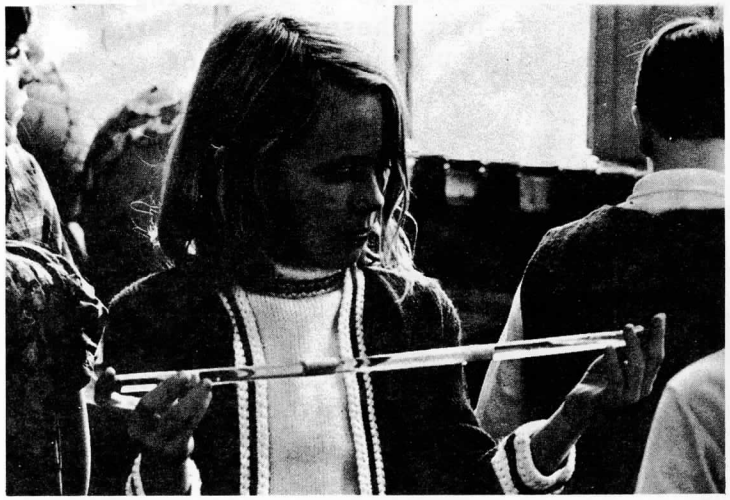
OTHER EXPLORATIONS WITH TUBES AND WATER

In all the classes, children found many interesting things to do with tubes and water--some related and some unrelated to sound.

One child tuned a set of pipes with water so that they would play the notes of a tune. She marked the water level in each tube. Then she cut off the part of each tube which had contained water and capped the remaining lengths of tube. In this way, she made a set of empty tubes with which she could play her tune again.

A student in another class found that he could change the pitch of a single tube with water in it by squeezing the tube to raise the water level. He soon became so adept at adjusting the water level that he was able to play whole tunes on a single tube.

Another child made a set of "water tube" chimes by filling tubes with different amounts of water. She found that the tubes made sounds of different pitches but were not as resonant as chimes made from glasses with water in them.



Some children tried to find out how much water they could put in a tube before it would make no sound at all.

Many children found it fascinating to explore the behavior of water in tubes. Some would fill a tube partly full, turn it over, and watch the air bubble travel up the tube. Others took a small tube, filled it *nearly* full of water, and used the tube with the resulting air bubble as a level, testing it on many surfaces in the room. Some children put other materials in the tubes and watched them as they sank to the bottom of the tube, rose to the top, or remained suspended. They were thus able to explore the buoyancy of different materials. A few children put cotton or erasers in their tubes and watched what happened as the water flowed around obstacles. One boy noticed that when a water-filled tube was placed over some printing, it made the printing larger. He used his tube to magnify many other things.

A student in a fourth grade class brought in food coloring to add to the water. The children enjoyed making many colors by combining the few colors included in the packages. They also used colored water to explore the way water behaves in tubes and to make sounds with tubes and water.

These were only a few of the activities, not obviously related to making sounds, in which children engaged. Their teachers encouraged the children in these activities in the hope that doing these things would lead some of the children to explore other areas in which their interest was high. Indeed, one group of eighth graders eventually went on from making sounds with tubes to constructing pumps and siphons. In a fourth grade class, the children used tubes and water for a wide variety of explorations during one or two class periods. Many children alternated between using the tubes for activities with water and using them for activities with sounds. They would spend part of the period on one activity and then go on to another, returning often to those activities which interested them most.

Tubes, Caps, Water, and Other Materials (1-2 periods)

The children explore further problems involved in making sounds with tubes: the effect on the sound of blocking off a part of the tube, and the conditions that determine whether a tube will make a sound at all and how clear the sound will be.

MATERIALS

dried peas

cotton

Once there had been an opportunity to explore how putting water in tubes affected their sound, the teacher asked the children if they thought that other materials in the tubes would have the same effect as water. The children could not agree. Some thought that all materials would work in the same way as water. Others were not sure. One fourth grader ventured the guess that a tube with something like cotton in it wouldn't make a sound, because cotton was full of holes and would not block off the tube effectively. The teacher had supplies of absorbent cotton and dried peas on hand. After the discussion, she made them available to the children.*

*Children have also tried such materials as sugar, salt, sand, coffee, gravel, and bits of paper in their tubes.

There were striking differences in the way that children used these materials. A few children began by putting one material in one tube and another material in another and comparing the sounds. They went on trying various combinations and testing the results. Others immediately put peas, cotton, and water together in one tube. After a while, the children began to use the materials more selectively and were able to make comparisons between them.

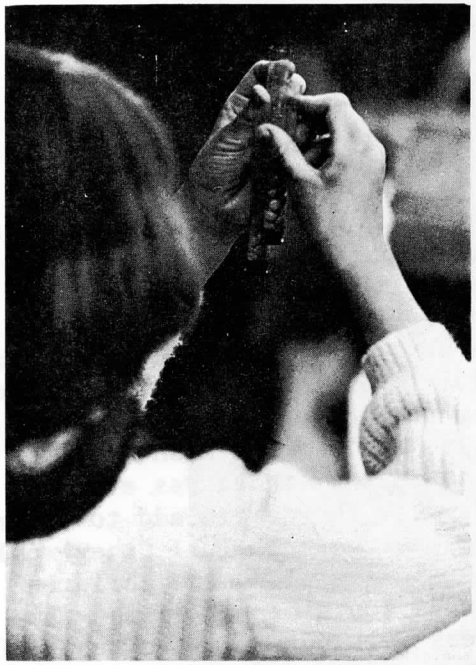
Some could not see the advantages of separating the different materials. To help these children, the teacher asked questions about the behavior of the tubes.

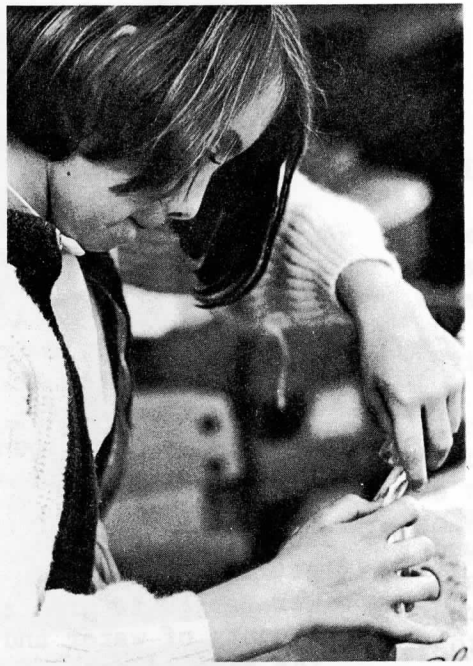
Would a tube with peas in it make a sound?

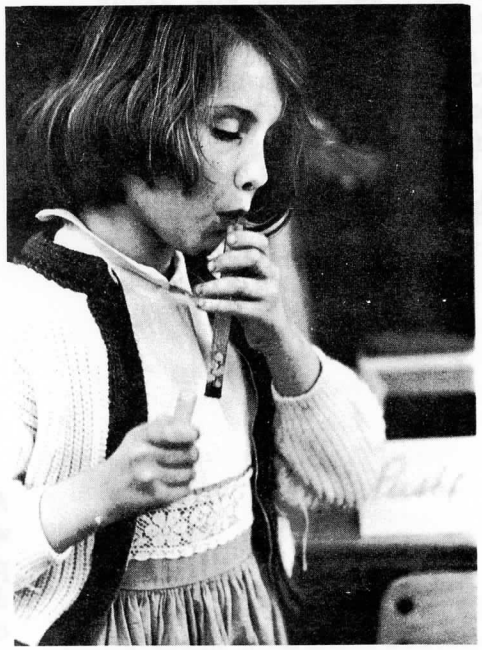
Can you get a sound in a tube with cotton in it?

Can you get the same sound from two tubes with different things in them?

In trying to find answers to questions like these, the children began to vary their use of the materials and to realize that they gained much more information when they tried materials separately and in different combinations.







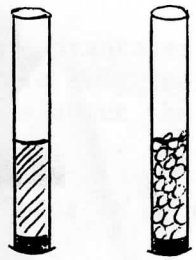
THE EFFECT OF COTTON IN A TUBE

Most children who tried putting absorbent cotton in their tubes found that they could not produce a sound. Sometimes a tube with a very small amount of cotton in it would make a sound when blown, but adding more cotton stopped the sound. This led some children to investigate carefully, to find out just what the "cotton limit" was for various tubes.

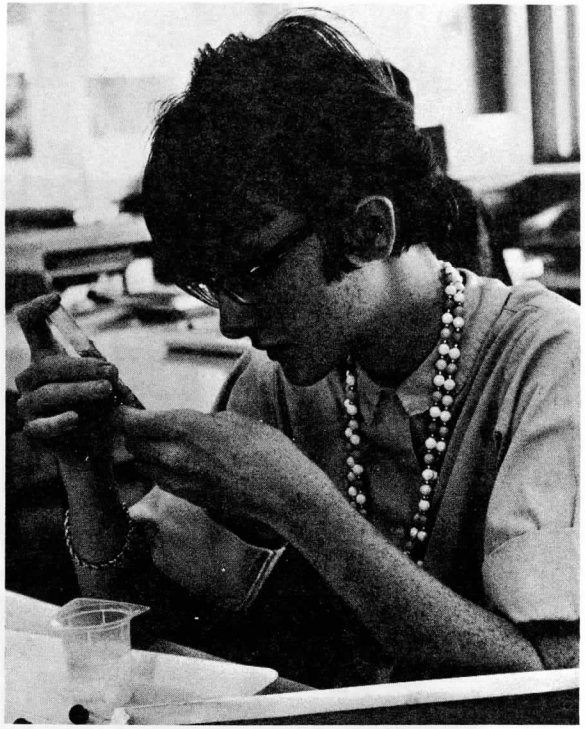
Someone found that if the cotton in his tube was wet, the tube would make a sound when blown. A few used this discovery to make slides for their tubes. They attached a piece of wet cotton to the end of a pencil and moved the cotton up the tube to change the pitch as the tube was blown.

THE EFFECT OF PEAS IN A TUBE

Those children who put peas in their tubes noticed an effect that seemed similar to that of adding water. Adding peas to a tube made the sound higher. After a number of peas had been added, however, the tube would no longer make a sound at all. One eighth grade girl, who made a careful investigation of this phenomenon, found that she had to add more peas to a long tube before the sound stopped than to a short tube. Other children had observed that there was even a limit to the amount of water they could add to their tubes. If they filled the tubes too full, they would get no sound. In a class discussion, the children were asked to predict what would happen if the same amounts of water and peas were put into two tubes of the same length.



A few fourth graders predicted that the tube with water in it would make a higher sound, because the peas didn't block as much of the tube as the water did. The teacher then tried this experiment with the class watching.



OTHER ACTIVITIES WITH PEAS

Sometimes children used these materials in unexpected ways. One group of eighth graders invented "police whistles." They cut a side hole in a short tube and put a pea inside. When the tube was blown, it made a shrill, warbling, unmistakable "police whistle" sound.

A fourth grade boy noticed that some peas which he had left in water over the weekend were growing "tails." In this class, several other children's peas sprouted--some in water, some in wet cotton, some in closed containers with water inside. The children were very much intrigued with the changes in their peas. They put more peas in water to see what would happen to them. They discussed many things about the peas: where the peas had been when they sprouted, what the "tails" were and where they had come from, the changes of color in the peas, the cloudiness of the water in which the peas had been sitting. The speculations continued. Eventually some of the children in this fourth grade embarked on a seed-growing project. They planted all kinds of things which people eat. Besides dried peas, they planted popcorn, dried beans, sunflower seeds, and also various kinds of frozen vegetables (corn, peas, and lima beans).*

* See the Elementary Science Study unit *Growing Seeds* available from Delta Education, Box M, Nashua, N.H. 03061.

Tubes of Different Sizes
(2-4 periods)

Children combine different sized tubes to make complex musical contraptions with which they can investigate conditions necessary for producing different kinds of sounds.

MATERIALS

20 7/8" diameter plastic tubes (For a larger quantity, cut some or all the tubes in half.)

70 7/8" diameter caps for tubes

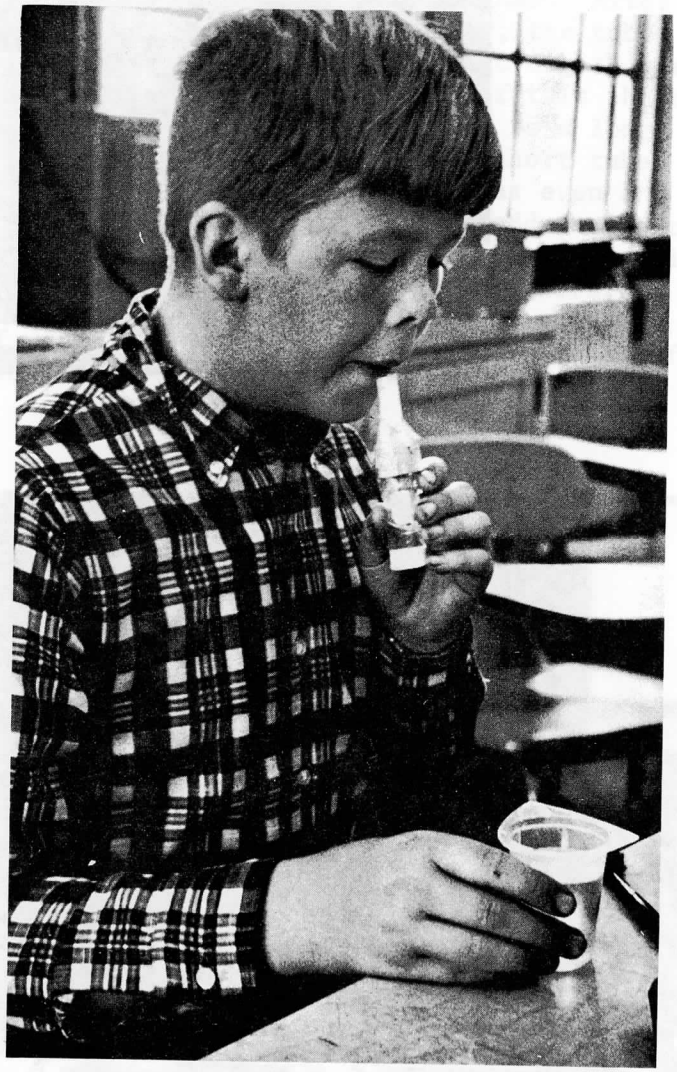
When children were given pieces of 7/8-inch diameter plastic tubes, they found that they could not make sounds as easily as they could with narrower tubes. This led them to combine their small tubes with larger ones to make systems of tubes which could produce sounds. Working with different combinations of tubes led to questions about the parts of their tube systems:

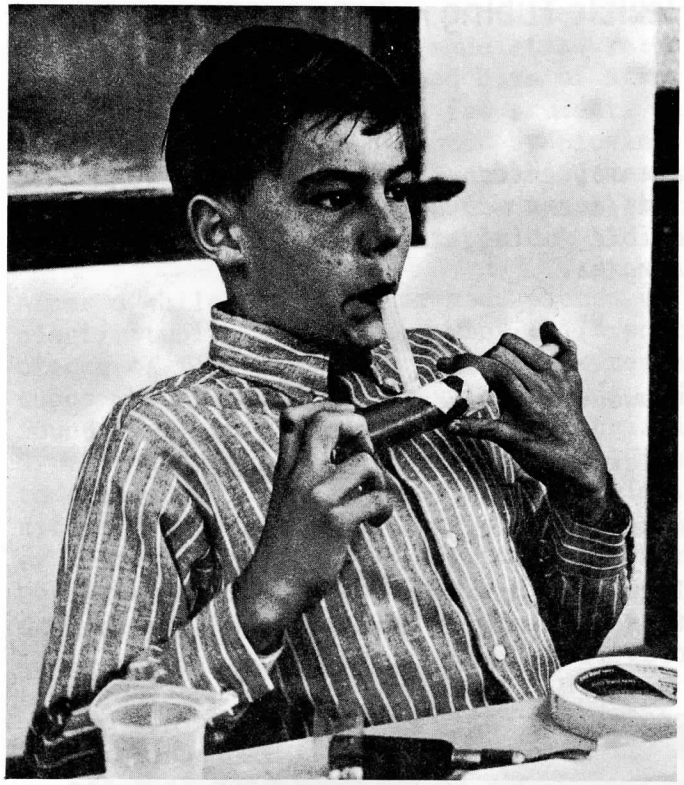
Which parts were essential to produce sounds?

Which parts could affect the pitch?

Which parts could be removed or changed without changing the sound?

Sometimes, what started out as random combinations of tubes led to insights that would not otherwise have been possible. David, and a number of other children, inserted a narrow tube into a wider tube partly filled with water. When he blew across the end of the narrow tubes, the increased air pressure forced the water down in the tube, producing a sound which was continuously lower in pitch.



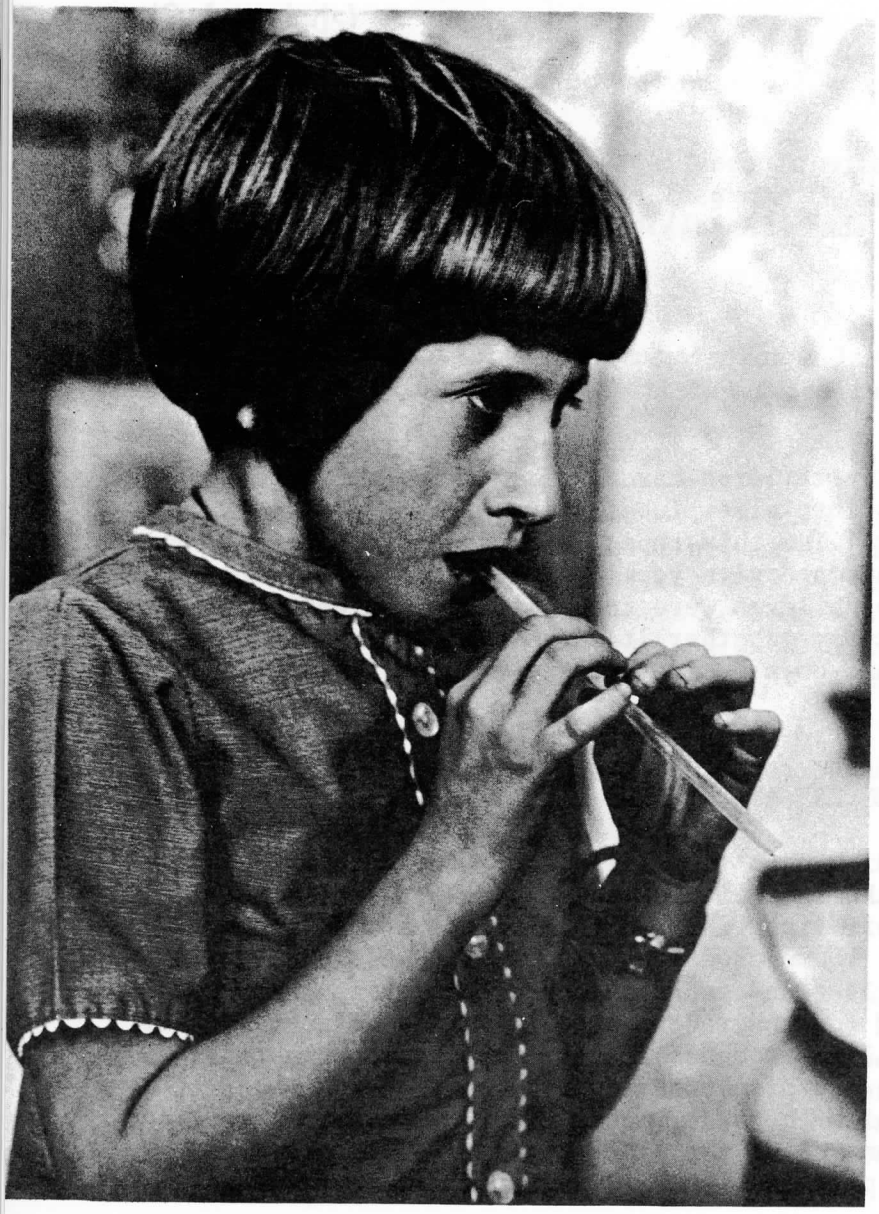


Some children inserted several small tubes into a larger tube. They found that when they blew across the end of one tube, it would not make a sound unless all the other openings were blocked off.

Occasionally children have experimented with putting thin tubes into wider tubes which were partially filled with water. The thin tubes were used both with and without caps and with varying amounts of water in them. The children were interested in the behavior of the thin tube: whether it sank or floated and how it moved up and down inside the wider tube.

MAKING "BUGLES" AND "TROMBONES"

Some children used the wide plastic tubes to make trumpet-like instruments. When they blew into their tubes, their lips vibrated to make the sound (see Appendix). Some used long pieces of tube alone. Others built sound contraptions with several tubes. A group of fourth graders used two sizes of tubes to make "slide trombones." By wrapping masking tape around one end of the narrower tube, they made it fit snugly inside the wider one. Sliding the narrow tube up and down inside the wide one, they could play many different pitches on their instruments.



Straws and Flexible Tubing (2-4 periods)

With plastic straws, children make straw reeds and investigate a different way of making sounds with air. With flexible tubing, they make instruments of different lengths.

MATERIALS

plastic straws (two different sizes)

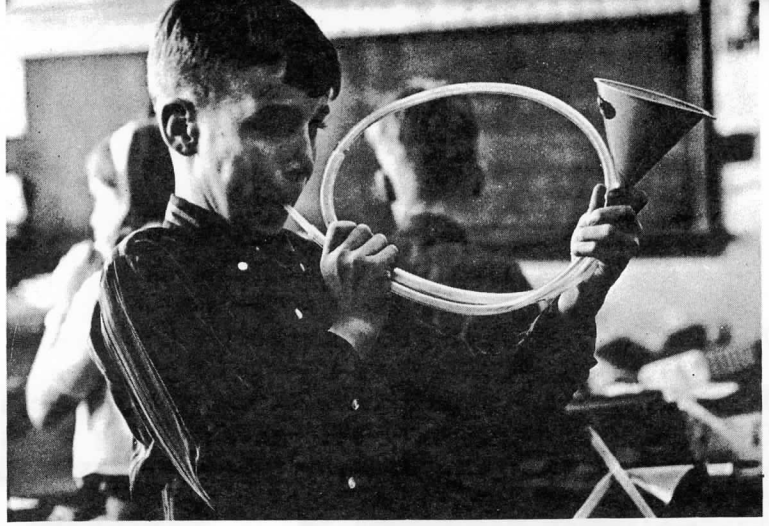
pieces of flexible vinyl tubing

funnels, sharp scissors, masking tape

After the children had spent some time making sounds by blowing across tubes, they investigated ways to make sounds with straw reeds (see Appendix).

In an eighth grade, one child made a reed on his own with straws he had brought to class. Other children in the class wanted to try to make one, and soon the whole group was busy experimenting with this new kind of sound maker. In a fourth grade, the teacher introduced straw reeds. She showed the class how to cut the end of a straw to make a reed and demonstrated how to blow into it to make a sound.

Some children were able to make their straw reeds work immediately. A few needed help from other children or the teacher in cutting a reed and getting a sound from it. All the children needed time to become acquainted with how the straws worked. After much informal experimenting and seemingly random blowing, they were able to make different sounds with the reeds and to control their blowing to get the kinds of sounds they wanted.



Some children concentrated on making shrill sounds for a while. Many of them experimented with cutting the straw. Some children made straw reeds of different lengths. Others snipped bits of straw to change the sound as they blew. A few students in one class tried making "blends" of sound by blowing two straws at the same time. Some tried making reeds from the stiff 1/2-inch diameter plastic tubes and from any other tubes that were available.

After a while, the teacher made pieces of flexible plastic tubing available. Many children combined pieces of flexible tubing with straw reeds to make long tubes which could play very low sounds. Some children found they could vary the pitch of their instruments by moving the straw reed in and out. Others were able to change the pitch by bending the tubing. Still others attached funnels to the ends of the plastic tubing or to the straws to make the sounds louder and more ringing. When the supply of funnels ran out, children who wanted to copy the idea made quite effective substitutes by rolling pieces of Oak-tag into cones. Children tried many combinations of straws, flexible tubing, and various kinds of tubes, to see what kinds of sounds they would make.* Their experiments raised questions about the effects of specific parts of the systems. What parts of their instruments could the children remove and still get a sound? How did adding or removing certain parts affect the pitch or loudness?

Some children wanted to make instruments of variable pitch. They used straws of two different sizes, one for the reed and another for a slide (after the fashion of a slide trombone). A few tried putting holes in their straws to see if they could get different notes.

In many classes, children formed "bands" and used the instruments they had made. Some groups were small. Occasionally an entire class would try playing together. Rhythm instruments, piano, tone bars, or other instruments at hand were often included in the music making.

*Some children combined mouthpieces from conventional wind instruments with different kinds of tubing. Others enjoyed making mouthpieces modeled after manufactured ones. One class that had learned to play the Flutaphone found that the Flutaphone mouthpiece worked well in combination with tubing.

OTHER ACTIVITIES WITH FLEXIBLE TUBING

One group of children discovered that long pieces of flexible tubing made very effective talking tubes. After playing with the talking tubes in class, one boy went home and made a stethoscope from a piece of flexible tubing.

With flexible tubing, many children engaged in experiments involving the behavior of water and air. A favorite activity among fourth graders was to put a small amount of water into a piece of flexible tubing and, alternately sucking and blowing it back and forth, to watch the motion of the water in the tube. Other children tried experiments with suction and siphoning.

During some classes, children would work for a while with water and then return to their sound experiments and instrument building. In this way, the different activities supported each other.

Often in the same class period, individuals or small groups of children engaged in a wide range of activities with the same materials. Because the materials stimulated a variety of investigations, children were able to work on many different problems in a manner and at a pace which was most suitable for them.

ACTIVITIES WITH STRINGS

In this section are descriptions of activities which have centered around children's constructing and using stringed instruments of their own design. Children have had many different ideas about how their instruments should look and sound. With these materials they have been able to explore those aspects of making and using stringed instruments which have been most interesting to them.

Making Sounds with a String
(I period)

Children confront the difference between the sound made by a string alone and the kinds of sounds associated with stringed instruments.

MATERIALS

1 3-foot piece of squidding line for each child

The teacher gave a piece of squidding line to each child and asked the children to see how many ways they could find to make a sound with it. Some of the many different ways they found were these:

plucking taut strings with their fingers or other objects

rubbing strings with rulers

rubbing strings across another object, such as a box, desk, or someone's back or knee

holding strings loosely, and suddenly snapping them tight

tying string between two desk chairs, and tightening and loosening the string to make different pitches by moving the chairs

One of the main problems that children faced was to find a way to fasten and secure the strings so that sounds could be made with them. They attached the ends of strings to pencils, tied them to desks, and wrapped them around shoe boxes or other objects. Working on the problem gave them an opportunity to find many ways of producing sounds with strings. Most of their solutions did not satisfy the children, and they saw the need for combining their strings with other materials.

Building Stringed Instruments with Boards and String (4-6 periods)

Children build a variety of stringed instruments of their own design and invention. They experiment with different kinds of string.

MATERIALS

wooden boards of various sizes

small pieces of wood (for bridges)

a supply of #112 screw eyes

a supply of squidding line, monofilament fishing line, elastic cord, string, and violin and guitar strings if available*

a supply of Elmer's Glue-All (or equivalent)

hammers--2, 3, or more for the class

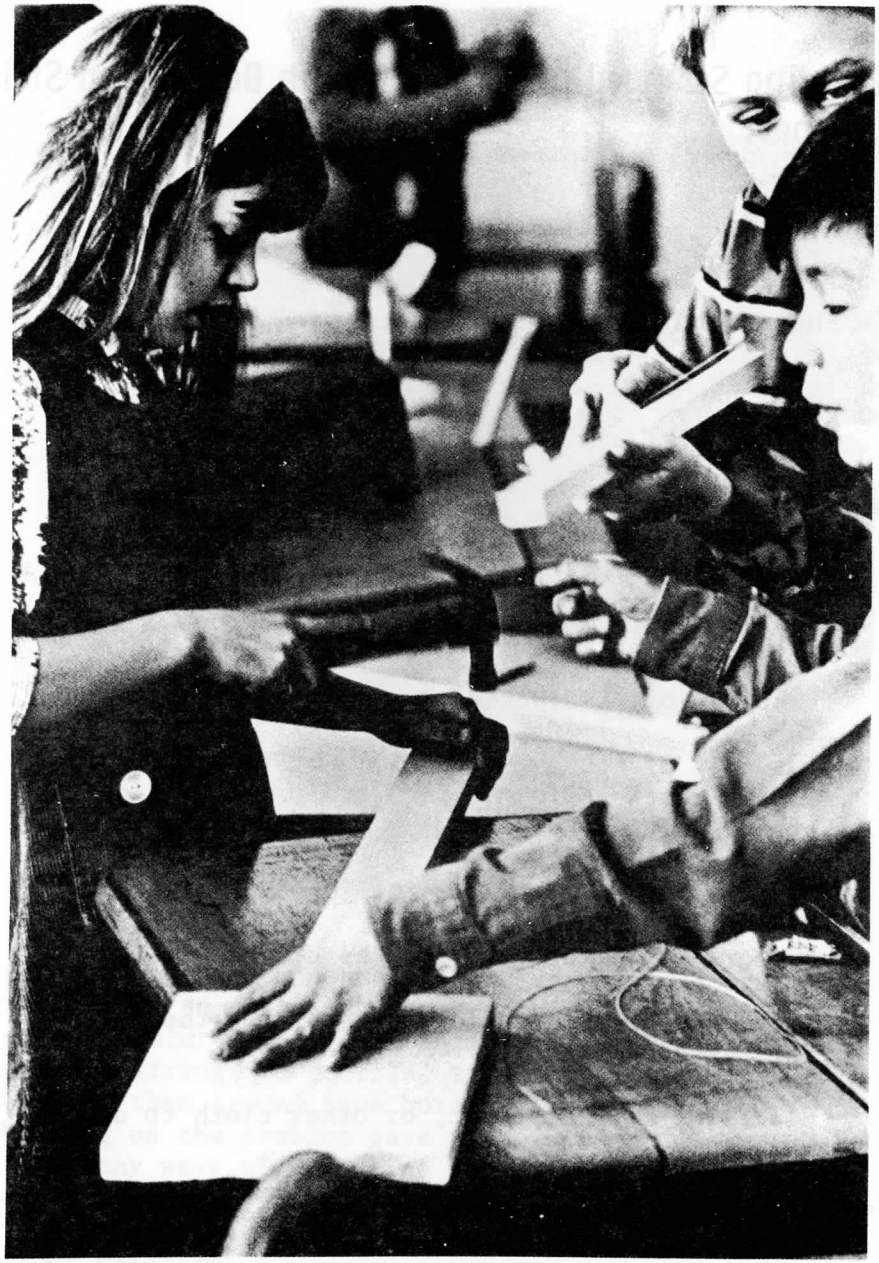
nails--1 for each child (for starting the holes for screw eyes)

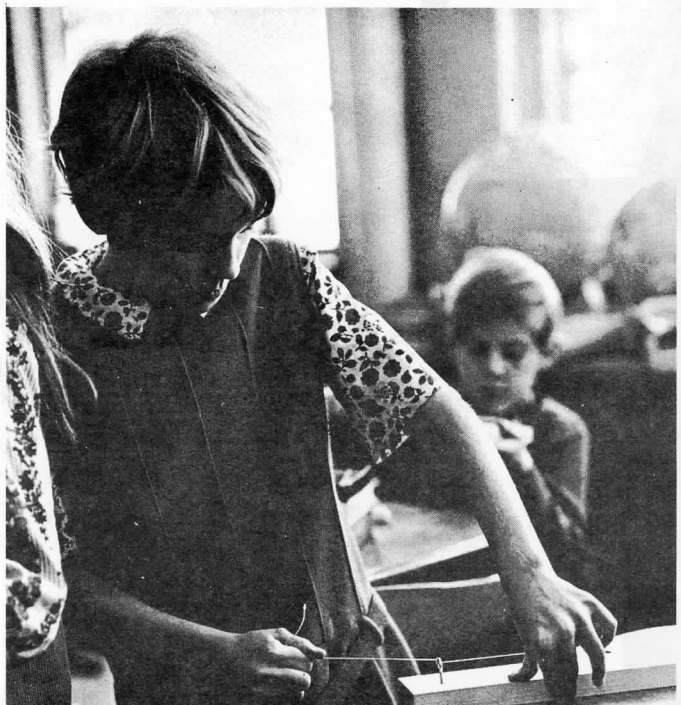
pieces of blanket, felt, or other cloth to deaden the sounds of hammering

*Some teachers have let the children use violin and guitar strings that were already on hand.

After making sounds with strings, children were very excited about the possibility of making instruments. Each child chose a piece of wood to work with and took as much string and as many screw eyes as he needed. Children who started with long, thin pieces of wood tended to make one-stringed instruments. Children who worked with wider boards usually began with an instrument of several strings. A number of children used two boards--a short, wide one and a long, thick one--which they joined with tape or glue to make an instrument which resembled a guitar. Eventually, a great variety of instruments were developed. Some children played theirs like violins; others, like guitars. One girl played hers like a cello. Some children made one instrument and worked with it for a long time. Often they made extensive revisions as they went along, changing the shape of their instrument, the number of strings, or some other aspect of its design. A number of children made two or three instruments of different kinds.

For the first two or three class periods, most of the children were involved in problems of constructing their instruments. In every class, there was great disparity in the abilities of different children to work with the materials. A few were still struggling with the initial stages of making an instrument in the time it took some children to complete theirs.





Some children had particular difficulty in:

starting the holes for the screw eyes (Hammer and nails are provided for this purpose.)

tying their strings to screw eyes

turning the screw eyes into the wood (A nail used as a lever is a help.)

gluing pieces of wood together

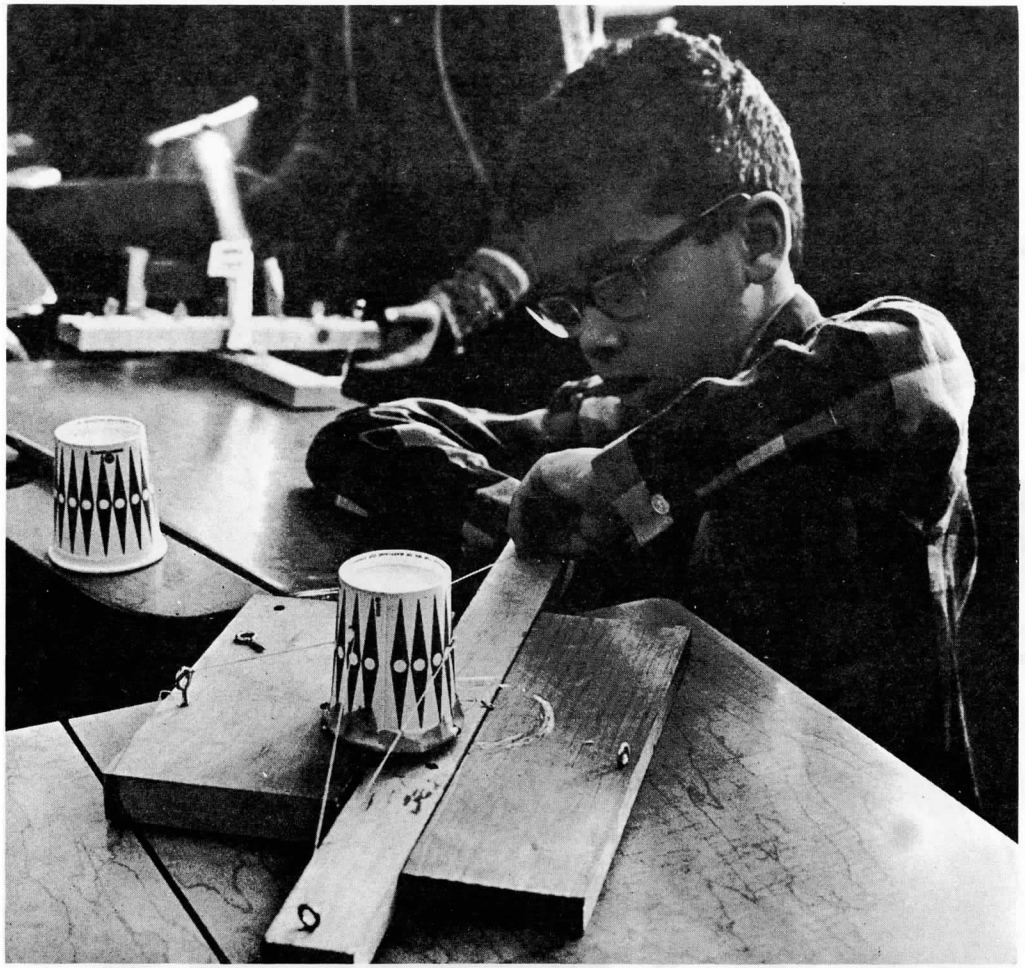
In most cases, children were able to solve their problems by themselves or with the help of a friend. Occasionally, the teacher helped a child who was hopelessly bogged down.

Jimmy made three instruments of different kinds. He exercised great care in the smallest details, such as filing tiny grooves on the bridge of his guitar to hold the strings in place.

A number of children were deeply involved for several periods in building instruments.

Ralph spent a great deal of time decorating his instrument, so that it would look like a guitar.

Mary started with a one-stringed instrument which she played like a cello. Later, she attached a crosspiece at the bottom and two more strings. She completed her work by adding a sliding bridge and coloring the whole instrument with a red crayon.

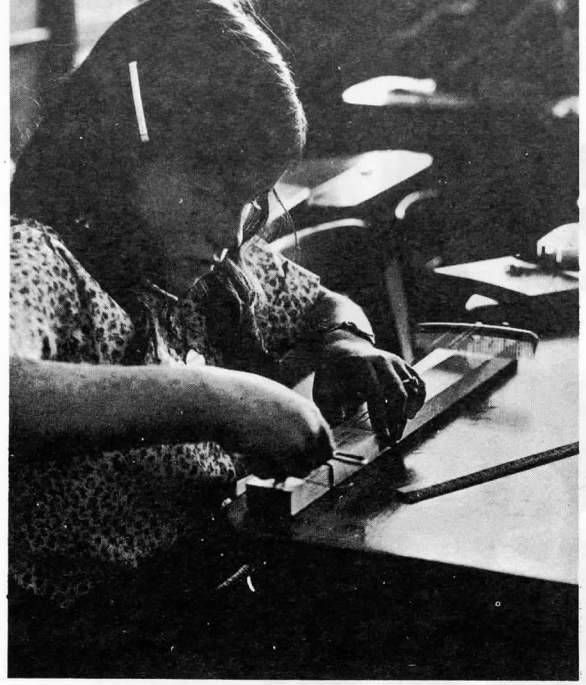


Richard devoted his time to constructing a series of musical contraptions. When he had finished one, he would work with it for a while and then dismantle it and use the same pieces of wood to build another of an entirely different form.

In the course of building their instruments, children explored some of the properties of the sounds made by strings. They noticed that they could raise the pitch of the sound by making the string tighter. Pressing the string against the board with a finger also raised the pitch. Loosening the string made the sound lower. Some children observed that tightening a string sometimes made the sound louder as well as higher in pitch.

Some children also noticed that an instrument sounded much louder when they held it against one ear as they played.

One child used a flexible board for his stringed instrument. He changed the pitch of the strings by bending the board and played his instrument by hitting the strings with a plastic tube.



BRIDGES

To eliminate the buzzing of strings against the wooden boards, many children began to add "bridges" to their instruments. To make bridges, they used any material or object which raised the strings from the surface of the wood--combs, pencils, pens, crayons, plastic tubes, small pieces of wood of different shapes, rulers, erasers, screw eyes, small cardboard boxes, bits of Styrofoam, corks, and paper cups. Some children were content with the first kind of bridge that they tried, while others continued to experiment with different kinds of bridges for some time.

Some of the children used their bridges for slides. They found that by moving the position of the bridge they could change the sound. In addition, when they had a bridge located near the middle of an instrument, children were able to get two different sounds by plucking the string on both sides of the bridge. Stephen and Andrew found that if they put their bridges exactly in the center of their instruments, the segments of string (of equal length) on either side would make the same sound. They recognized that using a bridge in this way "cut off the string," to make a higher note, just as pressing a finger down on a string did on other instruments.

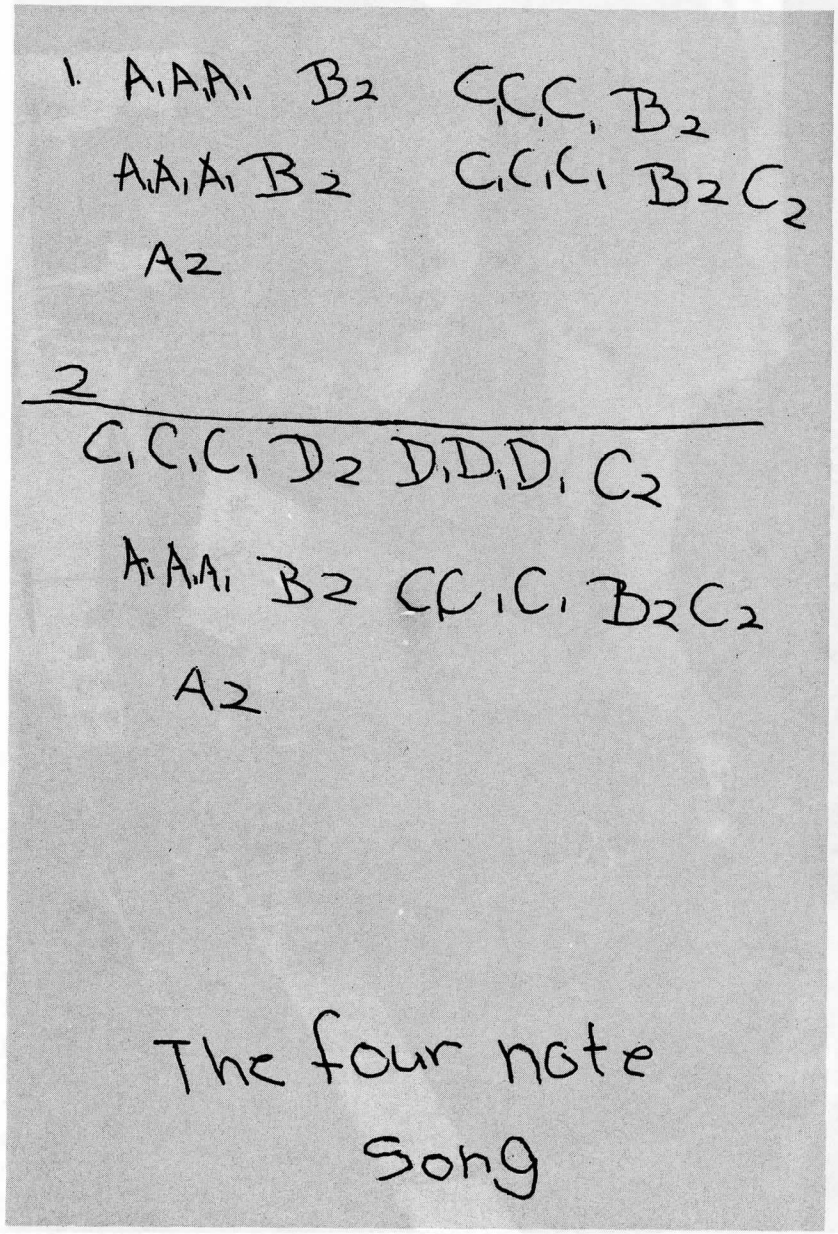
PLAYING TUNES

In one fourth grade class, a number of girls played tunes on their instruments. Sarah began by tuning her three-stringed instrument by ear, so that she could play "Mary Had a Little Lamb," using all three strings. Barbara, who had a guitar-like instrument, was able to play "Twinkle, Twinkle, Little Star," using only one string. She found the positions for the notes she needed by pressing her finger down in different places on the string. The first few times she played this, the notes were not exactly in tune.

The teacher suggested that Barbara work on getting the notes to sound as accurate as she could and then mark the positions, so that she would be able to play the tune again at some future time. Barbara worked on this for the rest of the period and, finally, had note positions accurately marked on her instrument. Once these notes had been marked, she found that she could use the same positions to play "Hot Cross Buns," "Mary Had a Little Lamb," and other simple tunes that she knew.

At one point, several girls took out some music books that their class had been using for recorder practice. They began playing the beginning of "Barcarole" by Offenbach--a simple three-note tune. In playing tunes from the music book, the children were very concerned to play the correct notes as they had learned them. They tuned their instruments to their recorders or to the classroom piano.* They produced the notes of the tunes on their instruments in different ways. Most used all three strings, with each string tuned to a different note. A few used their fingers to press down the strings. Christine had a bridge in the middle of her instrument. She plucked the string on one side of the bridge and tightened the string by pressing it down on the other side of the bridge. By pressing it down in different places, she was able to tighten the string more or less to play all three notes that she needed for the "Barcarole." Christine also found it useful to write out the notes of the tune in letters: "C, B, A . . . ." In this way, she devised a musical notation that was most useful to her.

*In another class, children tuned their instruments to tone bars which were in the classroom.



COMPOSING MUSIC

Pushpa spent three or four periods composing and writing down tunes of her own. She used a notation similar to Christine's, but she added numbers to indicate how long each note was to be held. A subscript 1 meant the note was held for one beat; 2 meant the note was held for two beats. At first Pushpa tuned the three strings of her instrument to the piano to play A, B, and C. She wrote three-note tunes for this instrument. Then she added another string, which she tuned to D, and wrote four-note songs. The picture shows one of Pushpa's compositions. Later, she tuned her strings to different notes and composed other four-note tunes.

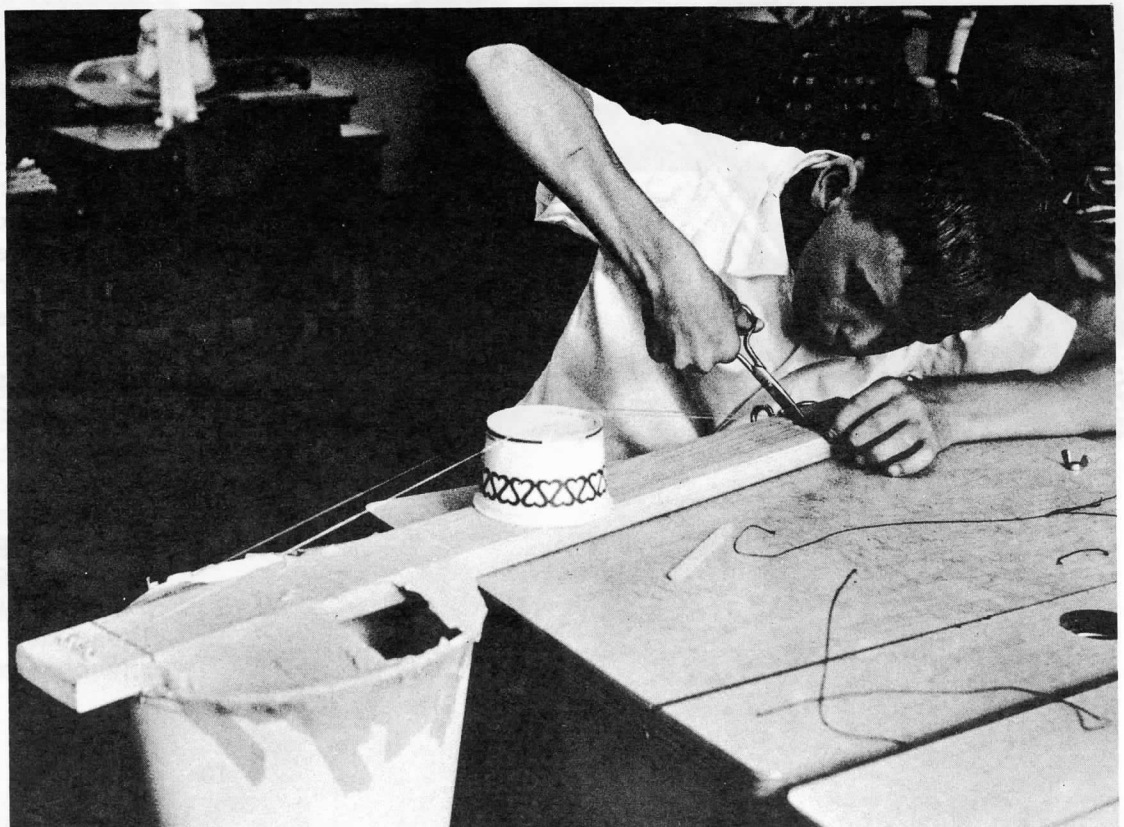
Paper Cups and Paint Buckets
(2-4 periods)

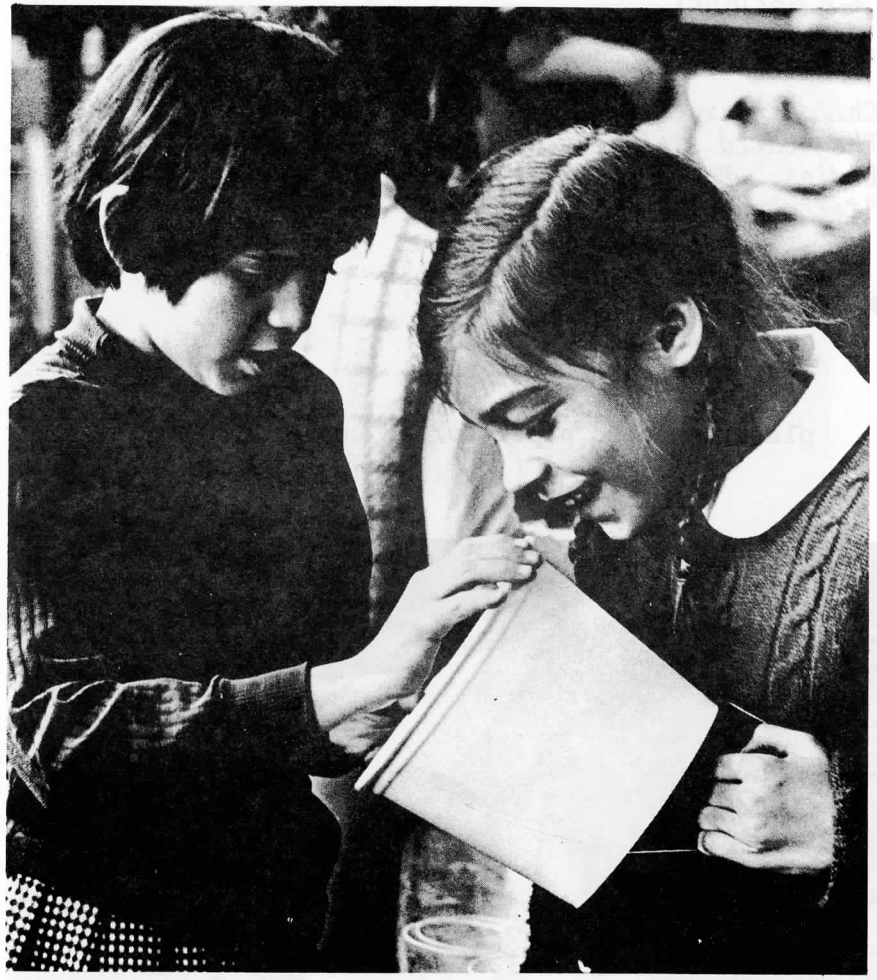
Children experiment with ways of making sounds louder. They build stringed instruments with paint buckets as bodies. Paper cups can be used to make paper-cup "telephones."

MATERIALS

cardboard paint buckets

plastic-coated paper coffee cups





In two sixth grade classes, all the children began with three-stringed instruments of the same size. They became very interested in making their instruments louder. After they had tried the resonating effects of their desks, waste baskets, cardboard boxes, and an old wooden desk drawer, they were given paper coffee cups and paint buckets. Some children taped their paint buckets to the bottom of their instruments. Others inserted paper cups or paint buckets between the strings and the wood. They experimented with covering the ends of their buckets, with punching holes in them, and with all sorts of combinations of different sized paper cups and paint buckets. With a variety of materials and plenty of time to work, they showed great ingenuity in dealing with what seemed most interesting to them--the problem of making their instruments louder.

The children in one fourth grade were more interested in using their paint buckets to form the bodies of musical instruments. A number of children used them to make drums. Others made stringed instruments from them by running strings over or through their paint buckets and fastening them as best they could. Some children were able to play sounds of different pitches by threading strings of different lengths through the paint buckets at different levels. Others found that by squeezing the buckets or pulling the strings, they could tighten and loosen the strings quickly and easily and play many different sounds.*

*If the supply of paint buckets is exhausted, children can get many of the same effects by using large plastic bleach bottles or other plastic containers. These may be brought from home or can be obtained at any commercial self-service laundry.

PAPER-CUP BRIDGES

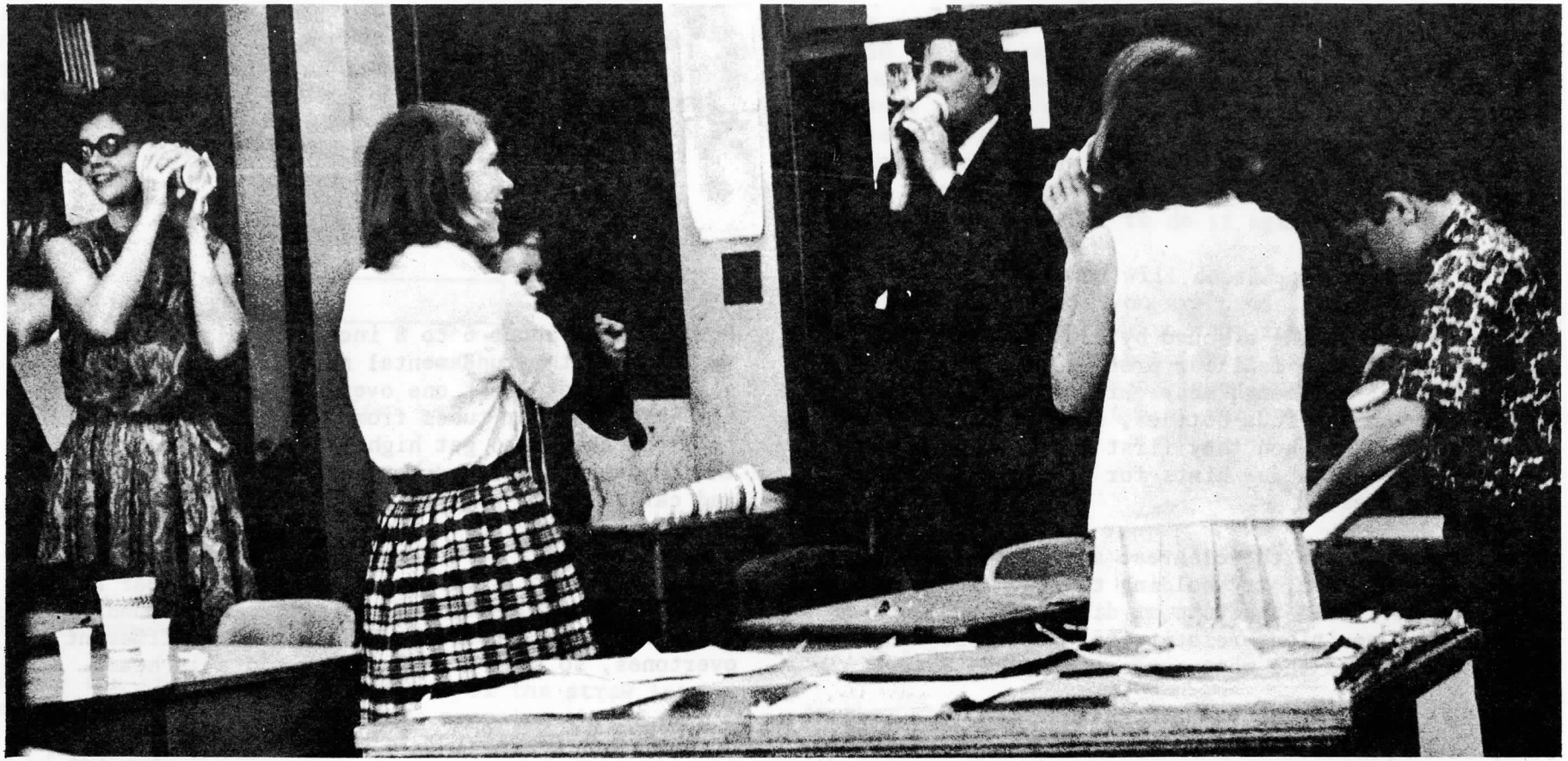
In a fourth grade, several children used paper cups as bridges for their instruments. They ran strings over the top of--or through--their cups. One boy ran strings through his paint bucket so that it acted as a bridge. Some of the bridges were fixed, while others were used as slides. Some children noticed that their instruments sounded louder with paper-cup bridges, while others seemed either unaware or uninterested. One boy explained the loudness of his instrument by saying that it was due to an "echo" produced by the hollow cup.

PAPER-CUP TELEPHONES

In several classes, children made "telephones" with paper cups and long lengths of squidding line. By trying different kinds of string and different kinds of cups, children were able to explore the transmission of sounds from one place to another. In one class, a group of children invented a "party line" by tying several strings onto the original "phone line." With this arrangement, they found that several people could hear the person who talked into the "telephone."

In *Whistles and Strings* classes, children worked most often individually or in small groups that enjoyed working together or that shared interests or problems.

Some teachers instituted occasional class discussions or asked their students to record their activities on experiment sheets for others to try as a stimulus for circulating ideas. However, in most classes, children were more inclined to *do* things together rather than to talk in large groups *about* the work they were doing. Problems and ideas were shared in more informal ways.



Among the large group activities which proved most successful were the performing groups which played music together on the instruments they had made. Some groups of children enjoyed describing their instruments and performing on them for other classes in their school. Some classes made illustrations or wrote descriptions of their instruments as a record of their project. Others made bulletin board displays describing their activities and the instruments they had made.

APPENDIX: On Making Sounds from Tubes

BLOWING ACROSS A TUBE

The process of making a sound by blowing across a tube is identical to the familiar process of blowing across a soda bottle. Although many children and adults know how to blow across soda bottles, some people have a little difficulty when they first try to blow across a tube. Here are a few hints for people who are having difficulties.

In order to produce the clearest and loudest sound from a plastic tube, try holding the tube in a variety of positions. Hold the tube at different angles and at different positions relative to your lips. In this way, you can find the most comfortable way to make a sound.

It is often possible to make more than one sound from a tube. The lowest sound that can be played on any tube is called the "fundamental" note of that tube. Higher notes, which can be played by blowing harder, are called "overtones." On fairly short tubes, the sound that you will usually hear when you blow across the tube is the fundamental note. For example, if you blow across a tube which is 4 inches long, you can get an overtone only by blowing very hard. For lengths shorter than 4 inches, it is difficult to get any overtones--you would have to blow too hard.

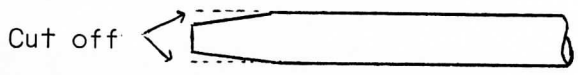
For tubes of about 6 to 8 inches, it is fairly easy to get both the fundamental note (by blowing quite softly) and at least one overtone (by blowing a little harder). For tubes from 8 to 10 inches long, it is often easier to get higher overtones than to get the fundamental note. You have to blow very softly and carefully to get the fundamental note. You may be able to blow four notes--the fundamental and three overtones--on a 10-inch tube without a great deal of difficulty. It is difficult to get any clear notes on tubes 12 inches or longer. Often the sounds made by long tubes are actually combinations of different overtones, so that more than one pitch is heard.

MAKING AND BLOWING A STRAW REED

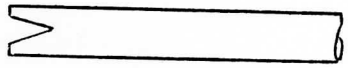
Some people, children as well as adults, can make a straw reed work on their first attempt. Many, however, will need to keep trying for a while before they succeed.

Take a plastic or paper drinking straw (plastic works better) and flatten a section about 3/4 inch long at one end. With a reasonably sharp pair of scissors, cut the two sides of the flattened portion as shown in the diagrams below. The end of the cut straw should look like this:

Top View



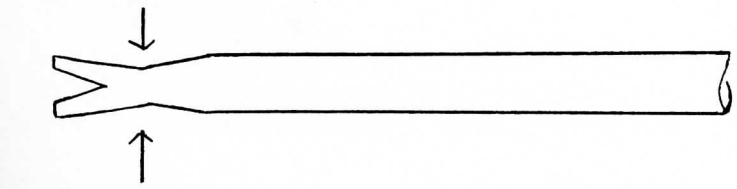
Side View



From the side, the cut straw will look a little like the open mouth of an alligator.

To play the straw reed, put the end of the straw into your mouth so that your teeth are pressing the straw on the top and bottom at a point a little beyond the end of the cut:

Side View



Press your teeth together slightly, and blow. You should get a buzzing sound from the straw reed. If you don't get a sound at first, you can vary the pressure of your teeth and the position of your teeth on the straw. Try moving the straw back and forth a little while you are blowing. Eventually, you will make a sound. When you have produced the sound once, it will be much easier to do it again.

The pitch of the sound will depend on how long the straw is, how tightly you are pressing with your teeth, where you are pressing with your teeth, and how hard you blow. You can use a slightly larger or smaller straw as a slide, to change the length of the tube and, therefore, the pitch of the sound that it makes.

MAKING A BUGLE SOUND

Another way of producing a sound from a column of air is to use your lips as the "reed" which causes the vibration. This is the way that bugles, horns, and other brass instruments are blown. Press your lips together tightly, and blow out hard through your compressed lips to produce a buzzing or razzing sound. If you blow into a tube in this manner, you can produce a resonant, bugle-like sound. The pitch of the sound that you get depends on how tightly your lips are compressed and on how long the tube is. You can vary the sound by changing the length of the tube, by connecting funnels to the tube, or by building other types of tube systems.