

NOTES FOR TEACHING

The activities in *Doing Science* were written so that they could be done by the entire class or by individual students. In either case the role of the teacher is critical in maximizing what students will learn from the experience. Careful timing of questions during the construction projects and thorough analysis of the completed structures through discussion afterwards will help make explicit what students have discovered intuitively. If you are not familiar with the structural concept, the best way to start is to do the suggested projects yourself before introducing them to your class. The *Ideas in Science* booklet reviews the main concepts of structure. The books in the bibliography are for a general audience and treat this subject in a nontechnical way.

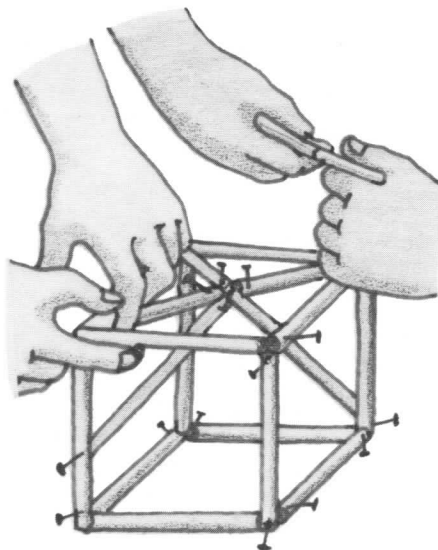
The materials for the activities and the proposed challenges were chosen with explicit considerations. The constructions could be done with tightly rolled up newspaper or commercially prepared kits. Plastic drinking straws offer several advantages over these. They are cheap and readily available, making it possible for students to do follow-up experiments in their own homes. Straws can be easily joined together and bent into a variety of forms. They are also uniform in strength which is not a property of rolled up newspaper. In addition, the flexibility of the straws allows the experimenter to see how a structure is reacting to a weight placed upon it.

The challenges are framed for students with a wide range of skills and abilities. If your students have had lots of previous hands-on experience, you might want to limit the number of straws used; for instance, the tower problem could be limited to 50 or 75 straws. Otherwise, it is best to leave this aspect open to the interpretations of the students. It has been observed in classrooms that some students will use more

straws to build their houses or bridges than others. Some students need this initial extra security to ensure success. With these students, one can wait till they have done some preliminary testing before suggesting that they remove some straws to see whether the structure still stands.

Students differ in their skills of constructing and analyzing a structure. Each has to be challenged according to his or her abilities. If a project is too difficult, students will become frustrated and soon give up. If it is too easy, they will get bored and miss opportunities for real learning. Manageable complexity is a term to keep in mind when approaching students with questions. For some of your students it may be enough to just get a house or bridge constructed, while others may be able to find ways of making their structures support the weight of many nails.

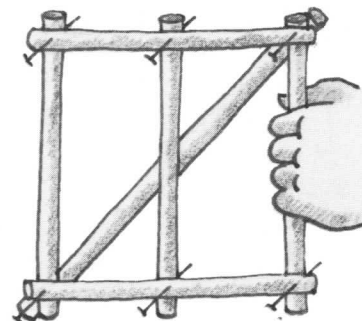
Each project may go beyond a 45-minute period, depending on the abilities of your students. It may be best to plan for two 45-minute periods, allowing time for cleanup and discussion. It is also suggested that students work in groups. Working in groups saves material and space,



and this project is an excellent one for building cooperation in groups.

While students are in the process of making their structures, some hints along the way can be helpful, but they ought to struggle with problems for a while. A real source of satisfaction will come to them when they discover solutions to the problems themselves.

One approach that is helpful during construction is to have students consider the structure one part at a time, rather than trying to think about the whole thing at once. In the construction of the house, students build a cubical framework and find that it wiggles. Have them work only with one side at a time and find a way of making the side rigid.



When testing the structure they should also be observing carefully where straws are beginning to bend and in what direction. This will help them understand how the load of the nails is being handled by the structure.

The three *Doing Science* projects are only a beginning to this kind of investigation. Geodesic domes and space-frames are others that can be constructed. In addition experimental investigations of beams and columns can be carried out as suggested in the books by Mario Salvadori and Forrest Wilson listed in the bibliography. Structures offer a rich area for investigation that can be fruitful in terms of meaningful and satisfying learning.