Structure Team Manager Guide by Bill Allen

Introduction

This guide hopes to provide a step-by-step approach to teaching kids about building structures in a way that won't direct them to specific solutions. While this guide was not originally written with this year's Structure Challenge in mind, it has been modified to try to make it less "balsa centric". Anyone reading this guide should be aware that the team must thoroughly read and understand the rules for the current year Structure Challenge.

This guide will cover:
-- Tools and construction environment.
-- Helping teams to learn about glue and material characteristics.
-- An introduction to the "art of gluing".
-- Some discussion on issues that can impact the consistency and quality of the structures the team builds.
-- Some pointers to where teams can go to learn how load is supported.

Tools and Safety

As a Team Manager, there will be some details that need to be addressed before letting the kids do any building. The most important is safety. There are many tools for cutting and forming things. Nearly all of them are VERY sharp. Taking the team on a "field trip" to visit a school wood shop (or even the local hardware store) for a lecture on "tools and safety" is a nice way to start the year.

This should be a general lecture -- so it's probably a good idea to not tell the lecturer any more than "the kids need to design and build something completely on their own this year -- but they need to know something about tools and shop safety before they get started".

Two good general safety rules are:

1. Sharp edges should ALWAYS be directed away from flesh.
2. Wear eye protection while cutting and shaping things.

Cutting and Shaping

Razor blades (which includes X-acto knives) and razor saws are the most commonly used tools used for cutting balsa wood. This does not guarantee that these tools will be the best for cutting something harder and/or more brittle than balsa. VERY different tools are used to cut and shape hard, brittle material. In fact, trying to cut hard materials with tools intended for cutting something softer can be downright dangerous (and can ruin the tool in the process). Teams should experiment with different tools to determine which works best with each material they consider using. Finding the "right tool for the job" can save a LOT of time (and aggravation).

In looking at the best way to cut very hard, brittle material, it might be useful to consider how glass and ceramic tile are shaped. One method is to "score" the glass at the desired length and then break the glass along the score line. There are special tools (with VERY hard cutting edges) for "scoring" glass. Another method used to shape glass is to use a grinding tool (files, abrasive disks, etc.).

Shaping is different from cutting, even though the same tools are often used to shape materials. Shaping usually removes a small amount of material at a time, while cutting separates materials into distinct pieces. Sanding and filing are examples of shaping.

Many ceramics (like that used in pottery) start out as a malleable paste that must be "fired" (exposed to high temperature for a period of time) before the material becomes hard and strong. Clearly, the job of making a pot would be MUCH harder if the ceramic were fired before it was given the desired shape. Teams should notice that the size of things can change slightly during firing.

Mail order tool and glue suppliers

SIG Manufacturing is a supplier of tools and supplies for model airplane builders. Their catalog (which is provided free with a minimum purchase) is FILLED with tools and supplies that have potential for use in building all kinds of structures (not just balsa). The tools and materials offered in the Sig catalog are intended for the model airplane builder. Consequently, not all of them are relevant to Destination ImagiNation Structure builders. This also means it is NOT Interference for the kids to read any suggestions in the SIG catalogue. It's GENERIC information, so it can't be interference. However, the kids should decide which of the information (if any) they choose to consider relevant to their efforts.

SIG can be reached at:

SIG Manufacturing, 401 Front St., Montezuma, IA 50171
(800)-247-5008
http://www.sigmfg.com/index.html

Another source is Micro-Mark:

Micro-Mark, 340 Snyder Avenue, Berkeley Heights, NJ 07922-1595
http://www.micromark.com

Sources for pasta is something teams will have to investigate for themselves. While it would not be Interference for a Team Manager to go to the grocery store and purchase a broad array of pasta to make available for the team, this seems like an activity the team would have a lot of fun doing for themselves. It is important that Team Managers encourage their team to read the Challenge **thoroughly** -- and brainstorm their options **before** providing too many materials. Failure to allow the team to go through their own "brainstorming process" might end up inadvertently "steering" the team towards a particular solution. Team managers should remember that the material selection (and construction) processes are part of the team's solution.

This means the team should make **all** decisions about what materials to use, how to use them and how they will build their structure.

Workspace considerations

Most first time Team Managers won't figure out that their kitchen table is a **bad** place for the team to build Structures until it's covered with glue and cuts. These are **wonderful** momentos of that first year. However, anyone who won't treasure these momentos may prefer to set up a "sturdy but expendable" table in a well-lit, well-ventilated location and insist all Structure building be done there.

There are some types of plastic (called polyethylene) to which most glues will not adhere. Hard, flat "cutting boards" of this material can be made to provide a consistent (and disposable) surface for the team to work on. It's also possible to buy sheets of this material to try to protect the table. The kids will wreck the table anyway, but the cutting boards might slow the inevitable.

Lots of light is a **key** element to an effective workspace. In addition to good over-head lighting, it's generally a good idea to have desk lamps available. A scale capable of measuring to 0.01 grams is a **huge** benefit. Aside from measuring the weight of the finished structure, a scale is **extremely** useful in tracking the weight of components.

A white board (or flip chart) is a useful tool to facilitate brainstorming. Plenty of graph paper, rulers, pencils, squares, and protractors are handy to have around so the team can draw out design ideas. Calculators (or computer spread sheets) can be **very** handy to aid the team in planning how much they expect their structure to weigh. A first-aid kit **will** be needed at some point -- so have one handy. A **lot** of trash will be generated -- so multiple trashcans might help contain the mess.

Glue selection

The Team Manager should review the safety recommendations on all glues made available - and be prepared to accommodate safety concerns noted on the packaging. It would **not** be Interference for a Team Manager to say "this glue is too dangerous, you can't use it". There is a **huge** variety of "glue" out there. Teams should see this as an opportunity to do research, conduct experiments and determine which glues work best for them. In addition, the Challenge provides a very "loose" definition for "glue". This allows the team to consider using materials not formally labeled as "glue" in constructing their Structure.

Mixing glues together is generally a "bad idea". The team should also be aware that some glues stick to skin better and faster than they stick to anything else. Usually, there is something called "debonder" sitting on the shelf (or in the catalog) right next to this kind of glue. Debonder will soften the glue so it lets go of most of the skin. In many cases, acetone (or finger nail polish remover) will act as a debonder for glues that adhere to skin. Teams can also purchase low cost painter’s or surgeon's gloves at most hardware stores and pharmacies.

The team should get in the habit of wearing safety glasses while doing construction work of any kind. There isn't much flying debris from gluing a Structure together (unless your team is like the ones I coached). However, safety glasses make it difficult to rub irritated eyes with glue-coated hands. An even better idea is to have the team practice the art of gluing things together until they can do it without their hands getting covered in glue!!

Glue selection is a very important variable the team has to work with in designing and building their Structure. It is not Interference for a Team Manager to purchase a broad variety of glues and have these available for the team. However, since many things not labeled "glue" can be used, it **would** be Interference for the Team Manager to suggest "glue-like" materials for the team to consider.

Similarly, it would not be Interference for a Team Manager to provide a "starter list" of glue properties for the team to consider (i.e. strength, flexibility, viscosity, drying time, etc.). However, this is also an activity where the team will feel the most “ownership” of their solution if the team brainstorms for themselves which properties they feel are the most "relevant".

The way brainstorming works is the team tries to think of **all** possible properties of glues. They then prioritize that list to identify which of those properties are the most important. They also try to devise tests they can conduct (and measures they will use) to aid in their assessment of which glue(s) they like best. Keep **all** lists the team generates. Revisit this process a couple of times during the year. As the team gains more experience, they will likely view things differently. Since this is so critical, here is a “starter set” of properties the team will likely develop:

-- Can the glue be used safely?
-- How strong is the joint created with that glue?
-- How easy is it to create a joint with that glue?
-- How consistent are the joints created with that glue?
-- How long does it take to "set"?
-- How much weight does the glue add to the structure?

These are just a “starter set”. Ask the team if they can think of other properties for “glue” that might be relevant to this Challenge.

The team won't be able to decide which glue works best for them until they've gained some experience building things using only glue and pasta. When learning to glue things together, the primary goal is to develop a process that assures complete adhesion, but with as little excess glue as possible. A team can gain experience gluing things together by building simple 2-d shapes, "pasta art" or even short, simple structures (without worrying too much about the Challenge specifications). The goal here is for the team to develop a "facility with building" -- which means they understand how to shape materials, glue pieces together and construct something to a plan. Until they develop this "facility with building", it's pretty pointless for them to try to build a complete Structure.

In the end, different team members will likely develop a preference for different glues -- or different approaches for building Structures. Take advantage of this by encouraging "build offs" -- where each team member builds a structure to the identical plan (which could be smaller than a competition structure) -- holding as many things constant as possible. This means that the **only** differences between the structures are the different glue and/or approaches (and the different builder). Compare how much the structures weigh and how much weight they support. At first, the team will be **amazed** at the variability in the structure weight and supported weight of these "identical" structures.

Once a team can make consistent glue connections, the next exercise should be to get to where they can reproducibly build a simple structure to a plan, have it weigh about the same each time it's built and hold a similar amount of weight. Until they can accomplish this, it will be almost impossible for them to tell whether a new idea is better (or worse) than the previous idea (or simply demonstrating variability in the construction process). It takes a lot of work to get to this point -- so what they build during these early days should be pretty simple. Again, the focus of these early structures should be gluing and construction technique (instead of high weight-held).

Material selection

If the team members just use whatever materials they lay their hands on to build a structure, it's guaranteed that some of it will be stronger than others. Once the weakest piece fails, the structure collapses. In the "real world", engineers carefully define the properties of materials to be used in construction. For example, an engineer might specify the composition, manufacturing method and surface treatment -- as well as the pre- (and post-) construction conditioning of the material. Engineers do this because any of these "details" can alter the strength of the finished product **significantly**.

Two outwardly "identical" structures can differ by **hundreds** of pounds in the weight they will support. Understanding the properties of glue and the properties of pasta -- and how these properties can be used to optimize a structure design -- will enable the team to build stronger structures. Equally important, it will allow the **same** structure to be re-built and hold a similar amount of weight.

What are the properties of materials -- and which are relevant to structure design? The list of potential properties is actually short enough that it makes sense for a team to brain-storm it for themselves. Once they've generated this list, they should devise some experiments to test which of those potential properties are relevant.

Here is a fun exercise for a structure team to do along these lines:

Materials:
-- Have the kids pick out and/or create a variety of test pieces using different pasta and/or glue

Some useful tools:
-- A gram scale capable of measuring to .01 gram. **

-- A micrometer (or vernier caliper) capable of measuring to .001". **
-- A powerful magnifying glass
-- Something to cut a variety of materials (i.e. razor saw)
-- A ruler
-- Pencils and "lab books" for the kids to keep notes in

** If the scale and micrometer aren't available, the kids can still take qualitative measures of the width and weight of the samples (i.e. compare the size and weight of samples to each other and record the apparent order), or make a simple balance like a teeter-totter.

Activities:
1. Have the team members pick out test pieces that look or feel “different” from each other.
2. Have the team cut these sticks into samples of given lengths (i.e. 1", 2" and 4").
3. Have each team member take notes on the characteristics that appear to vary between samples.
4. Have the team members bend, pull, twist and compress the samples using their fingers -- and record their observations. Of course, more formal testing will allow even more definitive conclusions.
5. Encourage them to look for patterns.

This exercise encourages the team to observe, measure, question, organize and test their ideas. Not a bad start to their year!! It's also likely they'll learn a bit about the characteristics of materials that will enable them to make stronger, more consistent structures. Of course, it's tough for the team to know what's relevant until they've built a few structures. As the team becomes more proficient in building structures, they'll also become more discriminating on the characteristics of materials that can influence the strength and/or consistency of their structures. Consequently, it's a good idea to have the team go through this exercise several times during the year.

Gluing technique

At first glance, gluing two pieces together sounds trivial. However, Structure builders strive to glue pieces together so the joints are consistently strong, yet do not use excess glue. The key here is consistency -- a consistently strong joint and a consistent weight of glue used.

Think of gluing two billiard balls together. The billiard balls would only contact each other at a single point. The "gap" between the balls gets relatively large as you move away from the contact point. Consequently, it would be almost impossible to get a good, solid glue connection between the billiard balls -- no matter how much glue was used.

Now think of gluing two sheets of glass together. A single drop of glue would spread to a very large area when the two sheets of glass were pressed together. Consequently, even a few drops would make it impossible to separate the two sheets of glass. If you put a drop of water between two sheets of glass and then apply pressure, you'll see the size of the drop increase (and then decrease when the pressure is removed).

If you look at nearly any material under a microscope, there will be peaks, valleys and even tiny cracks -- even if the piece appears smooth to the naked eye. Trying to glue two pieces together that still have "significant irregularities" on them is a little like gluing billiard balls together. The team should be aware that sanding material can cover the surface with dust -- which can prevent the glue from properly penetrating (or adhering to) the material. In short, gluing things together is something of an “art form”.

“Foreign material" on surfaces to be glued can prevent the glue from adhering properly. This means the team should wash their hands before doing any serious gluing. Some glues can be dangerous if ingested. This means the team really should not be eating while they are working with glue. Some glues are irritants. This means the work area should be well ventilated.

Pressure is also a key element in gluing anything. Take a wet sponge and set a dry sponge on top. The upper sponge will get a little wet on the surface, but the water will not penetrate too deeply into the upper sponge. Now apply pressure to the two sponges. Water will not only soak into the upper sponge, but will likely squirt out all over the table. This is an excellent analogy to what can happen when you glue material together.

Glue adheres two strips of material together not by simply forming a layer between the two strips, it can actually penetrate into the material. Too little pressure and the glue won't penetrate properly into the underlying material. It takes experience with the material being used to learn to apply the "right amount" of glue -- so that excess glue doesn't squirt out of the joint when pressure is applied.

The process of applying pressure while the glue is drying can lead to "residual stresses" in the Structure. This can either weaken or strengthen the structure. Engineers sometimes intentionally put residual stresses into materials to protect them in some loading conditions. Experimentation and experience are the keys. The "correct" gluing technique will vary from glue to glue. If instructions aren't included with the glue, it might be interesting for the team to see if the manufacturer will provide instructions for creating strong, consistent glue joints using their product (without telling the manufacturer the details of the project the kids are involved in). Again, **generic** knowledge is **not** Interference.

Since gluing expertise is key to building strong structures, it's a good idea for a team to begin simply gluing material together -- without trying to build anything in particular. They should carefully examine the joints they create:

-- Are there "gaps" where the material isn't glued together?
-- Did the glue squirt out of the joint area?
-- Was there complete adhesion between the glue and the underlying material?

They should then push, pull and twist the glued material to see how strong the joint is (and how it fails). A well-glued joint is often stronger than the underlying material -- so the material around the joint will break before the joint fails. Armed with these observations, the team can brainstorm refinements to their gluing technique -- and then glue some more!

Building to a Plan

Of course, the first requirement for building something to a plan is to **<u>have</u> a plan**. Quick sketches are adequate for brainstorming. Ad hoc structure building makes it possible for kids to visualize how elements will go together **much** easier than is possible on paper. However, ad hoc structure building does **not** lend itself to building strong, repeatable structures. It's a good idea for teams to get in the habit of making a detailed "scale drawing" before beginning "serious" construction.

For some structures, enough symmetry exists that a single "side view" is enough to fully describe the structure. However, for most structures, at least two "views" are needed. More complex structures might require any of the following to fully characterize:

-- a "view" for each side
-- "top view" (looking down on the structure)
-- "sections" (imaginary "slices" through the structure)
-- "details" (which, as the name implies, provide a close-up look at some aspect of the structure that is not 100% clear in the other drawings)

In the "real world", there might be even more detailed drawings:

-- "Isometric view" (rather than drawing the structure "straight on", this view is from up and to the side a bit. This allows the top and two sides to seen in the drawing -- and aids in visualizing what the 3-D structure looks like)
-- "Exploded view" (this pulls all the individual pieces away from each other -- so HOW they are assembled can be captured in the drawing)

It can be fun for the team to put a date on their drawings -- as well as which team members participated in the design, drawing and construction. Some teams like to give each design a name (and put that on the drawing as well). The drawings can then be photocopied and collected into a binder. Of course, all the information the team feels it needs to know about the design to be able to re-create it should be recorded as well! A lab book where team members record this information as they do the construction can be a big help in recalling these “details”.

A lot of teams have found that it is a good idea to photocopy each side of the finished structure. This will capture both the "as built" structure (to be compared to the “as designed”. The team should be aware that many photocopy machines shrink (or enlarge) the image slightly. Consequently, it's prudent to put a ruler in the image (to provide a "true" scale). If the structure stays more-or-less intact, a photocopy of the "crushed" structure completes the picture. However, some structures come apart so completely when they fail that the "crushed" image would be pretty useless.

It can be challenging for a team to decide where their structure is weakest if it fails in a manner that leaves little of it intact. There is generally a "domino effect" where different elements of the structure fail in rapid succession. Quite often, the most dramatic (i.e. twisted) elements were the LAST to fail. Consequently, simply looking at the wreckage can be misleading. If a Structure Tester had good Safety Shields (as it should), a team member can get down where they can see the Structure clearly as it is loaded. This can allow them to see which element of the structure is "giving" before the structure fails. A video camera can also be useful for this. However, for most structures, the video camera will show an intact structure in one frame -- and a blur in the next.

In addition to the "relevant details" for re-creating the structure, the team should record the structure weight and the "weight held" for the structure. This should make it easier to see what changed between their structures -- as well as the impact each design change had on "weight held".   One useful insight from this approach is that it's probably a good idea to not vary the design too dramatically between tests. If there are too many variables changed at once, it can be difficult to determine which is impacting any improvement (or degradation) in weight-held of the next structure.

A 1:1 scale drawing means that 1" on the drawing represents 1" on the structure. For many teams, a 1:1 scale drawing is used as the "template" to construct their Structure. This can be as simple as laying the pieces to be glued on a photocopy of the drawing to get them in the right position (a piece of plastic wrap placed over the drawing will help keep the Structure from getting glued to the drawing). However, a "construction jig" which holds the pieces to be glued firmly in place will allow the structure to be assembled even more exactly (and consistently). With the flexibility this Challenge offers, molds or even extrusion techniques might be employed. The team must design and build **any** “construction aids” (other than “off the shelf” tools) used to build their Structure.

A jig doesn't have to be complicated. Laying a drawing on a piece of cork board and setting pins in the drawing to act as "stops" to hold the pasta in place can be effective. The same plastic used to make the "cutting boards" can be cut into strips to be used as "stops" and "spacers" as well. The pasta could also be held in place by magnets against a metal background. Other teams cut shallow grooves in material to hold the pasta to be glued in place. The “novelty” of this year's Challenge means that **all** teams will be looking for new ways to construct their Structures.

These examples are certainly not the ONLY way to build construction jigs. The team should experiment with the above approaches (to get some experience in the use of jigs) and then brainstorm all the approaches to construction jigs they can think of. They should build and test some of these jigs to see which they like best. The team **must** decide what construction jig(s) (if any) they decide to use. In addition, they **must** construct any jigs they use for themselves. Moreover, it would be Interference for a Team Manager to **insist** the team use a jig -- or to dictate the kind of jig the team used.

To be of any real use, the jig must be constructed so it holds the pieces to be glued firmly and accurately to the intended plan. A "bad jig" (one which did not yield consistent, repeatable results) can be worse than no jig. However, using jigs takes a bit of getting used to. Consequently, teams should try out different jigs (or no jig) as they gain experience. Their preferences (and their results) will likely change with experience.

Part of building to a plan is planning out the **order** elements of the structure will be assembled. It can be **very** difficult to anticipate how "details" (like overlap areas needed for gluing) will affect assembly. Some "quick and dirty" ad hoc constructing of key elements of a structure is probably the fastest and easiest way to uncover assembly issues. It is **very** common for teams to assume a structure can **only** be assembled in one order. It's entirely appropriate for a Team Manager to encourage the team to brainstorm alternate assembly orders/processes.

Following the above steps, the team should be able to pick out a glue, select materials, glue material together, create a plan and build to that plan. The next step is to learn enough about what makes strong structures to develop a plan that will hold significant weight.

Design Basics

Start by getting a couple of good texts intended to teach the team design issues. Here are some books recommended in Rosemary Bognar's Resource list (ordered by age recommendation):

-- Messing Around with Drinking Straw Construction, Bernie Zubrowski, Little, Brown & Co, Ltd, 1981, ISBN 0-316-98875-8, 164 pgs, Grades 3-Adult

-- Building Toothpick Bridges, Jeanne Pollard, Dale Seymour Publications, Palo Alto, CA, 1985, ISBN 0-86651-266-7, 32 pgs, Grades 5-Adult

-- Structures, Bernie Zubrowski, Cuisenaire Company of America, White Plains, NY, 1993, ISBN 0-938587-35-8, 96 pgs, Grades 5-Adult (Excellent)

-- The Art of Construction, Mario Salvadori, Chicago Review Press, Chicago, IL, 1990, ISBN 1-55652-080-8, 200+ pgs, Grades 6-Adult (Excellent)

-- Structures or Why Things Don't Fall Down, J. E. Gordon, DaCapo Press, Inc., New York, NY, 1978, ISBN 0-306-80151-5, 395 pgs, Grades 9-Adult

-- Why Buildings Stand Up: The Strength of Architecture, Mario Salvadori, W. W. Norton & Company, New York, NY, 1980 ISBN 0-393-30676-3, 323 pgs, Grades 9-Adult

These can be hard to find in bookstores or libraries. However, they all can be ordered on the web from:

http://www.amazon.com

The kids will learn that their structures must have:
-- Strength
-- Stability
-- Designs that can be constructed reproducibly

Strength

Buckling is a failure mechanism where long, thin members loaded in compression end up "bowing" (and eventually breaking) near their middle. This is by far the most common mechanism for failure of structures in compression. Buckling depends on:

-- Length (shorter members support more load than longer)
-- Cross section (fatter members support more load than thinner)
-- Material properties (stronger material supports more load than weaker)

Stability

A pencil balanced on its point (so it's standing straight up) could support a moderate load. However, it would be almost impossible to apply that load without causing the pencil to fall over. MANY structures "fail" because they start to lean -- and the leaning loads one side of the structure more than the other.

Manufacturability

An elegant design that is impossible to construct is of little value. The designs the team considers should be a balance between what will minimize the load on the elements (hold the most weight without breaking) and something they can build, test and learn from in the shortest amount of time. This would imply that teams would be well advised to consider building the simpler designs they think up first -- and save the more complex designs for after they gain a bit of experience with construction technique.

Finish details

One of the KEYS to building REALLY strong structures is to spend enough time on "following through on the details" -- to be sure the finished structures actually adhere to the intended design. For example, a wonderfully constructed structure could be turned into a "leaning tower of Pisa" unless it is checked to be sure it is "plumb".

Similarly, the team should check to make sure that all parts they expect to carry load actually contact the upper and lower surfaces of the tester!! Overlooking this “finish detail” could easily leave one leg unable to support any load (and torquing the Structure as well).

Water in the air can become trapped in the structure. This means that the more humidity there is, the heavier a structure will become. Many teams tried to remove some of this moisture from balsa structures before Weigh-in. Some of these teams learned that Glues can degrade when exposed to extreme heat. Consequently, teams should carefully brainstorm, quantify and test any techniques they consider using for removing water from their structures to be sure they understand what the impact will be on both the structure weight and the structure strength.

Weight placement issues

The PROCESS of placing weights on the structure is an area many first-time structure teams don't give sufficient attention. The order weights are placed, the positioning of the weights and even such details as hand positioning can impact the stresses the structure experiences during weight placement. Planning, practice, brain-storming of the issues and more practice is key. Again, since this is a key aspect of this solution, the team must decide how these issues will be resolved. However, Team Managers CAN point out that teams need to spend time considering these issues.

After all, weight placement during the tournament is the "focal event" for a structure team's year. Consequently, it makes sense for there to be as much thought, planning and practice for this aspect of the teams presentation as there is for others. At the very least, the team should have a plan –- and contingency plans -- so they don't have to make any "snap decisions" they might regret.

A last comment

The goal of Destination ImagiNation is to encourage the kids to learn, stretch themselves and have fun. Kids that really enjoy the Structure Challenge will begin to see the structure in everything around them. They will wonder WHY things they see are designed the way they are. They will also be able to recognize and admire the “design elegance” they see in natural structures. This awareness, appreciation and curiosity is perhaps the greatest benefit this Challenge has to offer. It is certainly **not** interference for a Team Manager to encourage teams to question and explore how the "real world" deals with the issues they are trying to resolve. After all, that is part of what this process is all about!!

Balsa Info for Structure Teams

Many teams are intrigued by the Triplicity Challenge, but afraid to give it a chance. This article is meant to help teams and Team Managers get started with structure building. The resources contributing to this article are many, I thank them for their tips, suggestions, and ideas.

The very best hands-on experiment I've heard to illustrate buckling was to take the "foam noodles" kids take into pools and cut them into various lengths. The kids could then push down on each and feel how much weight it would support. Since the noodles were made out of the same material and had the same diameter, this made it quite clear that the length of the column had a profound impact on how much it could support. -

Another demonstration that seemed to make a strong impression was to take a long board and put one end on a bathroom scale and the other on the floor. I had one of the kids stand on the scale to see his weight and then asked everyone to guess what the scale would read if he stood in the middle of the board (half way between the scale and the end supported by the floor). I was amazed that most of the guesses had the scale showing MORE than his original weight (so much for this all being intuitive). Anyway, after a few experiments, they seemed to have a much better grasp of how a load is distributed between the supports.

Balsa Pages on the Internet

Balsa Tower:
http://hobbs.lessumit.k12.mo.us/Projects/Block/Towers/

Balsa Wood Bridges:
http://fms.crcmedia.com/technlgy/ind7brid.html

Safety Tips for Balsa Teams!

When working with glue, accelerator, or acetone, remember that they are toxic and hazardous materials, and follow the guidelines and precautions. It is easy to become complacent, as the hazard is not immediately obvious. Safe use of these materials requires that they always be handled with care and respect.

Work in a well-ventilated area. Keep sources of flame and sparks well away from the work area.

This includes not only the obvious things, like ranges, furnaces, fireplaces, cigarettes, and candles, but also the less obvious, such as pilot lights on gas appliances, and electric motors commonly found in power tools and appliances.
Keep food and drink away from the work area.
Always wash hands after working with glue materials. Keep glue, accelerator, and acetone away from the eyes. Safety glasses are recommended. Avoid rubbing the eyes, and keep the hands away from the face, while working with these materials.

Keep all materials and tools out of reach of younger children.

Preparation:
The surfaces to be glued should be clean, smooth, and flat. The cyanoacrylate (CA) glues can only fill a gap of a few thousandths of an inch with any significant strength. The surfaces to be glued should fit together smoothly, evenly, and tightly.

Rough surfaces do not glue well, and will tend to be weak. This is one of the reasons that the end surface of a piece of balsa will not glue well to another surface, and this type of joint should be avoided in the design if possible.

Sand surfaces carefully with fine sandpaper prior to gluing to remove fuzz or roughness. Be careful to keep the surfaces flat, and to avoid rounding them while sanding.

Gluing the surfaces:
Accelerator is used with CA glues because otherwise the setting time depends greatly upon the chemical properties of the materials being glued, and may vary considerably. The accelerator bottle should be kept, used, and stored away from the glue bottles. Using accelerator too near the glue bottles can lead to hardening of the glue in the bottle top (or even the glue in the bottle itself).

The recommended method for using accelerator is to apply it lightly to one of the surfaces to be joined, and allow it to dry. Glue is then applied to the other surface, they are brought together and aligned, and firm pressure is applied to press the two surfaces together until the glue has set (usually about 10 to 30 seconds).

The thicker grade of glue takes longer to set, and may be used if a longer period of time is required for alignment. If accelerator is present on the surface to which the glue is applied, it may cause the glue to begin setting immediately. This may cause a poor joint, as the glue may set along the surface before the pieces have been brought together and positioned. Therefore it is important to plan your work well, keep track of where accelerator is applied, and to avoid spraying it on pieces where it is not intended. Accelerator should be used lightly; only a little is needed.

After the glue in a joint is set, it may still require up to several hours before it has reached full strength.

When building an assembly using a jig or fixture, keep the assembly in the jig until it has been completed. Removing, handling, and replacing a partially built assembly can exert considerable stress on the joints, and they may be damaged or weakened. This is especially true at those stages during assembly when there are long pieces which are only glued at one end. Due to the leverage involved, a slight touch on the piece can put considerable force on the joint holding it.

Removal of glue:
The CA glue can be removed by using acetone, as is found in fingernail polish remover. There is also a product called Un-Cure, which will remove the glue, and is more effective for removing the glue from skin.

Caution: These products are highly flammable, and should be used only in a well-ventilated area well away from sources of flame or sparks. Acetone in particular will evaporate rapidly, and the vapors are also very highly flammable.

After a period of use, glue may begin to accumulate on the outside of the glue bottle cap, or it may begin to clog on the inside of the tip. It is useful to have a second set of glue bottle tops. (Hobby shops which sell the glue will usually also sell extra bottle tops and caps separately.) The clogged top can then be removed (use pliers if necessary) and dropped into a jar of acetone, and the spare bottle top is placed onto the bottle of glue. When the clogged top is removed from the glue bottle, place it immediately into acetone. Letting it set out will allow the glue on the inside of the tip to harden further, and will make it more difficult to remove. Also do not leave the glue bottle uncapped for any significant period of time. The jar of acetone must also be kept tightly capped.

If a clogged bottle top is left in a jar of acetone overnight or for several days, the glue may then be easily removed. Fingernail polish remover will soften the glue so that it may be scraped and removed. Industrial strength acetone will completely dissolve the glue, and little additional scraping will be necessary. Safety pins or straightened paper clips are useful for removing softened glue from the inside of bottle caps.

If glue is spilled on skin, rapid setting may also produce significant heat, which can cause a burn on the skin. Use care to avoid getting glue or accelerator on skin.

If unplanned objects are inadvertently glued to the structure (including skin, jigs, etc.), Un-Cure or fingernail polish remover may be applied to loosen the glue and remove the objects. Note that if these solvents are spilled or applied to any of the structure joints, those joints will be significantly weakened.

Tips from experienced teams on buying balsa:

There are several grades of balsa wood, each having certain characteristics helpful to the structure builder. There is a four-page discussion of the various grades and qualities of balsa wood available fro SIG (see below). Be very careful when buying wood to make sure you are getting BALSA, there are woods that have a similar look to the inexperienced eye. If you are buying from a retail store, ask the clerk to explain the difference and demonstrate tests team members can perform to assure they are getting balsa. If the clerk cannot show you the tests, be very cautious about the wood you buy!

Balsa does vary from about 2lb/cubic foot to about 6lb/cubic foot depending on where it's cut from the tree and how dense the tree is. Any number of books about building model airplanes go into more detail about this than I can remember. I recommend the 629 (Dewey Decimal System) area of your public library. It will have more than one how-to book on building balsa wood airplanes and a discussion of density and grain (Light, Medium and Heavy are recognizable, and grain alignments A, B and C.)

Because of inconsistencies in weight and the lack of uniformity in any supplier's stock, the pieces used by the team should be carefully selected...but without outside assistance!

·Make sure that you are buying balsa and not basswood, which may look nearly identical but is illegal to use in Destination ImagiNation® . Both should be clearly labeled. Basswood is heavier and smoother than balsa, whereas balsa is lighter and has open pores. Some suppliers may also carry spruce, which is even heavier and stiffer than basswood and is darker in color.

·Borrow model-airplane books from the library for information on density, grain and grades of balsa. Also, consult magazines such as American Modeler. Toys Galore, a hobby and toy store, distributes a fact sheet on balsa.

·Balsa is available at hobby stores, but one coach recommends buying "select" grade by mail order at 1-800-BALSA-US. You must purchase in bulk from this supplier, but the cost per piece will be less than if you buy smaller amounts at the hobby store. Your order should arrive within five working days.

Here are some sources of balsa wood:

SIG Balsa Wood, 401 Front Street, Montezuma, IA 50171

Balsa USA
Phone: 1-800-225-7287

Hobby Woods, 2931 Larkin, Clovis, CA 93612
Phone: 209-292-WOOD (9663)

Swenson Specialties, P.O. Box 663, 2895 Estates Ave., Pinole, CA 94564
Phone: 510-758-0179
Fax: 707-746-0554

Superior Aircraft Materials, 12020-G Centralia Ave., Hawaiian Gardens, CA 90716
310-865-3220
FAX 310-860-0327

You can specify "grades" A through D and they will hand pick wood that weighs within that grade range. Grades are:

A - 2.0 - 2.4
B - 2.5 - 3.0
C - 3.0 - 4.0
D - 4.0

Books on Balsa:

Building and Flying Indoor Model Airplanes, by Ron Williams
Fireside, Simon and Shuster, 1981
ISBN 0-671-41366-X

Structures, Fundamental Theory and Behavior, by Richard M. Gutkowski.
Most of the book is very mathematical and beyond most Destination ImagiNation® groups, but the end of chapter 2 has a good discussion on
stability and bracing, with diagrams.

Certainly, Sig Manufacturing would be happy to supply the sticks of balsa your project requires at a 30% discount to the competitors. When they call us for an order be sure they explain that the wood is for Destination of Imagination and the sales reps will give them the discount. Please remember, we do not sort, thus, the reason for the discount. This allows them to purchase extra for sorting purposes.

We would like them to go to their local Sig dealer if there is one however, they can order direct. Please let me know if I can help you with anything else.