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Zome Workshop

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"Smart kids: better world" -- Friends School Song

Abstract

This paper outlines how to conduct a Zome workshop for students, teachers or parents. I'll discuss the discovery learning philosophy, preparing for the workshop, conducting the workshop, follow-up activities and additional resources that are available for educators.

1. Introduction

Zome is a powerful manipulative that not only applies to many of the (US) national standards (1), but also integrates with other core subjects such as science and language arts. Many educators feel Zome is a great way to get kids excited about mathematics, but don't know how to get started in the classroom. Here's the structure and some content of a Zome workshop I developed for K-8 gifted students in the summer of 2006. Based on the "discovery learning" model, it can break the ice in the classroom, and facilitate a whole lot of learning in two hours that will leave students begging for more!

2. Discovery Learning

Discovery learning "is based on discovery guided by mentoring rather than on the transmission of information,"(2) i.e., the discovery process is as important as the learning that results. In a nutshell, you pose challenges and students try to solve them. With lots of ways to solve a challenge, an unusual approach may lead to unexpected discoveries. Students are not competing. When stuck,encourage them to get up and look at what others are doing. Sharing information leads to creative solutions.

You may dread the moment you can't answer a student's question. Fortunately, this happens fairly frequently with Zome. It's liberating to say, "I don't know. But that's a great question. Any ideas on how we could find out?" That's when learning really starts!

3. Preparing for a Zome Workshop

3.1 Familiarize yourself with Zome -- work (dare I say play?) with Zome before conducting a workshop. This is *not* so you can know all the answers (roughly equivalent to trying to know all the music that will ever be written before teaching your first piano lesson), but rather so you are better able to guide the discovery process. See through your students' eyes. Unstructured play is a good way to start; then work through some of the challenges or lesson plans listed in **Teaching Resources**.

3.2 Organize the learning space -- Organize the workshop space into 3 areas: 1) tables, where students can work in teams, 2) a discussion area for the whole group, and 3) plenty of floor space to accommodate larger projects as the workshop progresses. Allow at least 20 m^2 (215 sq. ft.) per team (4-8 students.)

Tables -- use round tables if possible, with enough chairs for teams of 4-8 students, and include about a 100 Zome parts per paricipant (see "5. Loaner Program" in **Teaching Resources** for cheap access to Zome parts.) Place the tables in a U-shape along 3 walls of the room, with plenty of space between them for bridges, towers, MetaZome structures, etc.

Discussion area -- separate the discussion from the tables and arrange seating so that students are encouraged to focus on you and and other participants during discussions. The temptation to continue "playing" with Zome is too great (even for adults!) when it is close at hand! It's best if they can't even see their own models during discussions (except as you invite individuals to share their work with the group.)

Space for larger projects -- the advanced challenges are an exciting part of the workshop, in which teams build large and complex models. Structures like the "Tallest Tower," "Longest Bridge" or "MetaZome" can have dimensions of several meters. Adequate space helps you control the chaos.

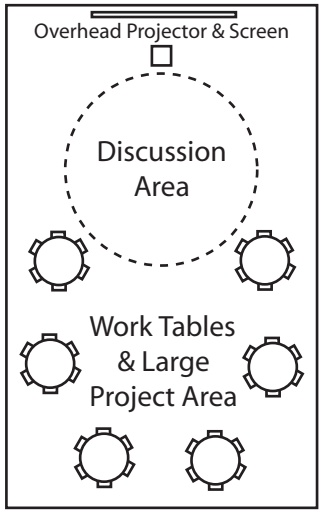

Figure 1. *Suggested workshop set up*

3.3 Rhythm and attention span -- Find a natural rhythm for the activities as you run the workshop. It's really important to alternate between challenge sessions, in which the students are engaged in hands-on activities with their team members, and group discussions, in which all attention must be focused on one speaker at a time. Don't let basic challenge sessions exceed 15-20 minutes without a break for discussion. Likewise, initial discussions should be limited to 5-10 minutes. I discovered this the hard way in some of the first workshops I facilitated, which ran from a learning experience to the Lord of the Flies and back in 2 hours. A number of studies (Johnstone & Percival, 1976, and Burns, 1985) suggest that even adults' attention begins to flag after 15-20 minutes in any one activity. In a lecture or discussion, the first 5 minute period has the greatest impact on learning. Attention will increase with student's interest, so advanced challenge sessions and discussions may naturally tend to be longer.

3.3.1 Two-Hour Workshop Schedule

Time*	Section	Attention to:	Comments
00:00-00:10	Intro free play	Zome parts	initial assessments of participants
00:10-00:15	Workshop rules	Facilitator	see section 4.2.1
00:15-00:25	Free play disc. & challenges	Participants & Facilitator	assign basic challenges based on disc.
00:25-00:45	Challenges I	Zome & team	teams work on basic challenges
00:45-01:00	Challenge I discussion	Participants & Facilitator	assign advanced challenges
01:00-01:30	Challenges II	Zome & team	teams work on advanced challenges
01:30-01:40	Challenge II discussion	Participants & Facilitator	teams present their final projects
(01:40-01:50)	(Photos)	(Parents)	assumes parents are invited last 20 min.
01:50-02:00	Clean-up	Work area	

*times are flexible, but in general, no session should exceed 20 minutes in length

4. Conducting a Zome Workshop

4.1 Initial assessment -- on arrival, encourage participants to try out Zome for a few minutes. (If parents bring kids to the workshop, advise them to arrive 15 minutes before the end of the workshop to see their kids' creations, take photos, etc.) Use this time to assess each participant: some will dive in and and start building structures, some may sit back with their arms crossed, some may walk around the room looking at others' work. Your assessments are important to building a successful workshop for all the participants. Use the information to assign challenges, change the composition of groups, avoid conflicts etc.

4.2 Initial discussion -- After the initial assessment, move to the discussion area to briefly discuss 1) the structure of the workshops, 2) the rules, and 3) what the students learned about Zome during the "hands-on" session. During this third part, assign challenges and finalize the composition of the teams.

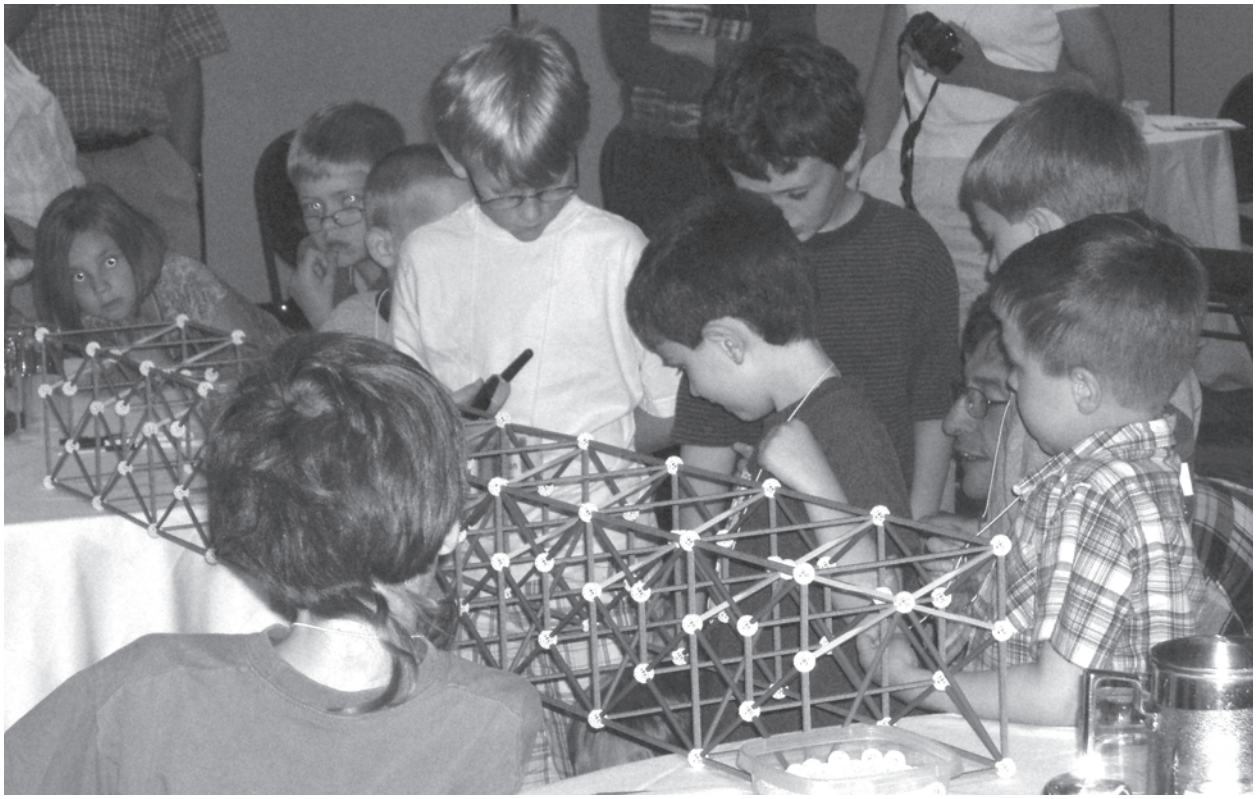

Figure 1: *Building the "longest bridge" at a Zome worshop for gifted children, Denver, July 2006*

4.2.1 Workshop structure -- briefly explain the structure of the workshop to the group. During hands-on activities, it's o.k. to experiment, create and build, to talk in a classroom voice with team members, and even walk around the room and see what other teams are doing. During group discussions, one person speaks at a time and all attention is focused on the speaker. Again, it is important to keep the discussion area completely separate from the work area. Even seeing their models is a distraction; being within arm's reach is too great a temptation to bear.

4.2.2 Workshop rules -- Discussing the rules helps frame the workshop as an educational event (or fun with a purpose, if you prefer) and not a free-for-all. It helps to *demonstrate* rules such as how to disassemble models, and the tip that "if it works, it works perfectly." This facilitates discussion and sets the tone for the discovery learning process. For example, you might ask, "why not just jump on a big model when we're

ready to take it apart?" to start a brief but interesting discussion. The building tip "if it works, it works perfectly" offers an excellent demonstration opportunity: you can show students how to "sight" one ball through the hole of another to discover which strut fits between the two. This demo leads naturally to the meat of the initial discussion, in which students share their first impressions of the tool.

The Rules

- Maintain relaxed, focused attention. While building, converse quietly about your work. During discussions, listen to the speaker. You can't give attention to one person while talking to another.

- Tighten your model as you go. Gaps between the shoulder of the strut and the ball face accumulate and lead to trouble, especially in dense models like the "pincushions" and trusses.

- "If it works, it works perfectly" (...and if it doesn't work, it doesn't work at all!) Struts should never be bent, twisted or under tension in finished models (the reason for this will become clear as you work with Zome.) But it's o.k. to bend struts to fit them into a tight position. To see if a strut will fit between two balls, try looking through one ball to the other ball. The holes will line up!

- Disassemble models carefully! Hold the strut close to the ball and push the ball with your thumb to release it. Do not rip models apart, jump on them, throw them against the wall, or use any other form of destructive testing. The parts will break. If you do break a part, give it to the workshop leader (rather than mixing them in with the good parts!) Think of the next students to use them (5).

- If you use it, put it away. Leave the space cleaner than you found it!

4.2.3 Discussion -- "So what can you tell me about Zome?" "The balls have different shaped holes... Some struts are twisted; some are straight... Only certain struts fit in certain holes... There are different colors and different lengths of struts... Blue struts are 'squares'... Yellow struts are triangles... Red struts are 'hexagons'... The struts come in short, medium and long lengths... if you put a short and medium together, it makes a long... Reds and blues are the 'same' length, but yellows are shorter..."

Let participants struggle with ideas rather than answering their questions directly. Use questions like "what do you think?" or ask the group, "do you agree? who has a different idea?" to keep ideas flowing. It also saves you from having to know it all!

4.2.4 Assign challenges based on your initial assessments and the initial discussion. I tend to make the assignments during the discussion based on participants' initial observations. For example, if an entire team builds "pincushions" during the free play period, they're great candidates for the basic challenge, "How many holes in the ball?." Or a table may have several guys who only seem interested in building cubes with the long blue struts. You found the "Lego heads." They'll be good candidates for the Super Structures strand (i.e, build the longest bridge and/or the tallest tower.) It's a fair bet that by the end of the workshop they'll have a gut feeling for triangulation, among other basic engineering concepts.

Another approach: you can simply pre-assign basic challenges by team, table etc. Such prearranged marriages will also meet success. Any strand you choose will lead the students to real, exciting learning. Once the teams return to their tables but before they begin the hands-on work, explain to each team their challenge in detail, especially if you are using challenge cards (see **Teaching Resources**.) Often participants don't read the card and simply build the illustrations.

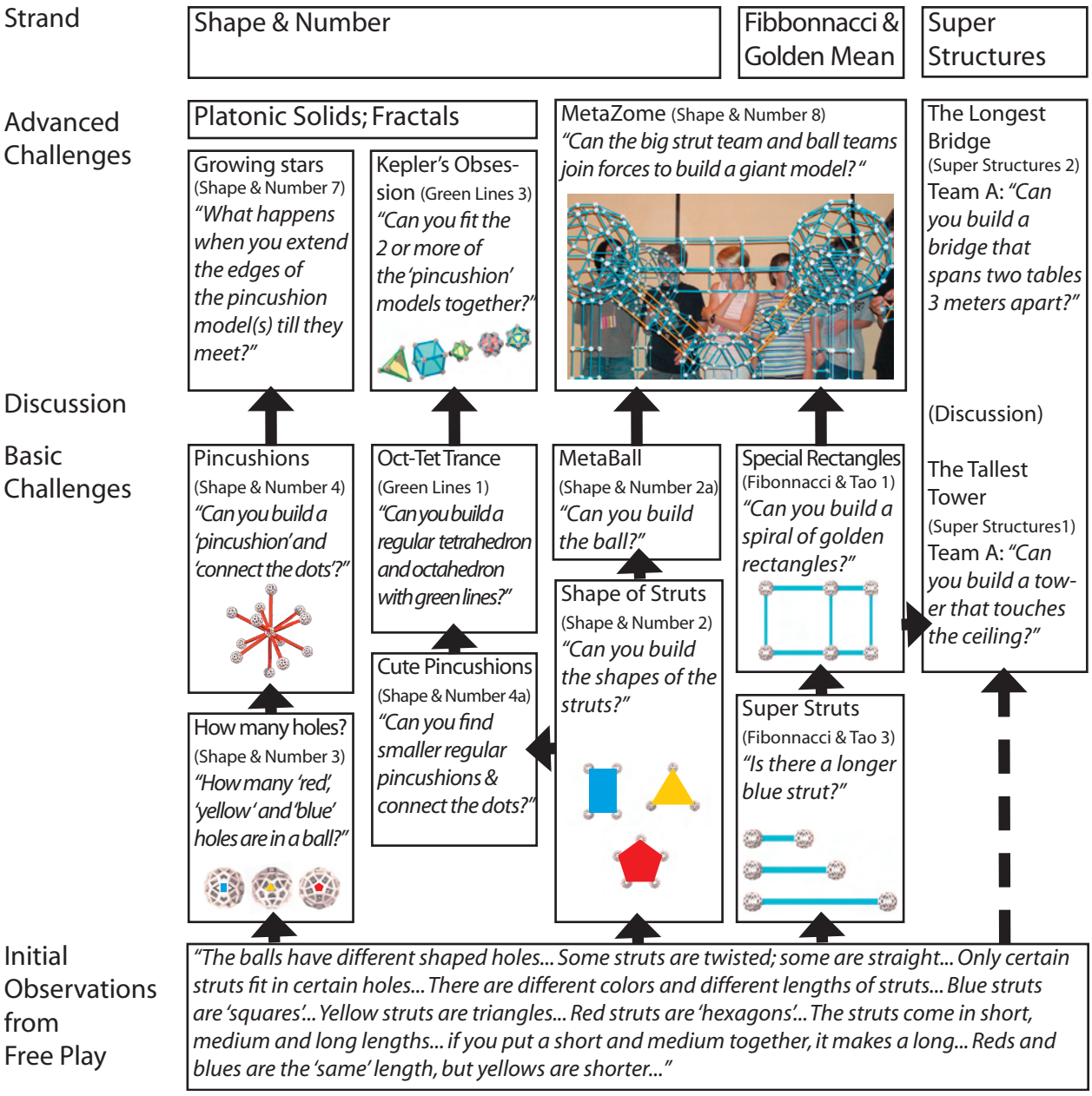

Figure 3. *Some possible strands showing how basic challenges build to more advanced explorations (the chart progresses from bottom to top.)*

4.3.3 Address problems and facilitate learning -- At this point, begin the hands-on session. The first few minutes can determine the effectiveness of each team for the whole workshop. You may need to encourage, redirect or reconstitute them. In some cases, an individual or small group may ignore the challenge altogether and go their own way. Treat these departurers with courtesy; as much or more learning may occur in such a context. It is certainly test of your skill as a facilitator!

Despite vigorous protests, participants will leave their models and return to the discussion setting every 20 minutes to refocus attention. One at a time, have a volunteer bring her model to the discussion area, explain the challenge and what the team discovered. Facilitate a brief discussion and encourage the other partici-

pants to applaud the volunteers for their efforts. Assess participants with the goal of assigning a follow-up challenge. Some may wish to complete what they started and others may want to follow an individual path. Many want to work in teams to build larger and more elaborate structures, such as "a bridge that spans at least 2 meters between two tables" or a MetaZome structure.

Conduct the second hands-on session in the same way as the first. At this point, it's a fair bet the teams will be galvanized and motivated, and their questions may go beyond your current grasp. Once again, a great opportunity for learning: "I don't know; how can we find out?"

4.4 Closing the workshop -- Use the same discussion format after the final session. Often participants are exuberant about their work and will want to show it off to friends, parents, take photos, etc. Use this enthusiasm to reinforce the learning that's taken place. Draw parents into the excitement when they arrive.

Depsite the pain of disassembling their creations, participants must clean up. It's a good time to remind students of the final rule, "Leave the place cleaner than you found it," so that the nest workshop participants can have as much fun as they did.

5. An Example: the MetaZome Challenge Strand

Simple challenges can lead to profound results, even in a 2-hour workshop in which no one has been exposed to Zome before. Here's an example built from the basic challenge, "Can you build the shapes of the struts?" (Shape and Number 2.)

To start the initial discussion, you ask, "so what do you know about Zome so far?"
Trevor: "The struts are different colors and different shapes."
You (repeat): "The struts are different colors and different shapes. What are the different shapes?"
Diana: "Triangles, squares and hexagons."
You: "Triangles, squares and hexagons. Does everybody agree with that?"
Students: (general agreement, with some dissenters.)
You: "Most people agree, but not everybody. Who doesn't agree? Why not?"
Julia: "The blue struts are rectangles, not squares."
You: "The blue struts are rectangles, not squares. Does everybody agreee with that? O.k., what else? How many sides does a hexagon have?..."

Based on this interchange, you challenge Julia and her team to build the shapes of the three struts. After the initial discussion you meet with the team at their table to answer any questions. You encourage the students to walk around and see what other teams are doing if they get stuck. In fact, they build the Golden Rectangle quickly but stumble on the equilateral triangle and regular pentagon. But the team at the next table is building red, yellow and blue "pincushions," and discover triangles and pentagons quite effortlessly when they "connect the dots." Soon Julia's team triumphantly bids you back to their table. They're ready for the next step in the challenge.

"Great! So you can build the shapes of the struts! Since the ball is made up of rectangles, triangles and pentagons, do you think you can build that too?"

They dive in. You notice that they are struggling with 5 rectangles around a pentagon, and ask if the pentagons look the same on either side. Diana notices that the blue struts seem to "dish" inward on one side but outward on the other. Now the rectangles look right! The team shifts into high gear. In less then 20 minutes

they have two whole MetaZome balls on their table. Since the other teams need more time before the 2nd discussion, you casually ask, “I wonder if you could build a giant blue strut to connect these two balls/” Of course they can. And they could hardly be called reticent when it comes time to share their discoveries during the 2nd discussion -- they need to be reminded that one person talks and everyone else listens.

The rest is history. After their breif presentation, you challenge them to build a MetaZome Atomium (pictured in Shape and Number 8,) and suggest they join forces with the “Super Struts” team. This team recently discovered that super long struts can be built up from any two consecutive lengths (short/medium or medium/long) based on Fibonacci numbers -- an important insight, not to mention the fact that Julia’s team needs all the help they can get to build a giant body-centered cube.

The second hands-on session passes quickly. Parents are invited to the final presentation and are already snapping pictures of the proud members of the MetaZome construction crew and their creation.

6. Conclusion

This workshop is a great way to get started teaching with Zome. As you become more familiar with the tool, it’s likely you will increasingly find applications for Zome in the classroom. Or else you can schedule followup workshops at regular intervals to reinforce and “hardwire” the new learning.

7. Teaching Resources

Except for the Zome Geometry textbook, all of the listed resources are available to teachers for free in electronic format at http://zometool.com/educators.html.

1. Zome Learning Adventures (K-8) -- Middle school-age students engage in 3 standards-based challenges in a professionally produced 30-minute video.

2. Zome Challenge Cards (K-12)-- 24 illustrated “discovery learning” challenges written for use in Zome workshops

3. Zome Lesson Plans 1.0 (K-12) -- Standards-based lesson plans written by teachers for teachers

4. Zome Geometry (11, 12 & beginning college) -- supplemental textbook by George Hart and Henri Picciotto, published by Key Curriculum Press

5. Zome Loaner Program (all levels) -- teachers can borrow mass quantities of Zome parts for 2 months at a time, essentially for the cost of shipping. See *http://zometool.com/educators.html*

Notes and References

1. National Council of Teachers of Mathematics (NCTM) standards as addressed by Zome are summarized in an appendix to Zome Lesson Plans 1.0, pp. 201-208, 1998

2. The Boyer Commission on Educating Undergraduates in the Research University, REINVENTING UNDERGRADUATE EDUCATION:A Blueprint for America’s Research Universities, 1998

3. Broken parts may be returned for free replacement to Zometool Inc., 7475 W. 5th Avenue, Suite 204, Lakewood CO 80226. As of Spring 2007 we are implementing design and material improvements to make all Zome components virtually unbreakable.