Ting-Bing: Constructionist Architecture for Adventure Classrooms

Sam Kronick

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Introduction

In *Mindstuff,* Michael Eisenberg reexamines some of the "powerful ideas" of Seymour Papert's influential book, *Mindstorms*. He argues that the concepts of constructionism education that Papert lays out do not have to stay confined inside computers; learners can and should gain new understanding by making physical "stuff" as well as computer programs and digital representations. As a tinkerer who has learned more building with atoms than bits, I found this critique poignant. And as a student of architecture, I found the following extension highly compelling:

> ...in thinking of what "Mathland" might mean, *the room, and not the computer screen, is the most tasteful and productive grain size of design for educational technology*. That is: as educational technologists, we should try to imagine what the child's room (or maybe the classroom) might look like, not merely what sort of interface is provided on a computer screen. (Eisenberg 2003, emphasis original)

When I read this, I was already involved in designing an educational project on the room scale. My self-imposed challenge was to design a kit of architectural building blocks for a temporary structure that could be reconfigured, built, and rebuilt by high school students who would use it as their classroom. Initially, my motivation came from a simple desire to share what I loved about the act of building in hopes that it would create an empowering experience for a younger generation of learners. However, Eisenberg's perspective as well as related ideas from the learning sciences turned my thoughts to situating this project more specifically in the context of constructionism and new media literacies.

How could I focus and extend this project to enable more students to be more creative and collaborate while doing so? Specifically, how could I engage a wide variety of learners in the construction of their environment, creating an architecture that actively encourages appropriation of ideas and builds a collective intelligence? What different types of media would be appropriate for learners to work with and navigate between in this context? Similar to how Henry Jenkins sees potential for participatory media to be a powerful training ground for civic engagement via developing these new media skills (Jenkins 2006), could I develop a *participatory architecture* that informs and encourages active and critical inquisitiveness about the spaces we inhabit in our everyday lives?

It is this salient connection between participation via production and critical thinking that gave this project its name: ting-bing — a shorthand for "thinking" and "building."

Precedents

A number of existing projects have attempted to engage high school age students with the architectural or urban environments they learn in by assisting in creative and analytical investigations of these spaces. Though most of the following examples use creative and participatory processes as central activities, their educational goals do not specifically come from constructionism or new media literacy.

In Annette Krauss' *Hidden Curriculum* project, Krauss uses techniques from her contemporary artistic practice to foster creative works with her students. She asks students to take everyday objects found within their school, such as a typical chair, and create new and explicitly unusual situations by placing these objects in strange contexts. These constructed situations provide sites of reflection on the relationships of authority and power that shape the school environment, revealing a hidden spatial curriculum (Krauss 2009).

The Center for Urban Pedagogy (CUP) draws from the toolset of urban planners to investigate the conditions of the city in which students live. A typical CUP project asks students to use media tools (video, oral interviews, graphics, drawing) to produce exhibitions about issues such as public housing, waste management, and building codes (Hammett 2006).

While the previous examples primarily serve to create knowledge about a spatial situation, others seek specifically to construct new spatial arrangements altogether.

Architect Alex Gilliam, as a fellow with Auburn University's Rural Studio, worked with students in rural Newbern, Alabama to rebuild their aging school. The students documented issues with their building and lent their labor to physically construct a new place of learning (Rural Studio 2004).

Danish landscape architect C. Th. Sorensen developed the idea for a "junk playground" after he realized that children would rather play in the rubble of destroyed buildings following World War II than in his carefully designed playgrounds. He proposed, and others later implemented, a play space that would consist of little more than tools and materials with which children could build and care for their own structures. Many of these "adventure playgrounds" (as they are commonly called in English) were built around the world. Unfortunately, very few exist in the United States. While not designed primarily sites of learning, the act of play can be seen as educational in certain terms (Bengtsson 1972).

Papert's original formulations of constructionism drew heavily on the idea of immersion in a sort of "Mathland" that is actively built by the learner (Papert 1993). Though the activities he described and developed did focus on creating immersive environments, these environments remained for the most part virtual. Likewise, projects that explicitly followed down this path focus on the virtual environment first. As an example, the Scratch programming language gives learners a virtual programming environment in which they can create their own virtual worlds through games, stories, simulations, and art projects (Resnick et al 2009).

Especially relevant to this design project is the Computer Clubhouse - learning centers designed specifically for making constructionist projects, such as programming with Scratch, or using digital image and video software to make creative and expressive works (Rusk et al 2009).

The above examples range in scope and impact from site-specific interventions to networks of related projects over a wide geographic range. They also illustrate two different approaches to construction and space: some, like the Sunshine School project and the adventure playgrounds, are about making spaces, while others, like the Computer Clubhouse or the Scratch programming environment, are about providing spaces for making. The ting-bing project as described in this document seeks to bridge these approaches by developing a system of making spaces for making. Why are the spatial conditions in a Computer Clubhouse given when all the content produced within it is meant to be created by the students? In ting-bing, the space becomes the content, and the making of the space can become a fitting part of a larger constructionist curriculum. In doing this, it maintains some features from each of the above precedents: that spatial relations are intimately related to civic engagement and an understanding of space is important to civic participation, and that collaboration, appropriation, and sharing as facilitated by virtual tools can be a powerful tool of engagement and learning. It also seeks to facilitate the same experiences of play and tinkering found on adventures playgrounds and in Scratch.

Design Principles

The following are the design principles I have come to value and used to guide me through the life of this project:
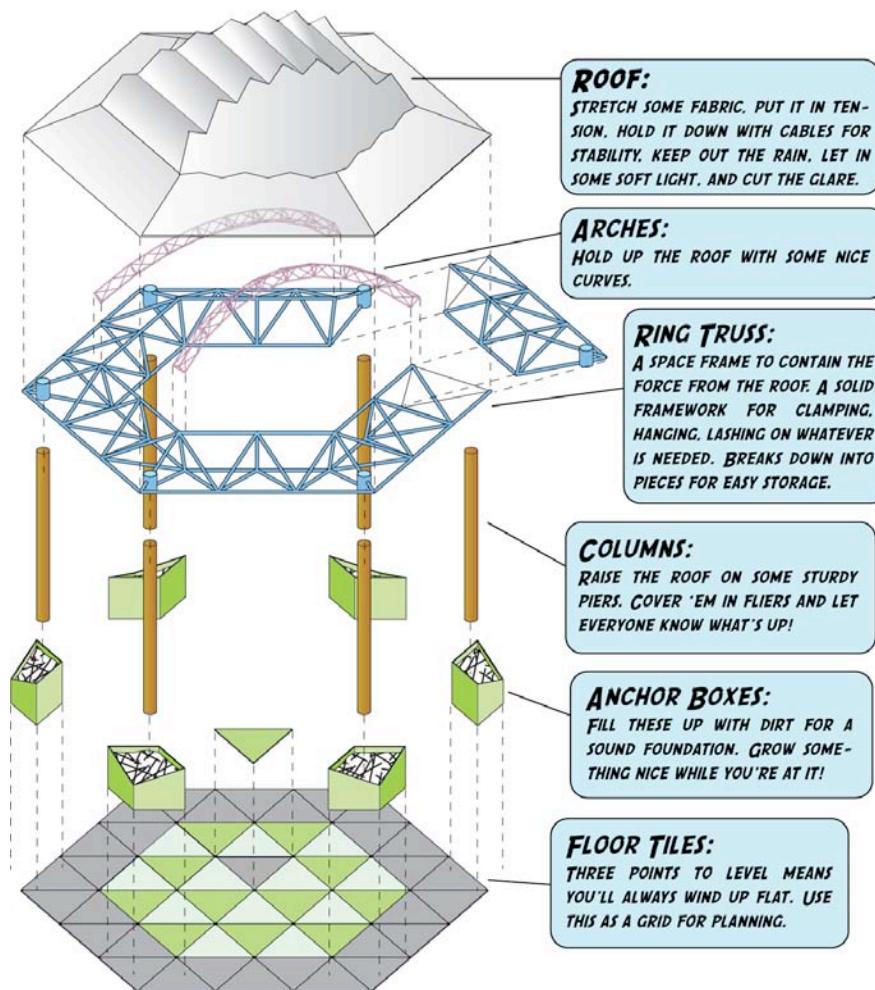
1. The structures created should be **temporary, rugged, and reusable** such that each new group of students has a chance to renegotiate, reconfigure and reconstruct the classroom as they desire.
2. Elements of **tinkering and play** should be the guiding mode of interaction.
3. A set of **standard components** should be provided to create a common design language that accommodates easy sharing amongst students and different groups building their own ting-bing classroom.
4. A **standard layout** should be given as a starting scaffold for adaptation within a framework.
5. The components should be **modular** in nature such that the standard layout can be **extended** or radically redesigned in addition to being used as-is.
6. Components and the layout should be expressible in **multiple media** appropriate to the context.
7. Designing and constructing the classroom as well as the activities provided within the space should accommodate a **diversity of learning styles** and interests.

Some of these principles correspond to the idea of creating construction kits with "low floors" (low barrier to entry, as expressed by the standard layout, standard components, and facilitation of tinkering), "high ceiling" (room for increasing sophistication, as in the modular extensibility), and "wide walls" (providing a wide range of activities and supporting diverse learning styles) (Resnick and Silverman 2005).
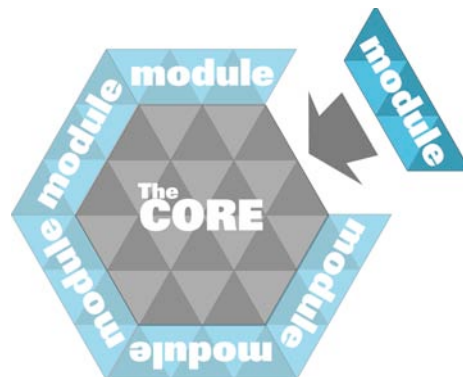
Design

The design process for ting-bing began in the spring of 2009 by finding a partner high school to develop the initial ideas. I met with a group of students and their teacher at Prospect Hill Academy Public Charter School in Cambridge, MA once or twice a week after school throughout the spring. During that time, I talked with them about architecture and asked them to share ideas that they had about what their ideal classroom might look like. These interactions demonstrated to me that flexibility of the space was important as the school was small and popular classes and activities experienced a high level of volatility. It also challenged me to accommodate the many interests and skills present in this small but highly diverse group.

At the end of the spring, I worked with fellow MIT architecture student Bill McKenna to develop a working design for the classroom based on what was learned. The design we came up with can be thought of as a collection of modular building systems: foundation, floor, vertical structure, and roof.

ROOF:
STRETCH SOME FABRIC. PUT IT IN TEN-SION. HOLD IT DOWN WITH CABLES FOR STABILITY. KEEP OUT THE RAIN, LET IN SOME SOFT LIGHT, AND CUT THE GLARE.

ARCHES:
HOLD UP THE ROOF WITH SOME NICE CURVES.

RING TRUSS:
A SPACE FRAME TO CONTAIN THE FORCE FROM THE ROOF. A SOLID FRAMEWORK FOR CLAMPING, HANGING, LASHING ON WHATEVER IS NEEDED. BREAKS DOWN INTO PIECES FOR EASY STORAGE.

COLUMNS:
RAISE THE ROOF ON SOME STURDY PIERS. COVER 'EM IN FLIERS AND LET EVERYONE KNOW WHAT'S UP!

ANCHOR BOXES:
FILL THESE UP WITH DIRT FOR A SOUND FOUNDATION. GROW SOME-THING NICE WHILE YOU'RE AT IT!

FLOOR TILES:
THREE POINTS TO LEVEL MEANS YOU'LL ALWAYS WIND UP FLAT. USE THIS AS A GRID FOR PLANNING.

Exploded isometric drawing of the original classroom building systems.

The organization of the floor plan itself was designed to accommodate reconfigurable learning "modules" that would plug in to a common "core."

Over the summer, we asked some of the students from the spring to join us in a series of workshops and actually build a life-size prototype of a portion of the design. Although we had a picture in our heads of what we wanted the students to produce and the sort of positive experience they might have, our sense of what and how the students needed to learn to get there was not very well informed.


The output of the summer: a full-scale portion of a classroom prototype.

Most importantly, we learned that working in one media of full-scale construction - even if it was modular in nature - limited what could be learned and what could be communicated between the different participants. For example, some of the students didn't like working with power tools that

were noisy and intimidating, while others relished that challenge. Painting the materials was a surprisingly popular activity, as it was both expressive and immediately accessible. The students also were used to working on projects that were desktop-sized or entirely computer-based and had a hard time thinking larger. After understanding more about the learning sciences and successful constructionist projects, it became clear that providing multiple modes of expression and engagement was an important next step. In architectural terms, I interpreted this as providing different scales of building activities centered on a common structure. This would hopefully "widen the walls" and "lower the floor" (conceptually speaking, of course; the representations of the building would physically get smaller!)

I then distilled the structure down into a smaller set of repeated components:
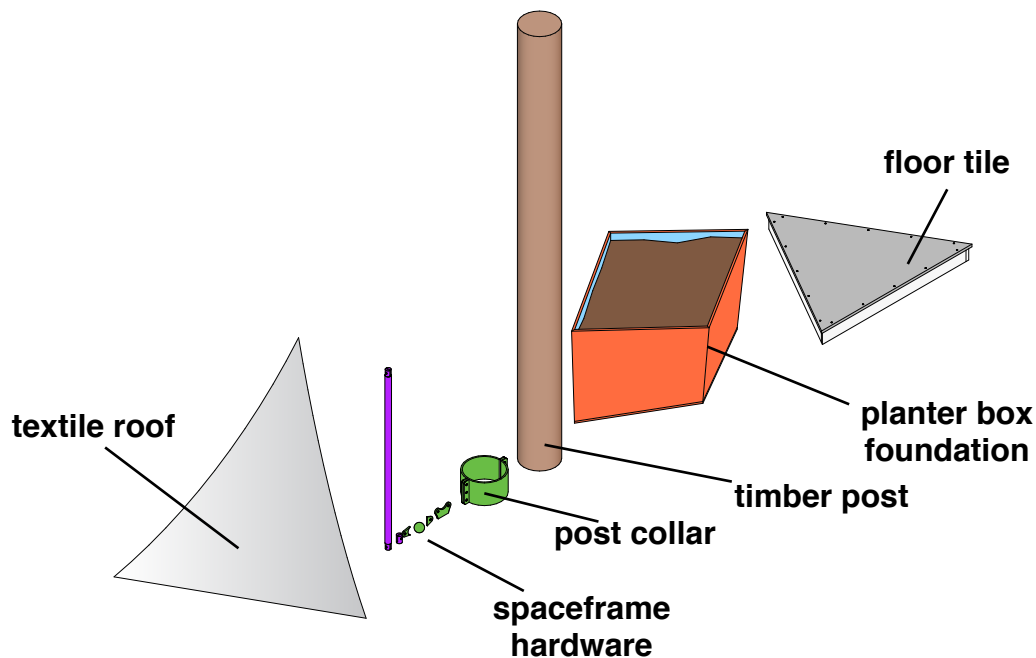

- The **textile roof** enables the structure to be lightweight and more easily reused. It can be constructed or modified using a sewing machine - a tool and skill set certain students might find more appealing and relevant to their existing interests.
- A set of **spaceframe hardware** provides a reconfigurable building system of steel hubs and struts for students curious about the physics of architectural structures.
- **Post collars** provide an interface for clamping the spaceframe onto the **timber posts** which serve as columns and provide vertical structure.
- **Planter boxes** serve as the foundation for the structure, using the weight of soil to provide stability while still being temporary. The large flat sides of the planter box provide an opportunity for custom decoration through painting and the soil provides a garden for students to cultivate plants - two acts of creative construction very different from building structures.
- The triangular **floor tiles** provide a modular geometric grid for laying out the classroom. They can be reconfigured, but their standard dimension lowers the barrier to thinking spatially by constraining the possible arrangements. Still, their large flat surfaces provide an open canvas for artistically inclined students to decorate.

In addition to providing life-size version of these components, I developed them in a **virtual** and **model** scale. Moving between these different modes of production and understanding the advantages of each is an opportunity to cultivate transmedia navigation skills (Jenkins 2006).
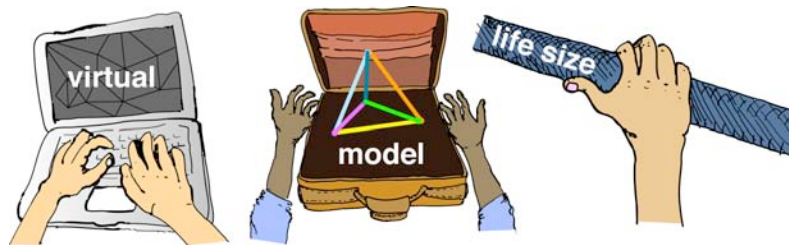
Virtual components are provided as 3D CAD files for Google SketchUp, a free and easy-to-use 3D modeling program. These components are stored in the Google 3D Warehouse where they can be freely downloaded and imported into a student's personal virtual model of the classroom. A large number of everyday and specialized objects are also available from the 3D Warehouse community, enabling a student to build a complex simulation of what could become a real learning space. In turn, the student's creations can be shared again in the 3D Warehouse for others to modify, extend, or look to for inspiration. Here students can develop skills in appropriation and witness the building of a collective intelligence as they interact with what their peers have made (Jenkins 2006).
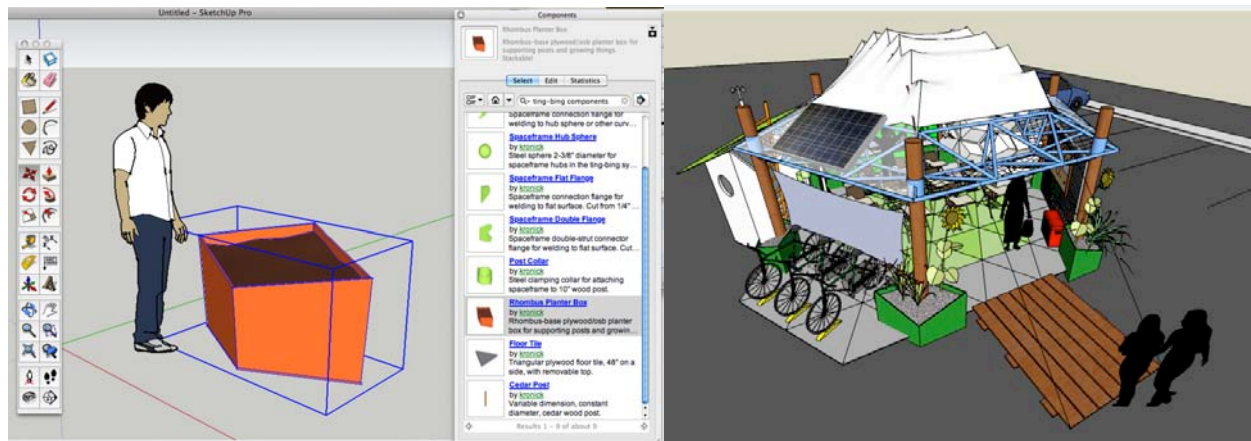
Bringing components into SketchUp and building a 3D virtual classroom.

The **model kit** facilitates tinkering with tangible "stuff" representative of the life size classroom. The scale factor of the model is exactly 1:8 of life size, making it tabletop-sized but still rather large. This is a scale factor larger than most doll houses and the same as the popular "fingerboard" skateboard toys that skateboarders play with to build their own skate parks. At this scale, it was possible to model the assembly and disassembly processes of the classroom in a realistic way - using materials such as using magnets, drinking straws, and small steel spheres to simulate the connections of the spaceframe. Of course, fitting all the pieces on a single table allows for much faster and easier tinkering than working with the full scale. The model has advantages similar to working with LEGO bricks, but its specific components provide a meaningful connection to both the virtual and life-size mode of construction. As with the other building modes, artistic expression is encouraged through the inclusion of paints and blank surfaces for decorating.

The model kit packed into a compact case, and unpacked for tinkering with structure and space. Inset detail of magnetic space frame node.

Building with the **life size** components allows students to construct a space that is both meaningful and visible to their community. The built space becomes meaningful through its connections to creative explorations in the virtual and model media, as well as the participatory nature of its construction. It is visible by virtue of its size, giving students a chance to display their creative and cognitive efforts for their local school and community publics. And at this size, teamwork is mandatory or nothing gets off the ground!

An immersive, tangible experience that only building life-size can provide.

Learning Scenarios

Melissa is a student that says she "hates math with a fiery passion," but she likes to draw. Her teacher asks her if she would be interested in designing patterns for the floor of the classroom on its equilateral triangle grid. This sounds interesting to her and she begins looking at triangular patterns online and in books at the library. She notices that different pattern styles and geometries tend to come from different cultures all around the world - they reflect objects from those peoples' everyday lives. She decides to draw her own patterns that incorporate symbols meaningful to her fellow students - iPods, cell phones, the flags of their parents' home countries, and the colors and icons of the subway system they use to get to school. She starts by sketching these onto model-scale floor tiles and playing with the different ways to rearrange them. She carefully adjusts the lines so they flow from tile to tile no matter how they are arranged. Finally, she works with her art teacher to blow up her drawings and make screen prints onto the full size floor. In the end, she has constructed her own meaningful example of tessellations and symmetry and situated it in a cultural context of architectural ornamentation. She thought she was *just* drawing, not doing math, too!

Jim, a student at another high school sees pictures of Melissa's floor tile designs after she posts them on Flickr. He happens to be an experienced Scratch programmer and thinks he can make similar patterns by writing a computer program. He does this and sends his project to Melissa. She is delighted by the ability to quickly tinker with her sketches and makes some new tiles in this way. Jim lives near a FabLab and uses the output from his program to cut some of Melissa's designs into plywood using a CNC router. From the CAD files he designed, other students working with ting-bing make and install their own Melissa-designed floors. From computer code, to virtual representations, to real sketches on models, to very tangible objects that make up the floor beneath their feet, these students are learning how to navigate and collaborate across multiple media.

Meanwhile, Jack is a Senior who has been accepted into an architecture college next year. He met Marcos, a friend from another state, at a summer design program and told him all about ting-bing. Marcos was excited by the idea, especially since his school is a drab, outdated, and uninspiring brick box. Jack and Marcos decide to work together on a design proposal for a new ting-bing classroom at Marcos' school. They trade SketchUp files of their custom design back and forth using the 3D Warehouse. Marcos uses the 3D files to convince a teacher to help him get materials for a physical model. He then uses the model to demonstrate to the school's students, teachers, and administrators how the design could be put together and how it could be stored when not in use. Because Jack has experience working with the common components of this system, Marcos has picked up a few tips that make him sound very well informed: he notes that it's especially important to consider how the room is oriented to the sun so that plants in the planter box foundations get the right amount of light to grow. A fellow student, Elise, likes gardening and volunteers to choose local native plants that will grow well in the dirt of the foundations. The administrators at Marcos' school are impressed by the proposal and the students' energy and agree to help make it happen. Marcos, Jack and Elise have demonstrated their ability to work together and become active advocates for the quality of their own environment.

Future Explorations

Now that the ting-bing tools have been designed and some potential uses have been outlined, the next steps involve implementing and evaluating this system.

The tinkering nature of the model kit makes it ideal for using in workshops with groups of students, teachers, and other potential designers. By going into schools and asking users to share their dreams for what their classroom could be through building with the model, I not only gain insight into the appropriateness of the tools, but I build familiarity in the schools with this system. If students are engaged and want to pursue playing with the building components further, they can work with the virtual models that are already available online or eventually through their own life size implementation. I would like to facilitate connections between different groups that are interested in pooling their skills to make this happen; workshops seem to be a great way to begin building such a community.

Also in the interest of developing a community and encouraging collaboration, a project such as this requires a participatory website that allows students and teachers to post their creations for others to see. Fortunately, many tools for sharing this kind of media already exist via Google 3D Warehouse, Flickr, Instructables, or YouTube. I believe it would be wise for a community website to leverage these existing systems to connect to a wider audience.

Finally, the specifics of how this system could fit into existing academic programs of high schools should be explored more. This should involve working with interested teachers to develop curriculum and lesson plans for a class that would focus on the opportunities of the ting-bing system.

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