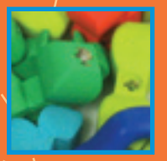

# topobo

A 3D constructive assembly system with kinetic memory

http://web.media.mit.edu/~hayes/topobo

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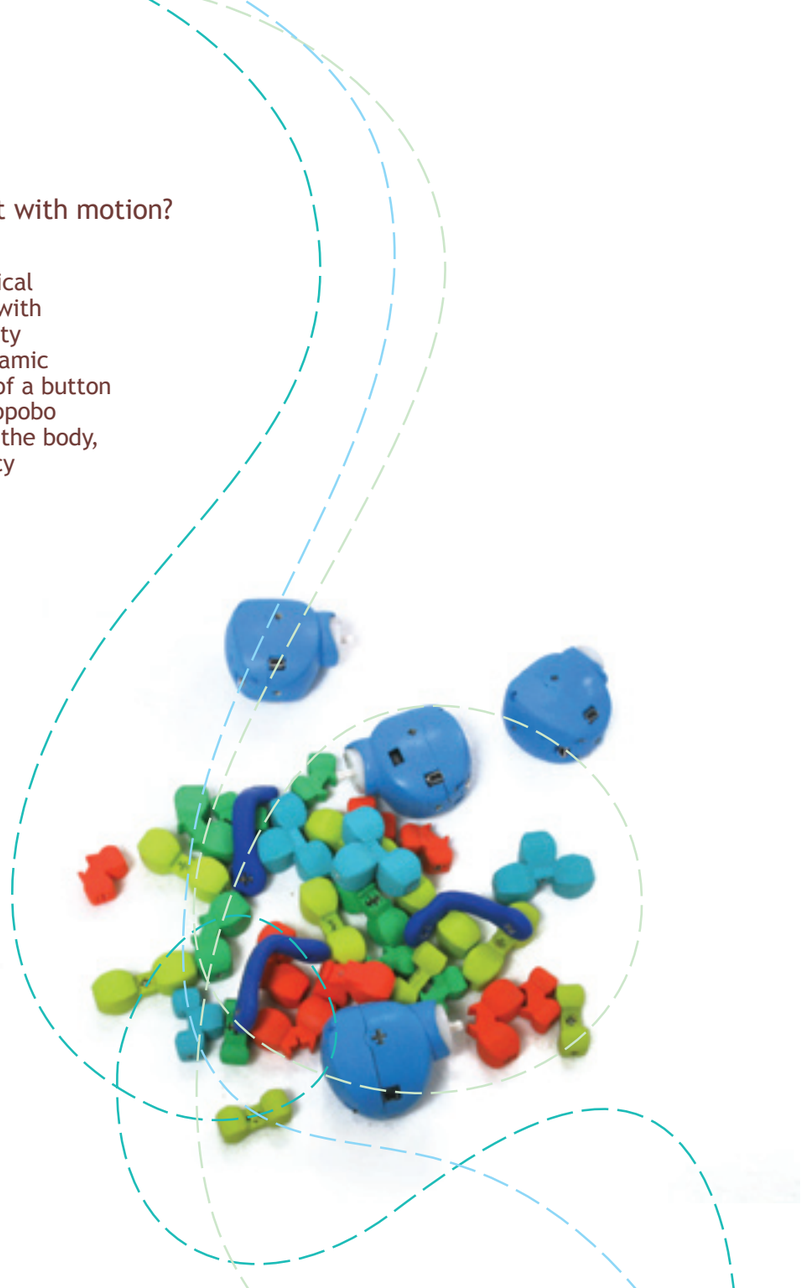
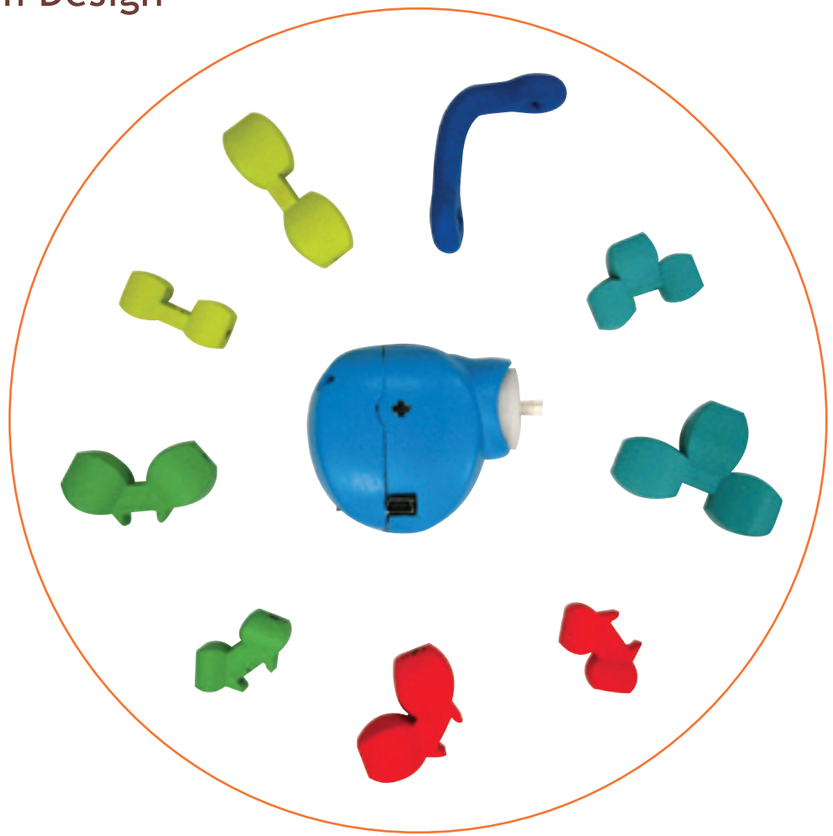
# The Concept

What is it like to sculpt with motion?

Topobo combines the physical qualities of a building toy with gestural recording capability producing a means for dynamic expression with the press of a button and the flick of a wrist.  Topobo works like an extension of the body, giving one's gestural fluency computation and memory.

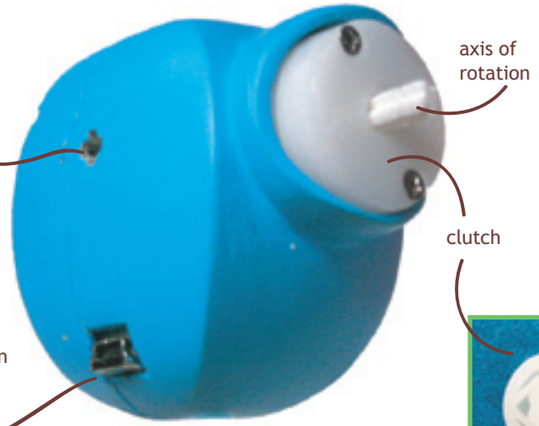


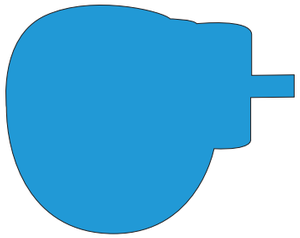
# System Design



The Topobo system is comprised of ten primitives that are connected with Lego Technics® connectors.  Nine of these primitives are called "Passive" because they form static connections. One motorized "Active" forms dynamic connections which allows the system to reproduce manipulations to a structure.

# The Active



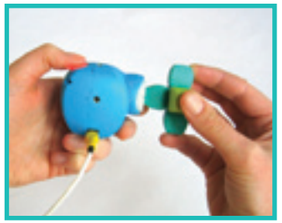



inside the clutch

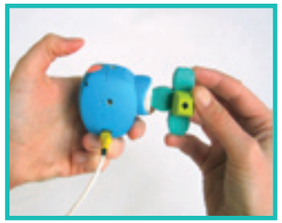
The Topobo Active uses a servo motor that has a built-in position sensor. A clutch protects the servo's gear train.

## programming an active

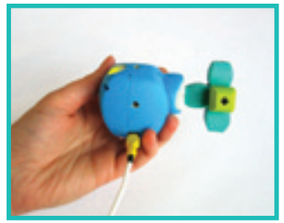
plug in the active



press the button to record

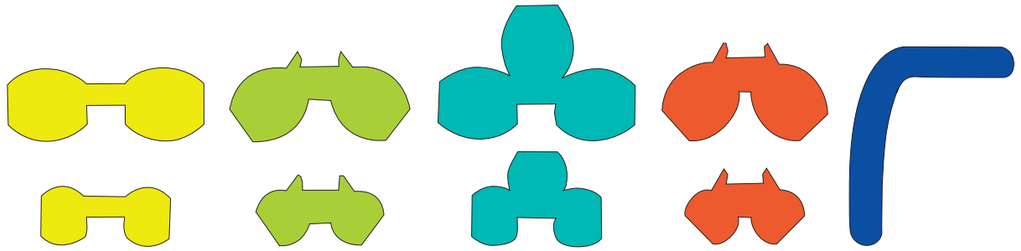


turn the axis with a motion

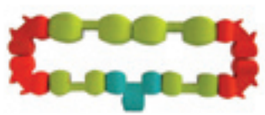


press the button for playback

# The Passives

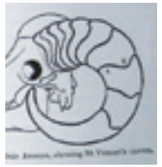


straight tetrahedral (108°) "T" 90° elbow

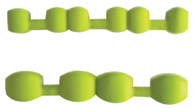


The Topobo passives can be connected end to end or with their central notches. The Topobo geometry allows for spatial loops

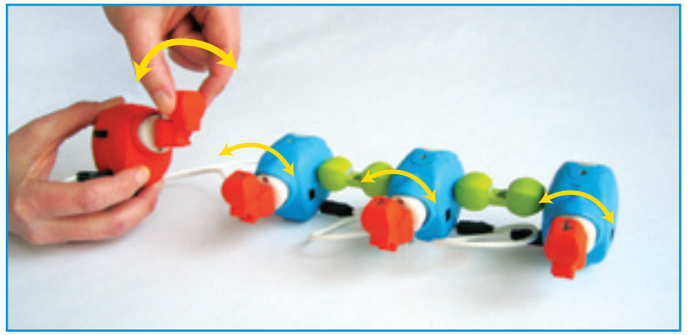
growth patterns & crystal structure inspired the geometry of topobo



scaling 3:2



# The Queen



Special orange actives called Queens can control many other Actives. In both record and playback, all motions made to a queen are mimicked by the other actives connected to the Queen.

## centralized control

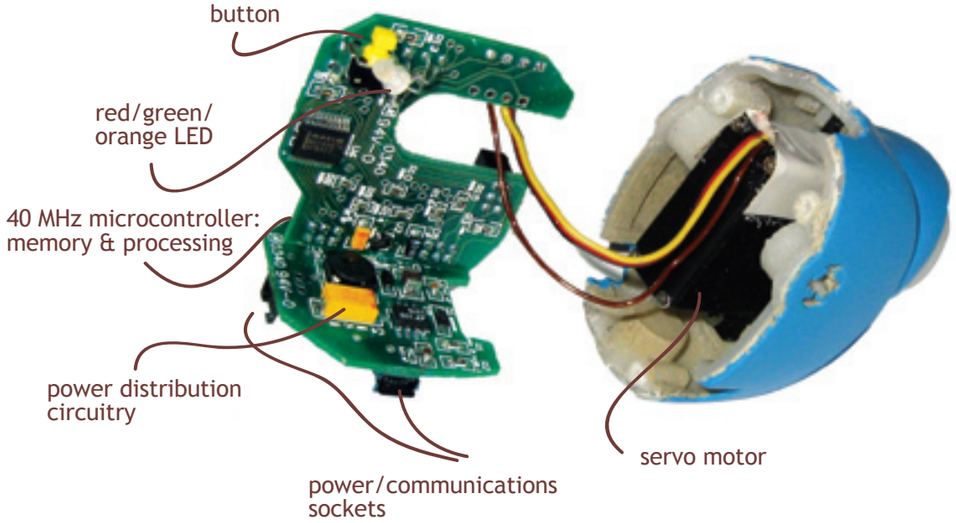
actives connected with tetrahedral passives create a spring-like helix when controlled by a queen.

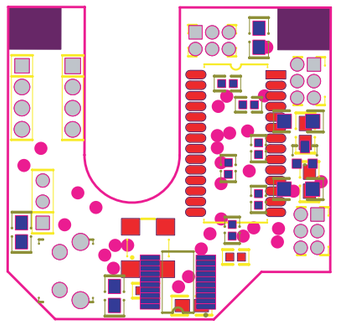
a linear sequence with a queen creates a circle

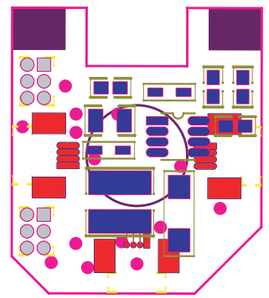
a special "decay Queen" tells each active to increas-ingly scale the Queen's motion. a linear sequence creates a spiral

a special "time delay Queen" tells each active to wait before mimicking the Queen. a linear sequence creates a wave.

# Topobo Technology



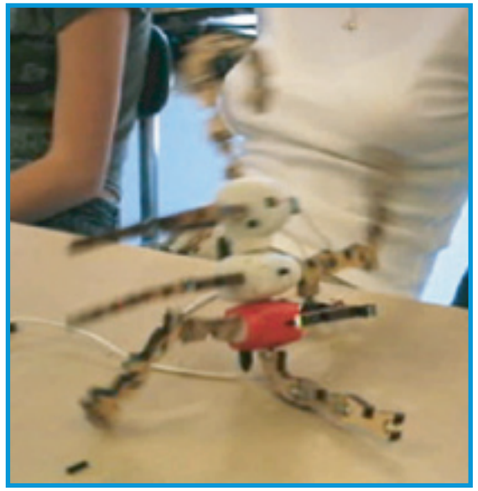





## electronics design

Topobo is based on modular robotics technology. Electronics inside every Active handle local memory and processing and power distribution. A custom peer to peer serial network allows Actives to communicate with each other through small, white cables.

# Topobo in action



We found that Topobo can help students ages 7-13 to learn about:

- Balance
- Center of Mass/Center of Gravity
- Coordination
- Relative motion
- Movement with Multiple Degrees of Freedom
- Relationships between Local and Global Interactions

## A tool for cooperative learning

When we took Topobo in to the classroom, kindergartners, second graders and eighth graders cooperated to make Topobo creations. Younger kids told stories with topobo and did open-ended explorations. Older kids focused on trying to make things walk.

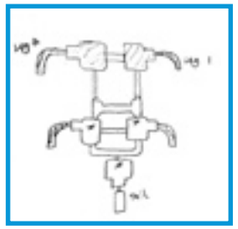
a 2nd grade collaboration

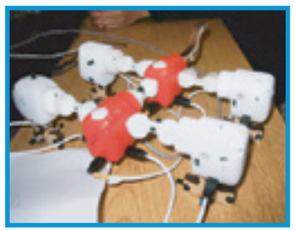
two 8th graders programming together

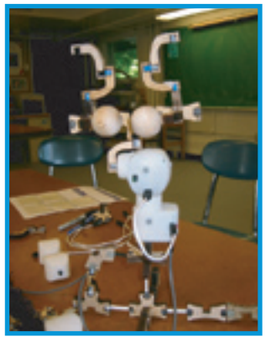
## Animals & Machines

Kindergartners, second graders and eighth graders all related to Topobo models with their "familiar knowledge" about animals and machines. Metaphoric allusions to machines (robotics) and especially to animals ("the elephant," "the ant," "the scorpion," "the horse," "the no-walking man") were descriptive and salient. Many 8th grade students changed their creations based on their ideas about how animals and people move.

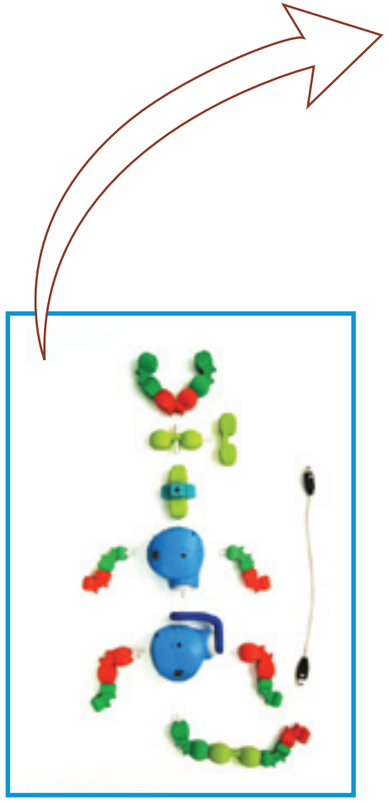
some 8th graders designed their creations on paper



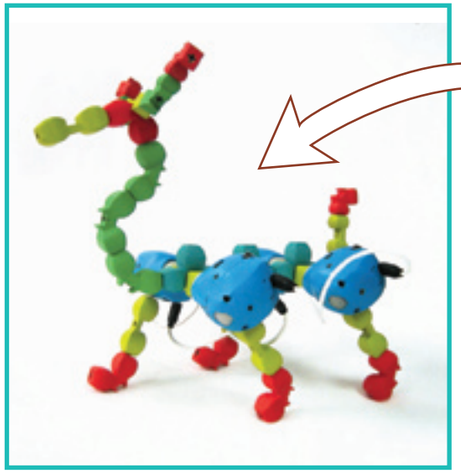


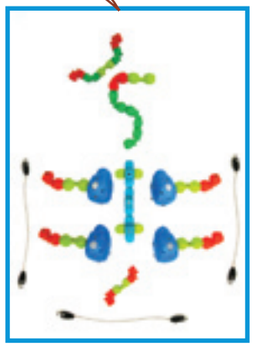


# Topobo Creations



a moose

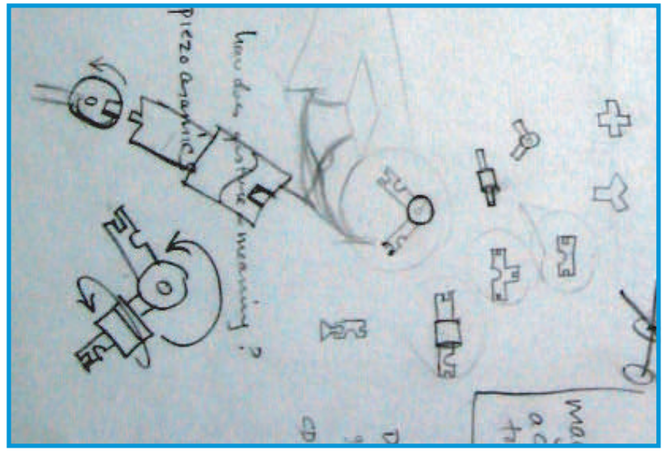




a griffin

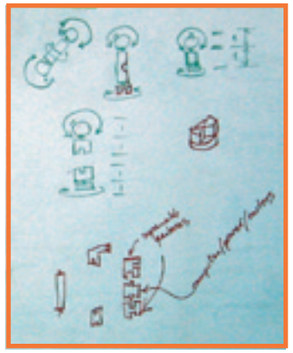
a one-active walker

# Concept & Early Prototypes

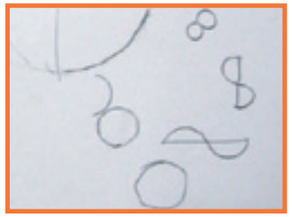



After choosing motors as our actuators, we did drawings to study spatial relationships possible with different arrangements of pivot joints. A branching system was an early choice for geometry.

studies of passive walking toys and electronic systems compare concepts of feedback and emergence in mechanical and electronic systems.

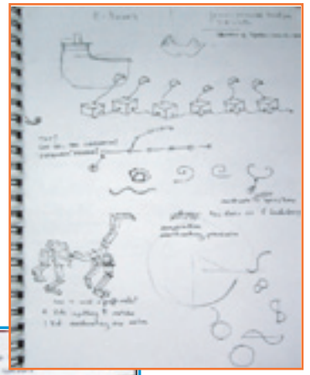


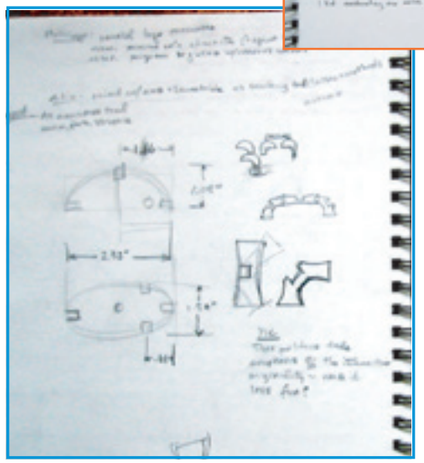
assembly drawings questioned the possibility of fitting motors and electronics in one designed system.



early studies of waves led to the time delay Queen.

We studied different housings with sketches, clay and cardboard models, and wooden exoskeletons for our electronics and motors.



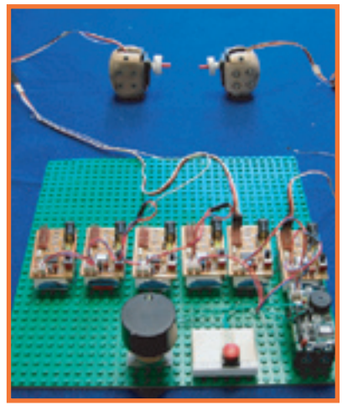


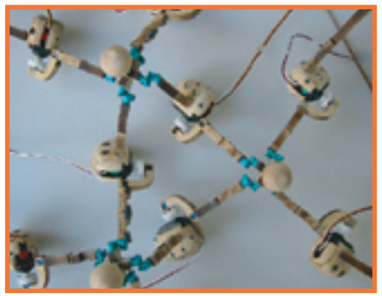
The passives, which are based on tetrahedral and cubic crystals allow 3D branching structures that could take advantage of rotating joints. They were sketched and prototyped on a lasercutter in a weekend.

The first prototype was made with wood and servo motors.

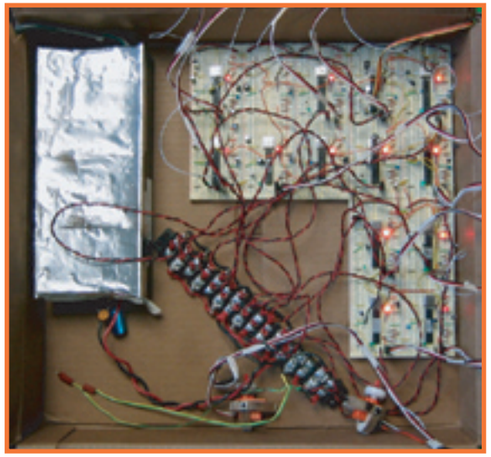
# Design Development

We initially built dozens of physical prototypes out of plastic and paper to study spatial geometries with rotary motion. This led to the development of the current system geometry and a proof of concept using Cricket microcontrollers and servo motors. The Cricket prototype was extremely fast to implement and allowed us to experiment with the capabilities of the system design.





Our first scalable prototype followed, made with wood, hobby servos and breadboarded electronics. Evaluations of this system with kindergartners and second graders helped guide the design of the current system.



In order to avoid the "spaghetti" of wires we had with our prototypes, we needed to design a power distribution scheme to power all of the parts in a creation through one daisy-chained set of cables

Electronics design began on paper and progressed through many series of iterations from "breadboarded" electronics to printed circuit boards.

After the wooden prototypes, we modelled a plastic housing and printed plastic parts on an FDM 3D printer.