MULTIMEDIA RESEARCH
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FORMATIVE EVALUATION OF *INVENTION WORKSHOP*

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INTRODUCTION

During half-hour sessions, four third grade girls and four third grade boys from a Long Island elementary school were observed individually while playing an early prototype of a computer game. Students played the game on a 15" Macintosh iBook with an optical mouse, accessing the game from the hard drive using Firefox 1.5.0.7.

All students had access to a home computer and most played computer games including Barbie, Hero Matrix on cartoonnetwork.com; Clubpenguin.com; Edheads.org. and even Cyberchase. None had played previously a game like *Invention Workshop.*

Students were introduced to the procedure as follows:

We're developing a computer game that lets you make or invent things to complete a task or challenge. The game is just at the beginning stages so what you see here is not fancy and not complete. But I want to get your feedback early in the design process, so we know what mistakes we've made and where to go from here. We want to make sure that the game is playable and fun. So imagine that you are an inventor. This is your workspace, and this is a table or floor. (Pointing to the grid area and base of grid area.) *These are the parts that you will use to make or invent things.* (Pointing to the left hand column of parts.)

The procedure involved assessment of student

- interpretation of the part visuals and renaming of parts once the game had been experienced;
- suggestions for additional parts;
- comprehension of the connection of parts;
- understanding of rotation feature;
- ability to respond to three different and successively more difficult challenges;
- ability to invent their own challenge for classmates;
- inventiveness in free play;
- interest in changing appearance of inventions; and
- suggestions for a name of the game.

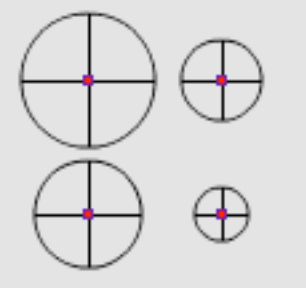
Students enjoyed playing the game and were interested in playing more, despite the limitations of the prototype at this time. They liked the challenges and making up their own challenge. They liked building with the parts in their own ways, sometimes in unexpected ways, and seeing what would happen when they clicked on <save>. They became more facile with the interface as they played. Problems observed and lessons learned are summarized below.

THE PARTS

Naming Parts. Users were asked to identify and name each part before playing the game, and then asked to click on each part and read the identification in the "type" box at the bottom of the screen. The "type" box at the bottom of the screen was not something that the users were likely to see and read on their own. Also, in a few cases, the 3rd graders had difficulty reading the font (e.g., platform) and difficulty reading the word (e.g., engine was read by one as "emergency").

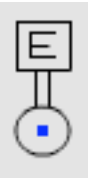
The game refers to this part as "platform." The table below shows what students named the part before learning its intended name (pre) and what they decided to rename the part after playing the game (post). Half of the students initially interpreted the parts as belonging to a creature – a robot, a character – as indicated by the interpretations of 'arm' and 'back,' etc. Even after using the platform in several challenges, the students were not wholly comfortable with the name, as indicated by the post-play name choices.

S	1	2	3	4	5	6	7	8
Pre	Table	Buttons	Arm	Back	Level	Box	Hand	Leg
Post	Log	Table	Platform	Road	Platform	Platform	Magnet	Floor



The game refers to these parts as "wheels." Two of the eight students identified the parts as "wheels" prior to playing with them, and six of the eight were willing to call them "wheels" after playing with them. See table below.

S	1	2	3	4	5	6	7	8
Pre	Round Table	Satellites	Gears	Tires	Wheels	Propellers	Body	Wheels
Post	Wheels	Wheels	Wheels	Tires	Wheels	Wheels	Circles	Wheels

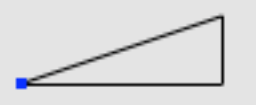


This part is an “engine.” Three of the eight students had some sort of idea prior to playing that the part would be a mechanism for making something ‘go.’ After playing, five of the eight were willing to accept the name “engine.”

S	1	2	3	4	5	6	7	8
Pre	Mailbox	Turns it on	Push it	Sign	Ball with picture	Sign	Head	Holds an engine
Post	Unicycle	Engine	Propeller	Sign	Engine	Engine	Engine	Engine on a stick

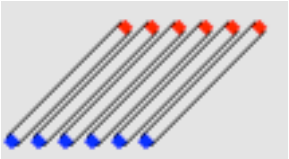
This is a “ball,” which only one student guessed prior to playing the game. After watching the ball bounce while playing the game, all agreed that “ball” is an acceptable name.

S	1	2	3	4	5	6	7	8
Pre	Cap	NA	Eye	Circle	Ball	Light	Eye	Button
Post	Ball	NA	Ball	Ball	Ball	Ball	Ball	Ball



This part was recognized as a “ramp” by half of the users before playing, and after playing, all users felt the term is appropriate.

S	1	2	3	4	5	6	7	8
Pre	Ramp	Something to build with	Leg	Triangle	Ramp	Ramp	Back	Ramp
Post	Ramp	Ramp	Ramp	Ramp	Ramp	Ramp	Ramp	Ramp



These parts are named “sticks.” Sticks was not a term used by students to describe these parts before playing, but three of eight students felt it was a good name after playing the game. Those who suggested the term “rods” felt that rods were sturdier than sticks. Student #3 pointed out, correctly, that the sticks act more like walls in the workshop.

S	1	2	3	4	5	6	7	8
Pre	Crayons	Pipes	Pipes	Bumps	Rods	Poles	NA	Logs with blue and red fire
Post	Crayons	Pipes	Walls	Sticks	Rods	Rods	Sticks	Sticks

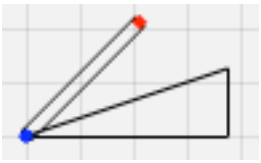
Adding parts. After meeting several challenges and inventing their own machines and challenges, students were asked what **additional parts** they would like. The list includes:

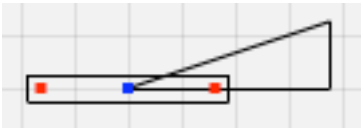
- squares (2 students); a block (1)
- box (2) (possibly so they didn't have to use sticks for the "catch the ball" challenge)
- cylinder (1), barrel (1)
- more wheels of the same size
- triangle
- circle
- a brake to stop the engine
- propeller
- flat wall
- windows
- doors that can open/close so a ball could roll through
- catapult stuff
- spoon
- spring
- top of a car
- garage

USABILITY

Connecting parts. At the beginning of play, students were told that when they drag parts into the workspace, some parts would connect and some parts would not. They were asked to use their mouse to explore and find out how parts connect.

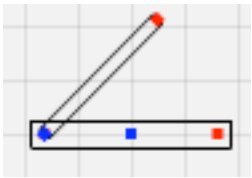
Four of the eight students first dragged the ramp into the workspace and tried to connect a stick or the platform to it, with the idea that a blue dot should connect to a blue dot and that parts 'connect at the ends.'
See drawings for examples. →





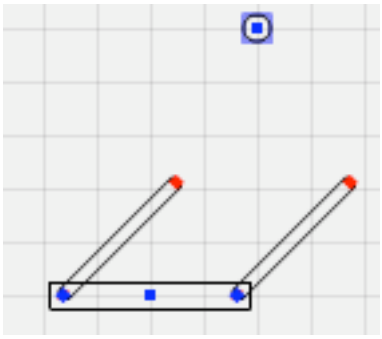
Two students started with a wheel and tried to connect a stick to it, focusing on matching red dots in order to make connections.
← See drawing for example.

Two students started with the platform and sticks and noted the appearance of the red line connector and the snapping-together action. See drawing →
Clicking on <save> showed six of the students that their parts were not connected, even though they looked connected via the dots. Through further exploration with parts in the workspace, all students eventually figured out that the red line indicated parts that would connect.



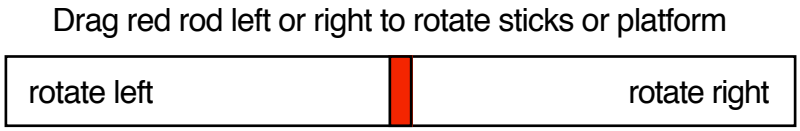
While working to meet the various challenges, however, an issue arose related to the sequence of connections. Many users tried to attach a wheel to an engine rather than attach an engine to a wheel, which is currently the only acceptable sequence in the program. Users also tried to attach the platform to a stick rather than a stick to the platform. These sequence requirements frustrated users. They would put their invention 'together,' click on <save> and see it fall apart, when logically it should stay connected. They would then try an entirely different idea until I intervened to explain the sequence requirements.

Rotating parts. Only one of the eight students noticed spontaneously the rotation feature when it became available for the sticks or platform. During the challenge of making a box or bucket to catch a ball, it became apparent that users wanted to adjust the angle of their sticks. See example →



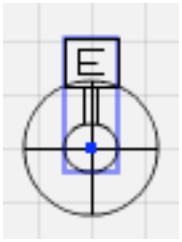
At that time, I asked if they could find something on the screen that would help them change the angle of the sticks, and a few noted the 'rotation' feature.

Students understand the meaning of 'rotation' as 'to go around.' They used the feature by clicking and moving their mouse only by going around within the narrow confine of the circle. This greatly limited the rotation movement and frustrated them. All users needed to be told to move their mouse in a line, left or right, to rotate the stick parts. Discussion with the students led to the suggestion of an alternative design for the rotation feature, like the following:

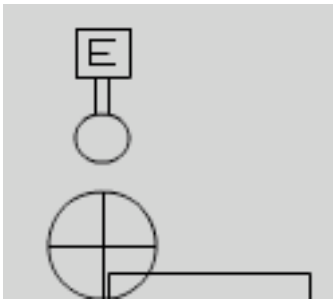


CHALLENGES

Challenge 1. Attach an engine to a wheel.
While attaching an engine to a wheel, many ran into the sequencing problem and saw their wheel and engine fall apart after <saving>. Users eventually learned (sometimes with my intervention) that the red line meant a connection is made. Most users were able to predict that the wheel would move when they clicked <save>, and they were pleased to see the rolling action.



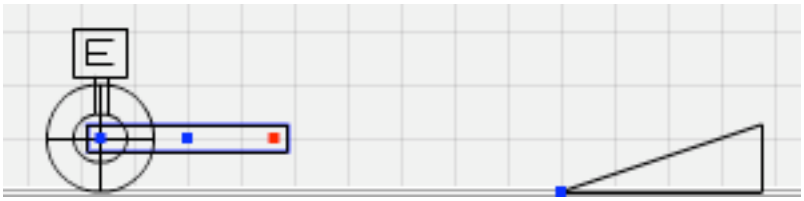
Challenge 2. Make a cart to roll up a ramp.
For this challenge, I placed a ramp in the workspace and asked the users to make a cart that would roll up the ramp. It typically took users more than one try to complete this challenge.

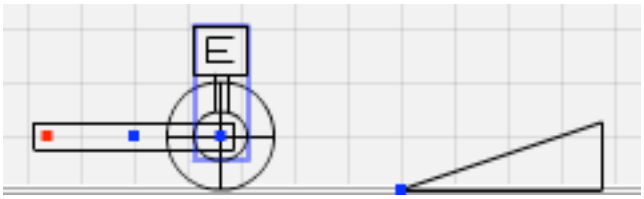


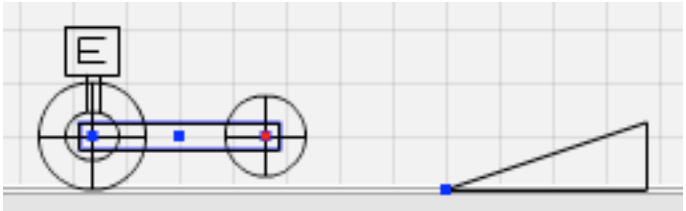
The main difficulty was a tendency to overlay a wheel on the engine or overlay the platform on a wheel instead of actually connecting in the opposite sequence: engine to wheel and wheel to platform. Their 'cart' would fall apart when <saved.>
← See example.

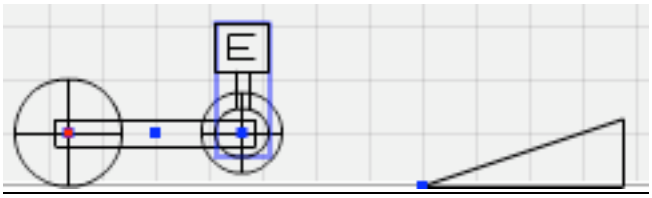
The second most common mistake was making a cart but forgetting to attach the engine.

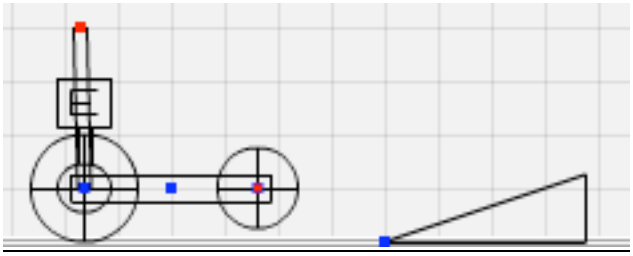
Here are some successful designs for this challenge. The children came up with many variations, using engines to push or pull, adding one or two wheels. No one tried to rotate the platform so that the wheels were both touching the ground; this discrepancy did not bother them.





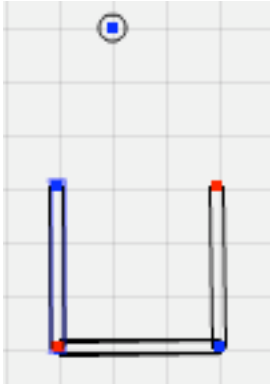


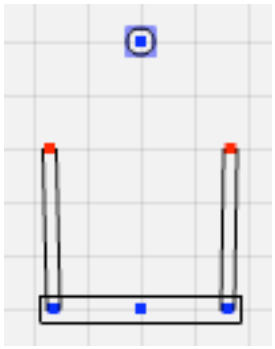


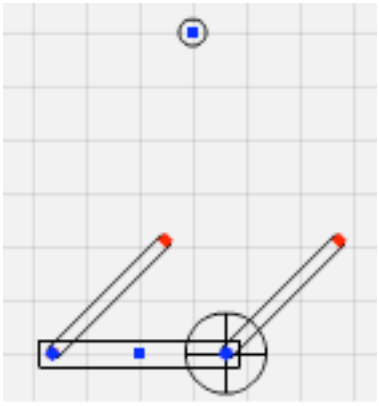


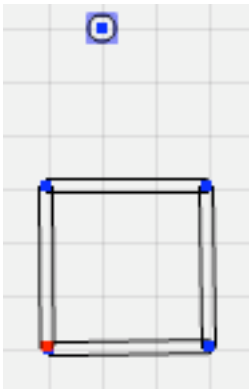
Challenge 3. Make a box or bucket to catch a ball.
I placed a ball in the workspace and asked what would happen to the ball when you click on save. Most students guessed correctly that it would bounce; two suggested it would roll. The challenge I then gave the students was to design a box, bucket or container to catch the ball. Two students had a difficult time with this task; asking them to draw a bucket with a pencil helped them focus on the design that they needed and led to successful task completion. Students took up to four tries before they completed this challenge successfully; one student was not successful.

Here are some successful and not quite successful designs:

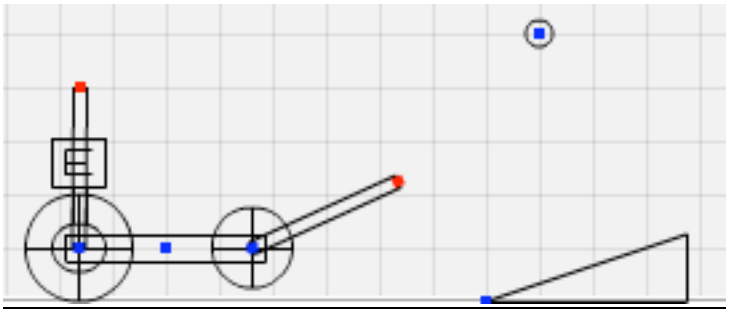






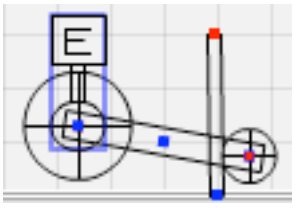


One student who solved this challenge quickly was given an extra task of catching the ball after it bounces off a ramp. He met this challenge with the design below. However, a problem occurred in the action: after the ball bounced off the ramp, the ball passed <u>through</u> the vertical stick rather than being stopped by the stick, as the user intended.

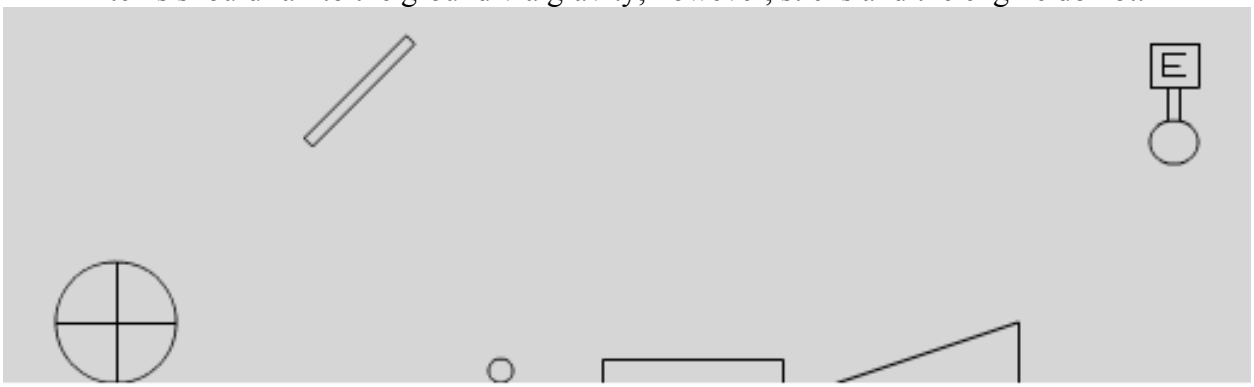


A few other problems with the physics in the program were observed in the motions of objects after 'saving:'

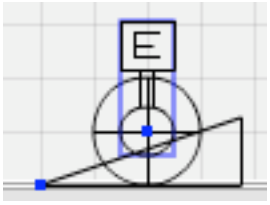
- A stick will sometimes (but not always) stop a ball's movement but a cart with an engine moves 'through' a vertical stick. →



- All items should fall to the ground via gravity; however, sticks and the engine do not.



- One wheel with an engine, a unicycle, will not run up the ramp; it will run through the ramp instead.

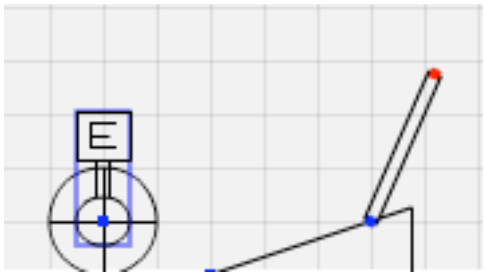


Make your own challenge

Users were asked to design a challenge for a friend. Here are the challenges that the kids came up with – some possible with the program as it stands, most not. Some students needed additional connection points and additional parts to complete the challenges they set for their friends.

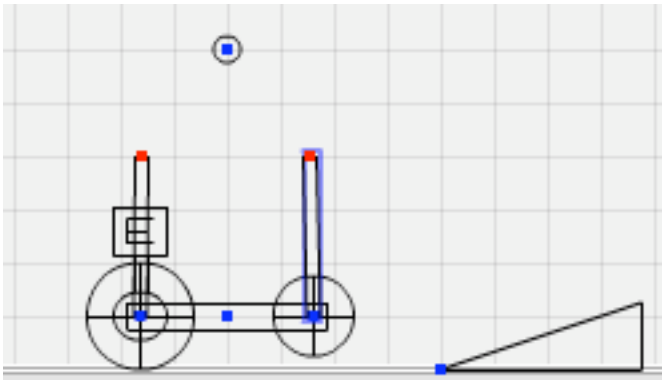
S1: Design a wiggling worm. (This student had the most difficulty with the interface and may have been at a loss for ideas, drawing upon a board game called 'glowing worm' that sat in a bookshelf near us.)

S2: See if a stick stops a wheel rolling up a ramp. (This user wanted attachment points on the ramp.)

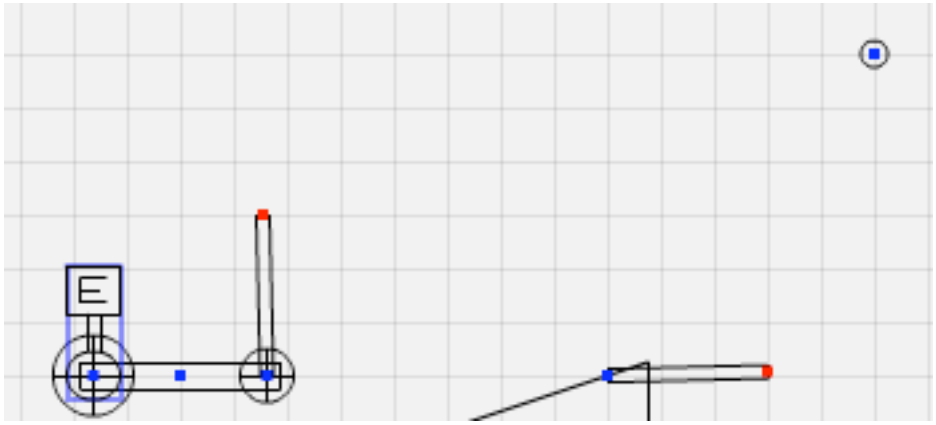


S3: Make an airplane that flies straight. (User suggested needing a propeller, a block (for the fuselage), windows, and an engine.)

S4: Catch a ball and then go up a ramp. (User took three tries to solve his own challenge idea.)



S5: Catch a ball as cart runs off diving board. (This user also wanted an attachment point on the ramp.)



S6: Make a cart that flies or floats or hovers off the ground. (User suggested needing helicopter blades, wings, plane engine, and a boiler for hot air!)

S7: Make a car that moves someplace.

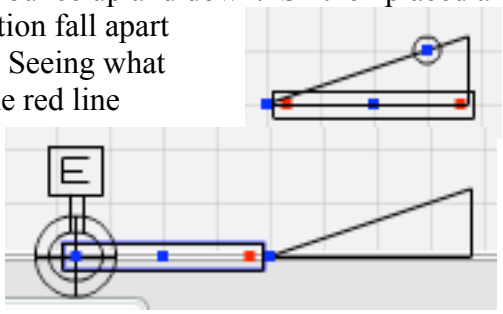
S8: Use sticks to build a wall to stop a bouncing ball from going out of a spot.

FREE PLAY

Users were asked to invent a machine that they wanted to make. The students were very persistent in this activity, trying numerous ideas.

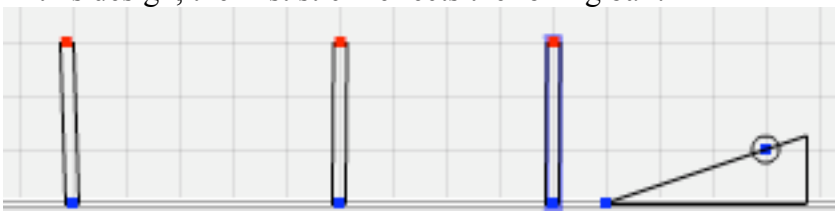
Five users played with a bouncing ball.

S1 first placed a ball above the platform and watched it bounce up and down. S1 then placed a ball on a ramp on the platform and watched the construction fall apart and the ball roll around because nothing was connected. Seeing what connects was difficult for S1. After being shown how the red line connection worked, S1 then connected an engine to a wheel to the platform and laughed at the motion as it moved up and over a ramp.

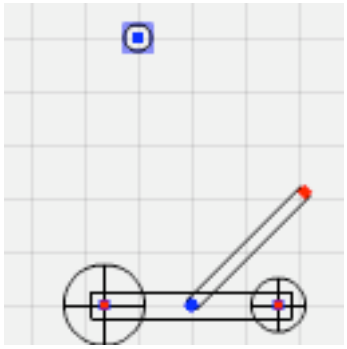


S2 placed a ball in the air with a vertical stick near it, expecting that the ball would bounce and maybe hit the stick. S2 then tried unsuccessfully to connect the ball to a wheel. Finally, S2 made a unicyle (one wheel and engine) to roll up and over a ramp, however, the program's physics is not working properly for this design. The unicycle rolls through the ramp and not over.

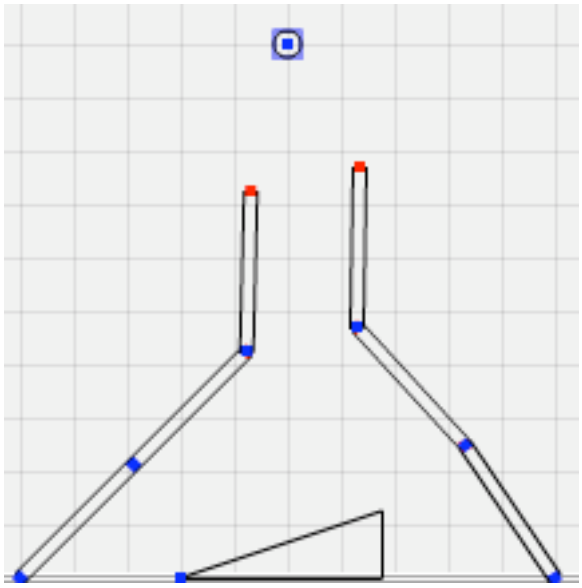
S3 set up sticks as dominoes, expecting that a ball rolling down a ramp would knock them over. In this design, the first stick reflects the rolling ball.



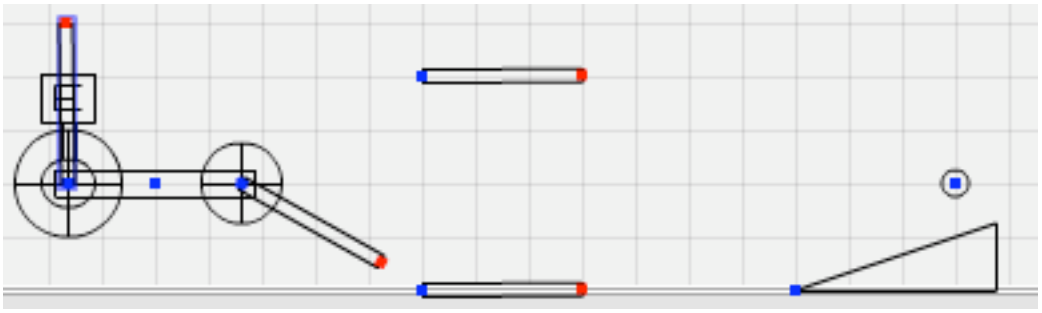
S4 played with catching a ball, starting with a platform and wheels, then adding a stick. In this design, the stick sometimes reflected the ball off but sometimes the ball went through the stick, as it bounced around the screen.



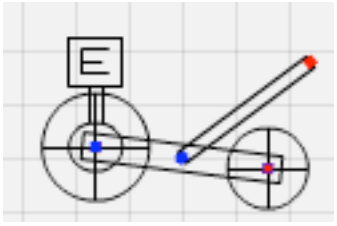
S5 was much more sophisticated in ball control designs. Beginning with a pinball contraption that S5 enjoyed very much. Again, the ball sometimes stayed within the enclosed area but on occasion bounced through the sticks and outside, depending upon the placement of the ramp.

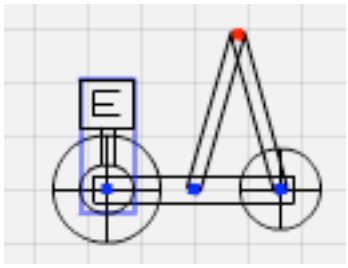


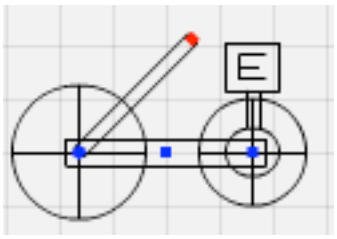
In the second ball control design (see below), S5 expected the ball to roll down the ramp, through the stick tunnel (sticks do not fall with gravity) and up the stick attached to the cart, to be stopped by the vertical stick by the engine. Expectations were met except at the end when the ball runs through the final stick instead of reflecting off.



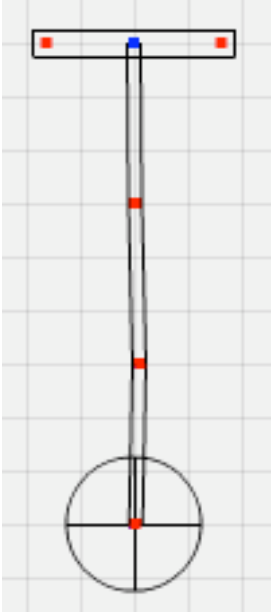
Making cars with two wheels, engine, and various stick arrangements was also popular. For example:







S3 tried to design a helicopter but did not recognize that the sticks won't attach to the wheel and the platform will fall. When this design is <saved>, the sticks collapse down into nothing and the platform falls to the ground, under the wheel. Other users also try to attach sticks to the wheels without success.



INVENTION APPEARANCE

Users suggested a variety of ideas to modify the appearance of the inventions:

- Paint or color (5 users). Users suggested cans of paint or a palette of different colors.
- Sound effects (3 users). Users suggested being able to attach engine noise, springs, thumps as things come off ramp, ping for a stick, boing for a ball.
- Different looks (2 users) such as frog skin, spikes, stealth look.
- Backgrounds (2 users) like an open road scene.
- Action lines like wind. User mentions funbrain.com.

GAME NAME

Users provided the following for a game name:
Putting Together Shapes
Inventions
My Workshop (or User's Name Workshop)
Great Inventions
Building Blocks of the World
Making Inventions
Don't know
Designers' World