



LEARNING MATERIALS WORKSHOP

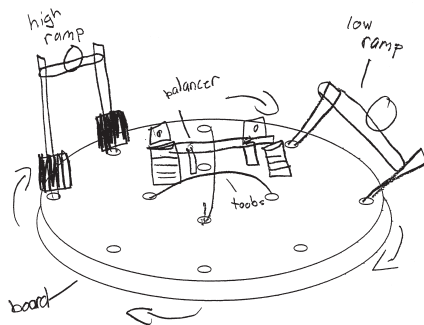
Scientists and Inventors

A guide to accompany *Kit 4: Scientists and Inventors, Pre-K – Fourth Grade*

By Pat Fitzsimmons

with Karen Hewitt

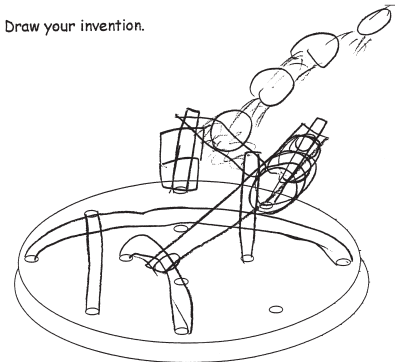
Draw your invention.



Explain your idea.

There are two ramps. One is high and one is low. The ball stays on the board when it's on the low ramp. But on the high ramp it rolls off the board. The balancer holds the ball and sees if it can balance.

Draw your invention.



Explain your idea.

My contraption flings the ball. The ball is on the top of the rubber band. When it springs the ball flings off the rubber band.

Scientists and Inventors

A guide to accompany *Kit 4: Scientists and Inventors*

By Pat Fitzsimmons

With Karen Hewitt

Learning Materials Workshop
274 North Winooski Avenue
Burlington, Vermont 05401
www.learningmaterialswork.com

August 2002

Acknowledgments

Special thanks to:

The “Cape Cod Kids,” Erin Fitzsimmons, Jack Fitzsimmons, Cara Fitzsimmons, Declan Quinlan, and Michaela Quinlan

The First Grade Class, Barre Town Middle and Elementary School, and their teachers, Heather Battistoni and Phyllis Wiggins

Jeanne Goldhaber, for her critical eye and thoughtful suggestions

Dave White, for reviewing the science concepts in this guide

Gregg Humphrey and Maura Carlson, for introducing me to the Cycle of Inquiry

*This work is dedicated to my mom,
Karen Flaberty,
who made possibilities a reality.*

Pat Fitzsimmons is a consultant for VISMT (Vermont Institute for Science, Math, and Technology), a Certified Trainer – STC (Science, Technology, and Children Units, First – Sixth Grade), and a math/science enrichment teacher. She is also a recipient of the Presidential Award for Excellence in Science Teaching.

Contents

Letter to Teachers iv

National Science Educations Standards v

Preface vi

Introduction 1

Inquiry 1

The Cycle of Design Technology 2

Quality Science Teaching 7

Invention in the Classroom 8

The Invention Center 8

Construction Basics for Teachers 8

Design Plans 9

Invention Scenarios 10

Assessment 14

Bibliography 17

Appendix 18

Snapshots of Children's Work: Conversations 19

Snapshots of Children's Work: Inventions 28

Recording Sheets 35

February 2002

Dear Teachers,

I have taught kindergarten for 14 years and previously worked in preschools and daycare. Recently, I became the science enrichment teacher for our large Pre-K– 8 school. What have I learned along the way?

I know that science allows me to actively investigate how people learn. As children explore materials, I engage in my own research about how to best support developing skills, concepts, and dispositions. It is a fascinating study that invigorates and informs my teaching daily. New questions continually arise when I watch and listen to children.

Initially, I used teacher guides within this process as a source of possible science investigations. Guides provided ideas about the things that I could do with children. Guides were perceived as resources to meet immediate concerns about what would happen in my classroom rather than as tools for building upon my current pedagogical knowledge. I never read the information for teachers. Well . . . at least not until I went to a workshop about Science and Technology for Children. I learned there that teacher guides could contain truly useful information. My teaching could benefit from reading the thoughts contained in those initial pages. My hope is that you will view this guide, *Scientists and Inventors*, in the same way. The heart of your work with students, the Cycle of Design Technology, is described within this guide. The inventions students create will be directly influenced by the quality of this cycle.

While reviewing *Scientists and Inventors*, you will notice that it is not broken into grade-level sections. My work with children from preschool through eighth grade has confirmed the notion that the process is similar regardless of the age of the child. Children at different levels may spend more time at a certain stage within the cycle of inquiry, or the content expectations of the teacher may vary, but the process remains fundamentally the same. Additionally, skillful observations and meaningful conversations are vital teaching/learning/assessment strategies throughout the years.

So . . . if you have time to read only part of this book, please read the beginning sections. Then, follow your students' lead. They will teach you more than I could possibly include within these pages. When you provide engaging materials, blocks of time for exploration, responsive teacher support, and opportunities for peer interaction, wonderful ideas will emerge in your classroom.

The invention materials within this kit invite child-initiated investigations. Children are intrigued by the movement possibilities the turntable suggests. The plastic tubing, elastic bands, dowels, and slats are novel materials that beg to be explored.

Last June, I went to a preschool to retrieve the Invention Kit. The teacher looked disappointed when she saw me and woefully explained, "We hoped you'd forgotten that you left the invention materials here!"

Explore. Imagine possibilities. Invent.

Warm regards,

Pat Fitzsimmons
phitzyp@aol.com

National Science Education Standards

The *National Science Education Standards* provide clear expectations regarding what all teachers and children should know, understand, and be able to do in regard to science. Standards for children and teachers that are related to the Invention Kit are listed below. For additional background information, please refer to the *National Science Education Standards*.

Content Standards for Students

Unifying Concepts and Processes

Standard: As a result of activities in grades K-12, all students should develop understandings and abilities aligned with the following concepts and processes:

- Systems, order, and organization
- Evidence, models, and explanation
- Constancy, change, and measurement

Science as Inquiry

Content Standard A: As a result of activities in grades K-4, all students should develop:

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Physical Science

Content Standard B: As a result of activities in grades K-4, all students should develop an understanding of:

- Properties of objects and materials
- Position and motion of objects

Science and Technology

Content E: As a result of activities in grades K-4, all students should develop:

- Abilities of technological design
- Understanding about science and technology

Science Teaching Standards

Teachers of science plan an inquiry-based science program for their students.

Teachers of science guide and facilitate learning.

Teachers of science engage in ongoing assessment of their teaching and of the students' learning.

Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science.

Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning.

Teachers of science actively participate in the ongoing planning and development of the school science program.

Preface

Children encounter many scientific concepts while building with blocks: properties of objects, motion, energy, cause and effect, force, systems, and patterns and relationships. They also engage in the scientific process: questioning, theorizing, constructing models, testing, predicting, modifying, measuring, classifying, and describing.

This Scientists and Inventors Kit includes blocks and construction parts to stimulate scientific thinking and design technology with a focus on simple machines and motion investigations for children in grades Pre-K – 3.

The Kit includes the following parts:

| | |
|--------------|------------------------------|
| 8 bobbins | 28 dowels |
| 12 cubes | 2 rectangular bases |
| 6 tubes | 1 round, revolving turntable |
| 12 beams | 8 rubber bands |
| 6 connectors | |

Introduction

Young children are accomplished scientists. Throughout their early years, exploration and experimentation are the predominant strategies they use to build an understanding of their bodies, other people, and the world around them. An infant persistently attempts to guide a finger into his mouth. Repeated trials improve results. A toddler playfully drops a favorite toy. Will a trusted adult return the toy? A preschooler squeals with delight as she squeezes a bottle of water to create a fountain. A harder squeeze creates an even more dramatic result! Children will poke, probe, and problem-solve enthusiastically. They think and ask about important things—where does the sun go at night, how are skyscrapers built, or why does water cling to windowpanes? Some have a “full-body” approach to science exploration that can be messy and noisy. Others explore quietly.

Children are also keen observers and creative communicators. They view the world from a unique perspective in which the impossible is probable—and laws of science are yet to be discovered. This perspective influences how they see the world. You might know a child who firmly believes that monsters can, will, and do sneak into homes at night and hide under beds regardless of countless adult attempts to influence their thinking otherwise. We are not always immediately aware of children’s special ways of viewing the world. Often, only through careful observation, conversation, and reflection do we expose the richness of children’s thinking.

Inventions are defined broadly within this document as systems of interrelated parts designed to meet specific needs or desired outcomes. The guide provides a framework for appreciating and supporting the tendency of children to wonder, observe, experiment, and invent. It illustrates the role of the teacher as an architect of the inquiry process and discusses key components of the classroom.

Inquiry

The Standards rest on the premise that science is an active process. Learning science is something that students do, not something that is done to them. “Hands-on” activities, while essential, are not enough. Students must have “minds-on” experiences as well. (National Science Education Standards, 1996, p. 2)

The word *inquiry* conjures up many different images. Some people envision a chaotic environment where children are messing about aimlessly with many different materials. On the opposite end of the spectrum, some see a picture of a teacher manipulating materials with children looking on from their desks. Still others imagine individuals thoughtfully exploring, questioning, investigating, and researching their ideas. Although there is certainly a valued continuum of inquiry experiences that moves from teacher-guided to child-initiated investigation, the view of the child as the instigator of inventing is the final portrait this guide will attempt to create.

Inquiry for adults is a process for teaching as well as for learning. Inquiry as a teaching process involves engaging children with thought-provoking materials; observing interactions between children, adults, and materials; facilitating exploration; discussing emerging ideas; and thoughtfully moving children through the stages of inquiry. Inquiry as a learning process for teachers involves raising questions about the teaching process, testing theories, observing, collecting evidence of student thinking, researching other perspectives, and revising ideas or practices. This “cycle of inquiry” fuels good teaching because it is an interactive process that builds upon itself.

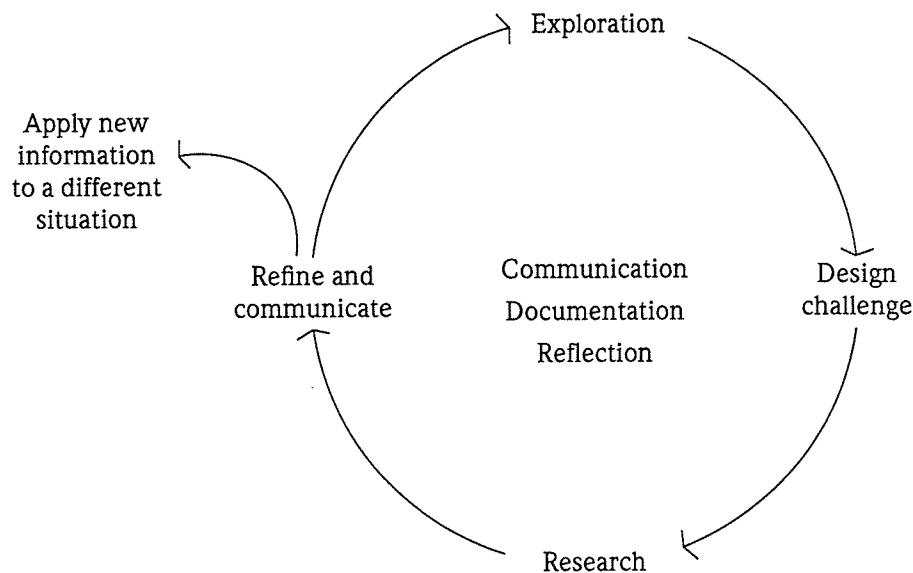
Student inquiry’s premise is that children are motivated learners who actively seek out and organize information. A process that respects and supports children’s curiosity and ability to construct understanding through multisensory investigations is reflected in the cycle of inquiry. Similar to the teacher’s cycle of inquiry previously described, the children’s cycle includes being engaged in a process of exploring materials,

developing investigations, proposing explanations, applying knowledge and skills, and, finally, developing new questions.

This is a very brief glimpse of inquiry. The National Science Standards along with *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning* provide an in-depth study of classroom inquiry (please refer to the bibliography). These books are strongly recommended for individuals wishing to explore inquiry further.

The cycle of inquiry envisioned within the National Science Standards has been tailored for the Scientists and Inventors Kit to reflect the design technology process, a strategy for planning and creating inventions based on children's needs, interests, and experiences.

The Cycle of Design Technology



The stages within the design technology cycle follow one another in a logical progression. Teachers should, however, feel comfortable moving back and forth within this cycle, revisiting previous stages in an effort to foster deeper conceptual understanding, further develop science process skills, or enhance attitudes that support scientific inquiry. This cycle is intended to actively engage children, as well as teachers, in a “hands-on” and “minds-on” process of inquiry.

Perhaps the best way to become familiar with the nature of engineering and design is to do some. By participating in such activities, students should learn how to analyze situations and gather relevant information, define problems, generate and evaluate creative ideas, develop their ideas into tangible solutions, and assess and improve their solutions. To become good problem solvers, students need to develop drawing and modeling skills, along with the ability to record their analyses, suggestions, and results in clear language. (Benchmarks, 1993, p. 48)

Exploration

Children need time to experiment with possibilities before they are ready to use materials in an intentional way. During this initial stage, materials are purposefully set out by the teacher to provoke exploration. Children examine the physical characteristics of materials as well as the various ways pieces fit together. Since each child needs to construct an understanding of the materials' capabilities, play is often parallel at this stage. Exploration provides the foundation for more complex work that will follow.

Teacher's Role: The teacher's role evolves throughout exploration. Initially, she sets the stage for learning by arranging materials in a way that invites children to explore. The teacher observes how children use the materials and watches for common threads emerging among children's work. She listens carefully and records ideas, interactions, and dialogue. Recording might involve writing down observations as well as capturing student work through photographs. In an attempt to gain a better understanding of children's thinking, the teacher may begin to work as a "co-investigator," manipulating and exploring materials. She recognizes that students bring a wealth of prior knowledge to this experience that influences their perceptions. Conversations, rather than one-way questions, serve to inform the teacher about children's goals and current thinking.

Abby holds up connected pieces of clear tubing. "Look! It's a jump rope! It couldn't be a hula hoop because it's too floppy!" she enthusiastically explains to her nearby friend. Anna's focus, however, is on the turntable. Anna experiments with the turntable. She applies various amounts of force to the turntable—a gentle push and then progressively stronger pushes. She carefully observes the effect of her pushes on the movement of the turntable.

Anna's turntable experiments attract Kiley to the Invention Center. "Wow. . . That is really fast! Let's make it go really, really fast," suggests Kiley. "You go two times and then I go two times," she continues. Kiley sets the rules for the "game." The girls take turns spinning the turntable and are delighted by its movement.

Anna and Kiley decide to explore the materials further. "Let's put the really big ones (tall dowels) on," Anna proposes. Abby joins her friends. The three girls fill the turntable's outer holes with tall dowels and then, once again, take turns spinning it.

They decide to make the structure more complex. "Let's put all these ones (cubes and bobbins) on and see how it turns now," directs Anna. They work together sliding cubes and bobbins onto the dowels. Abby predicts, "We'll have to push even harder now." The girls add another level of cubes and bobbins. They explore the relationship between the weight of their turntable and the effects of varying amounts of force.

Design Challenge

After children have had sufficient time to explore the various possibilities with materials, they begin to create representational structures. Materials are intentionally used to meet self-selected design challenges that reflect the child's experiences, interests, or needs. For example, constructing a merry-go-round, a maple syrup machine, or another mechanism becomes the focal point of children's work. Play is more collaborative at this point since a common goal provides a context for children's mutual work. Children can be encouraged to record their work through drawings or other media.

Teacher's Role: The teacher facilitates the construction process by organizing materials and helping children to obtain any additional resources. She encourages children to create a plan that will guide their collaborative efforts. Acting as a co-investigator, the teacher may model alternative uses of materials, but children determine final design decisions. Time for group discussions is arranged within the schedule. A format that allows children to share ideas with peers provides motivation for drawing plans or diagrams to explain developing inventions.

An adult can pose a design challenge. Thoughtfully asking, “Can you find a way to. . .?” or “What will happen if. . .?” provides a challenge that prompts children to think about using materials in a different way. This challenge needs to be complex enough to engage children at various levels. Design challenges should be based on observations of children’s work. These challenges are an opportunity for children to apply or extend their current thinking.

Photographs can be used to enable children to reflect on changes over time and explain the reasons for their design decisions. Displaying these photographs along with students’ thoughts and/or a teacher interpretation demonstrates your respect for and appreciation of children’s efforts. Parents, other teachers, and administrators also are given a clear picture of what is valued and supported within your classroom.

A new question develops. “What if we got some people and they could sit on it and hold on?” Anna wonders out loud. She suggests, “Let’s pretend these ping-pong balls are the people.” Kiley and Abby happily agree to Anna’s idea. They carefully balance two ping-pong balls on empty holes toward the center of the turntable. Anna energetically spins the turntable and everyone laughs as the “people” slide off.

The excitement generated from these unexpected results doesn’t overshadow Anna’s original question. She still wants to give the “people” a ride on the turntable. “How can we get them to stay on?” Anna asks her friends. “Let’s put one here and another one here and put this (long dowel) across them,” Abby explains. Kiley offers an alternative. “I have a better idea. It could be like a merry-go-round. We could put these (long dowels) on the outside to keep them safe.” Anna agrees, “Yeah, let’s put them on the outside.” All three children construct a short outside wall with the dowels. Anna places the “people” on their “seats” (holes on the inside of the turntable) and slowly spins the “merry-go-round.” The three girls watch as the “people” remain propped on their “seats.” Anna spins the turntable harder and the “people” slide to the outside edge. The wall catches the “people” and prevents them from falling off. “We did it!” Anna announces.

Since center time is coming to an end, the girls are asked to draw and write about their invention. The merry-go-round is then safely placed on a shelf so that this work can be continued another time.

Research

Children are now ready to broaden their perspective by considering how other people have solved similar design challenges. At this point, children may refer to books, people, or actual objects for additional information. The goal is to have children seek out resources that instigate further thinking about their design or construction choices. In books, young children may be engaged in research through studying pictures and diagrams while older children can use their reading skills. Children should record design ideas and note how possible changes could influence their invention.

Teacher’s Role: The teacher elicits ideas from children about possible resources and then may provide additional suggestions. She helps children obtain identified resources and keep track of new ideas. Details that were not considered originally are discussed as teachers and children review materials together. Facilitating the processes of observing, recording, conversing, and documenting continues to be the teacher’s focus.

Anna, Kiley, and Abby bring their merry-go-round to the morning meeting the following day and share their discoveries with the class. They demonstrate how the “people” are protected by the wall they have constructed. Interest is renewed and the girls return to the Invention Center.

Invention books have been added to the center. The books capture the girls’ attention and they begin examining the fascinating pictures. A teacher joins the group and reads captions that the girls select. Center time slips away too quickly, but the girls have developed some new thoughts about inventions.

A picture of a trampoline was particularly interesting. "I went on a trampoline in Cape Cod," Abby remembers. "It was really fun!" Their teacher suggests that the girls mark the page with a sticky note so they can find it easily another time.

Refine and Communicate

At this point, modifications based on new information or ideas are applied. Children observe the effects of changes, make decisions based on desired goals, and complete final adjustments. Children record design modifications and assess how refinements influenced their invention. Previous predictions may be compared to actual results. At this point, children should have the opportunity to share inventions and describe details of the process by using visual documentation (photographs, sketches, diagrams, etc).

Teacher's Role: The teacher continues to facilitate and document the work of the children. She also finds time within the schedule for children to share final versions of their inventions. A "Celebration of Ideas" for parents, guardians, and administrators could be held to honor the children's creations.

Abby, Anna, and Kiley had been so intent on constructing a trampoline that their original discovery, the merry-go-round, had been forgotten. As the girls approach their work today, Kiley realizes the potential of combining the two. "Look! A spinning trampoline!" Kiley joyfully announces. She places one "person" on the merry-go-round below and holds the other "person" above the trampoline. Kiley spins the turntable and drops the "person" onto the revolving trampoline. The girls laugh at the ping-pong person's movements on their invention. They continue to experiment with design improvements. Walls are adjusted and a platform for jumping onto the trampoline is considered. Words are playfully combined as the group attempts to name their invention. They eventually agree to call their invention the Jump-and-Ride-Around. Blueprints for the invention are drawn so that another child might be able to reconstruct this work. Kiley, Anna, and Abby enthusiastically bring their invention to the class meeting and explain its important features as well as the development process.

New Applications

The cycle of design technology begins again as children apply their newly informed understanding of the relationship between materials, ideas, and inventions to meet a different challenge. Children use their discoveries as a springboard for exploring further and applying their ideas to other situations.

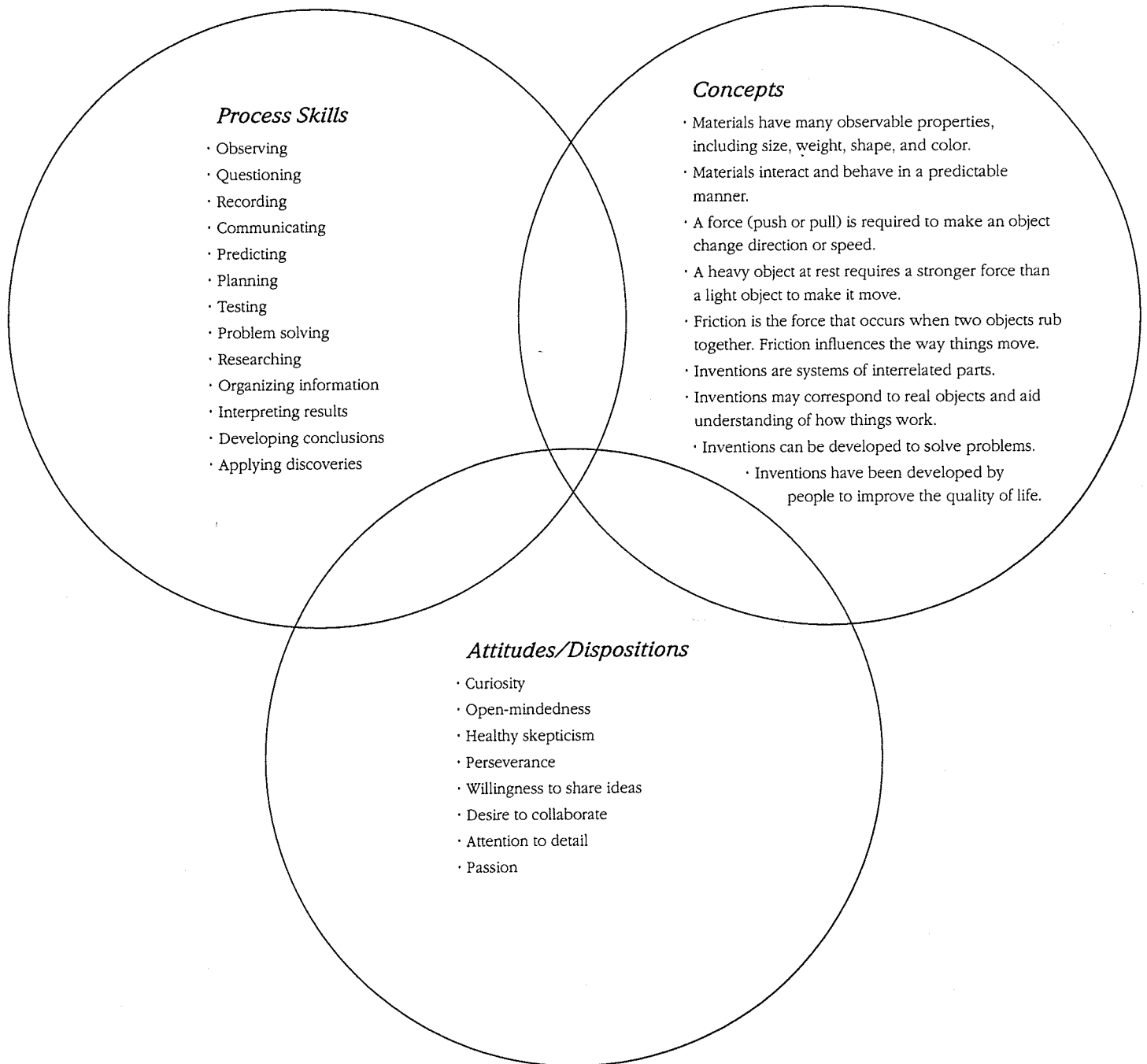
Teacher's Role: The teacher recognizes the value of children building on previous thinking and revisiting materials with a different purpose in mind. She encourages children to generate new questions related to their discoveries and provides time for continued exploration. Additionally, connections between the inventor's work and other real-world applications are discussed.

Note: Woven throughout this cycle of design technology are opportunities for reflection, documentation, and communication. Classroom meetings and small group conferences are vital parts of this cycle that allow children to attach words to their actions and thoughts. As children reflect through the use of documentation (photographs, diagrams, plans, notes, etc.) and communicate their ideas to others, segmented pieces of information are joined together to become a more cohesive whole. The importance of learning within a social context is honored. The interchange of thoughts among children and adults enriches the experience for everyone. Reflection, documentation, and communication then provide a way to connect the stages within the cycle of design technology, enable the teacher to glimpse the minds of children, and foster the development of a community of learners within the classroom.

How Can I Support the Cycle of Design Technology in My Classroom?

- Devote ample blocks of time to inquiry. Children need time to wrap their minds around intriguing problems and consider a variety of approaches or solutions.
- Provide opportunities for active exploration over time so that children can revisit and build upon prior experiences. Once is not enough.
- Create adequate protected space for inventions. Ideally, children's work should be left up and protected so revisions can be made.
- Organize materials aesthetically. Clearly identify where and how materials will be stored so that children can find and put away materials.
- Captivate children's curiosity by setting up materials in different ways. The unexpected attracts children. Combine materials in a novel way or partially arrange a set of materials. Pose problems with materials rather than words.
- Support inquiry by facilitating rather than leading the inquiry process.
- Document learning. Capture evidence of ideas as they evolve and grow through photographs, audio-cassette recordings, videotapes, and student work.
- Provide time for both small and large group discussions that allow children to reflect and build upon current thinking. Use documentation to support these discussions.
- Organize, display, and discuss student work as an integral part of the teaching/learning cycle.
- Develop a culture within the classroom that respects and appreciates diverse ideas by celebrating learning.

Quality Science Teaching: An Integration of Skills, Concepts, and Attitudes



Invention in the Classroom

The Invention Center

Create an organized, protected space for the invention materials. There should be room within this area for inventions to be displayed or saved until work is complete. Additional materials that could be available within the Invention Center include large paper clips, string, metal washers, different types of rubber bands, and ping-pong balls. Goggles are suggested to protect eyes from any stray rubber bands. Drawing materials such as plastic triangles, rulers, circle templates, graph paper, paper, pencils, and colored pencils should also be readily accessible within the Invention Center.

Note: At a class meeting, I introduce children to the safe use of rubber bands. I show children how I can slip a band around two dowels and then cautiously take it off so the band doesn't fly through the air. We talk about why rubber bands flying through the air might be a problem. If children need to send something flying through the air (and they might create an invention to do this), ping-pong balls are a safe alternative.

Construction Basics for Teachers

The construction ideas within this section are included so teachers will develop a repertoire of basic building strategies. In order to support children's work in the cycle of design technology, teachers need to understand how the invention materials can interact together. The following challenges are initially intended as "warm-up" exercises for teachers, but may then be used to encourage children to further their thinking. Construction Basics are not intended as lessons to be taught, but rather as building strategies to be explored.

How high can you build?
Is there a way to make a tall structure sturdier?
What happens to the tall structure when you spin the turntable?

How wide can you make your structure?
Is there a way to make a wide structure sturdier?
What happens to the wide structure when you spin the turntable?

How can you use elastic bands in your structures?
Can you find a way to keep a dowel from sliding through a cube?
Or
Can you find a way to keep a cube from sliding off a dowel?

How can you suspend a cube in the air?

Can you find a way to make two bobbins turn in the same direction by touching only one bobbin?
Can you make the bobbins turn in different directions?
How many different bobbins can you turn at the same time?

How can you make a dowel spin like a propeller?

What decisions are you confronted with as you build?

Design Plans

Children's ability to use plans to guide their work progresses with age and experience. Initially, a young child might need to understand that marks on a page can represent a structure or invention. Three- or 4-year-olds may want to trace the physical object in an attempt to translate the figure into a two-dimensional form. Skills required to record shapes accurately, as well as to spatially orient shapes, develop over time as children have repeated opportunities to draw their work.

Declan, 4 years old, seemed tentative about drawing what he had just made. I asked him if we could draw the "rocket-blaster-offer" together and he thought that was a good idea. I started the sketch and then Declan drew in the clear tubing. This idea of representing his "rocket-blaster-offer" through drawing intrigued Declan, but he decided to simplify the problem by drawing just one of the blocks. Declan chose a cube with holes, and we continued our work together. I drew the outside of the cube, and then he attempted the circular hole. His hand moved in a quick up-and-down motion in the center of the block. (Is he representing movement or unsure about how to represent the hole?) He shifted his focus from the hole to the block's outside edge. Declan decided to trace the cube. He held the cube firmly on the paper, positioned his pencil along one edge of the cube, and began tracing the cube. When his pencil reached the corner, Declan lost contact with the cube and made an arch around the cube. He lifted the cube to check his drawing. Declan seemed unhappy with his first attempt and immediately wanted to try again. He worked persistently to improve his representation of the cube (important to have time to try things again; self-directed desire to improve his work). I helped him by holding the cube and talking to him about his work. Declan continued until his drawing was a reasonable representation of the cube.

Declan now focused on the hole. He once again represented it with a series of up-and-down movements. I wanted to see what Declan would do if I demonstrated how to draw a circle. I told him, "When I draw a circle, this is how I do it." He watched intently and then copied the motion I made. He successfully drew circles inside the traced cubes. (I am not sure that I would have reacted the same way in a different situation. The circles were a tool that I wanted Declan to have in order to represent his invention. I thought that I would offer the suggestion and then it would be his decision whether to use this information or not.)

Children usually benefit from first being invited to draw concrete materials, then to draw inventions they have created, and then to draw a plan for an invention yet to be constructed. Inventions can be drawn from different perspectives showing proportional relationships. Plans require children to think of desired goals, mentally manipulate images, and then translate these images into a visible form.

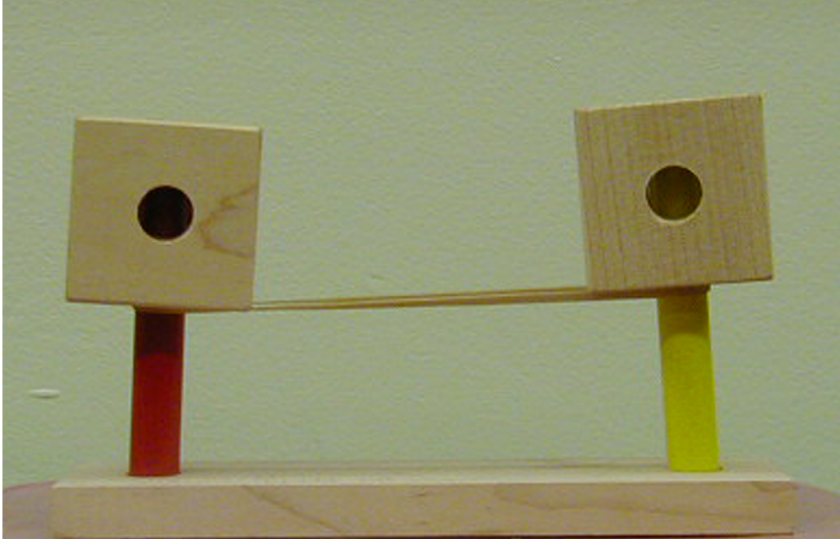
Plans can also be constructed out of three-dimensional materials. The goal is to provoke intentional behavior guided by a representation of an idea.

In an effort to support children's developing notions about plans, teachers can draw diagrams of children's inventions, show and discuss architectural blueprints, or share design plans developed for classroom setup. As children begin to draw inventions or plans for inventions, the teacher might ask a child to explain correspondences between the drawing and the invention. Pointing to a specific part of the plan, she might ask, "Can you show me this part in your invention?" If the teacher knows that a child is ready for an additional challenge and notices details that are missing within the plan, she might then point to the overlooked part of the invention and ask, "Can you show me where this part is in your plan?" Children will usually search their plan and then laugh, "Oh, I forgot that!" and busily draw additional information. Another strategy for stressing the importance of details within plans is to have another child attempt to recreate the invention by referring to a friend's plan.

Recording sheets are useful ways to help children organize information. Please refer to the Appendix for examples that can be used as is or adapted to meet the needs of your children. They were developed from ideas in Ellen Doris's book *Doing What Scientists Do: Children Learn to Investigate Their World*.

Invention Scenarios

The intention of this guide is not to provide step-by-step instructions for inventions, but rather to help set the stage for children's creative use of materials. The following scenarios are examples of children's work with suggestions for possible next steps. The Cycle of Design Technology described within the Introduction of this guide should help to inform these decisions.



Julie: Age 4 1/2

"Finish line for a race . . . a flying race for a spaceship.

"A telescope. We can look closer at the sky.

"Rocket-blaster-offer. That's for the blast off."

Next Step

As the structure evolved, it developed different identities. Julie needs to continue to explore the materials and experiment with possibilities. Look for intentional work where the structure maintains its identity before expecting Julie to meet design challenge expectations within the Cycle of Design Technology.

Potential Questions

What might happen when the runner hits the rubber band finish line? Would she bounce back?

How far would she bounce? Would she bounce farther if she were heavier?

What part of the telescope do you look through? What if the moon was on the other side of the sky?

Could you turn the telescope? How could you make it turn?

What can we use for a rocket? How can we make it blast off really high?



Evan: Age 5 1/2

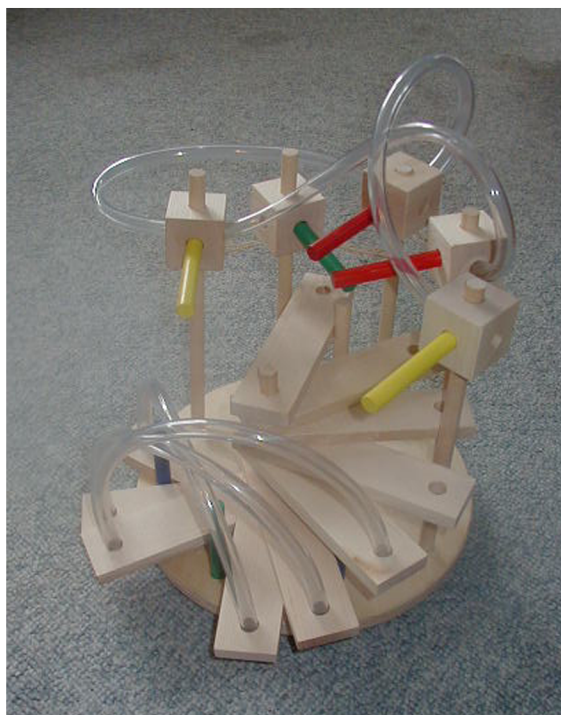
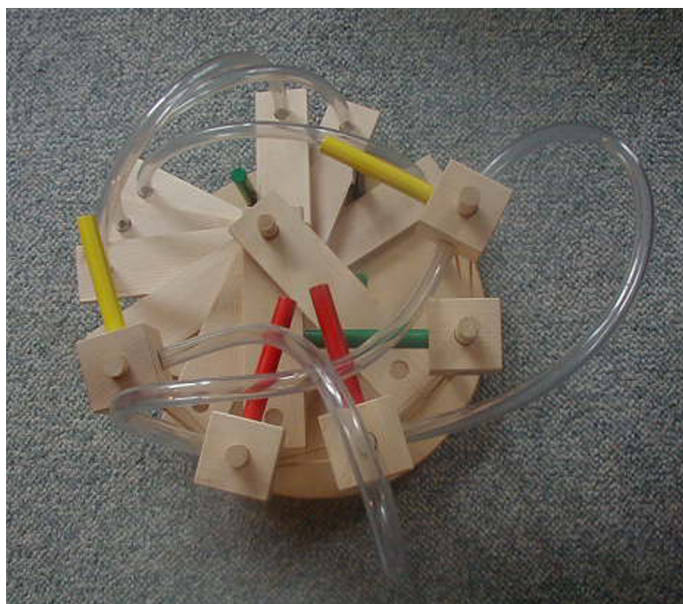
"A playground! This is the slide and here are the swings for the people. They can climb up these steps and then they can spin around."

Next Step

Visit a playground or look at pictures of playgrounds in books (research). Evan might draw pictures of his favorite pieces of equipment. He could be encouraged to think about and design equipment to make the playground even more exciting. (For example, a swing that would go all the way around the support pole!) Return to the design challenge stage and provide time for Evan to build his inventions.

Potential Questions

What makes the swing move? In what direction does it move? What makes the children go down the slide? How could they go faster? What makes the turntable move? How can you make the turntable slow down? Can you invent something to make it spin slowly?



Kate: Age 6 1/2

"A Water Park: One time there was this little boy and he was walking up the stairs and he looked down and saw a pool of water. He decided he'd jump and he realized that the stairs were double-purposed. They were springy like a diving board so he jumped. When he got into the pool, he saw that a slide went into it, so he thought he could find somewhere to slide down. He went to the top and found the water slide. He slid to the bottom."

Next Step

Double-purposed steps that spring, slides . . . hmmm. Would Kate be interested in pursuing one of these ideas and moving on to a design challenge? Or would a discussion at a class meeting about water parks inspire more ideas to explore?

Potential Questions

Could you invent something to make the boy jump higher? What part of your invention makes him go higher? What might happen if the turntable moved while he was jumping? How far would he land from the turntable?

Assessment

Curriculums based on state and national standards should define the knowledge, skills, and dispositions that are valued within school systems. Grade-level expectations are then clarified, allowing teachers to determine assessment strategies that identify the student's current thinking and record conceptual growth toward agreed-upon goals. Curriculum, teaching, and assessment are thoughtfully intertwined.

Classroom Assessment and the National Science Standards (2001, p. 14) suggests three questions to guide assessment decisions:

Where are you trying to go? Identify and communicate the learning and performance goals.

Where are you now? Assess or help the student to self-assess current levels of understanding.

How can you get there? Help the student with strategies and skills to reach the goal.

These questions continually resurface as teachers and students interact. This ongoing analysis of student thinking and behavior provides the basis for decisions about the next steps in the teaching process. Anecdotal observations, videotapes of students working, audiocassette recordings of conversations, student work, and digital pictures are all possible strategies for gathering assessment data. A critical review of this data is then used to inform teaching. Assessment is an ongoing, integral part of the teaching/learning cycle.

The chart "Quality Science Teaching: An Integration of Skills, Concepts, and Attitudes" (on p. 7) provides a starting point for schools without a curriculum. Appropriate grade-level expectations need to be identified so that teachers understand what their children should know and be able to do. I strongly encourage schools involved in the process of curriculum development to refer to this guide's bibliography (p. 17) for additional resources.

On the following pages are charts that can be used to record observations. On the first chart, each child's name should be written inside a box. Focused observations can be recorded and teachers can easily determine which children have and have not been observed. The second chart is for recording conversations. One child's name goes at the top of each column. (Charts can be made with additional columns if necessary.) This format allows the teacher to record and assess verbal interactions between children. Statements are recorded in order under the appropriate child's name in a "waterfall" fashion. If a child did not speak until the end of the conversation, the top of that child's column would be empty and his words would appear below the quote of the previous child. This format allows teachers to reflect on conversations and develop a better understanding of each child's contribution.

A final thought about assessment. I keep looking for a way to make assessment easy and haven't been able to find one. This year, someone I admire looked me in the eyes and frankly said, "Good assessment is *not* easy." I agree. Good assessment is time consuming and mentally challenging, but therefore thought-provoking and fascinating. I thoroughly enjoy figuring out what children know, thinking about how I can influence their thinking, and then checking to find how their thinking has changed or grown. Ongoing assessment allows me to continually develop as a teacher and stay engaged in the teaching/learning cycle.

Concept/Skill/Disposition:

Date:

| | | | |
|--|--|--|--|
| | | | |
| | | | |
| | | | |
| | | | |

Setting:

Date:

| Name | Name | Name |
|------|------|------|
| | | |

Bibliography

American Association for the Advancement of Science. 2001. *Atlas for Science Literacy*. Washington, DC: AAAS & NSTA.

American Association for the Advancement of Science. 1993. *Benchmarks for Science Literacy*. New York: Oxford University Press.

Caney, Steven. 1985. *Steven Caney's Invention Book*. New York: Workman Publishing.

Doris, Ellen. 1991. *Doing What Scientists Do: Children Learn to Investigate Their World*. Portsmouth, NH: Heinemann.

Gallas, K. 1995. *Talking Their Way Into Science: Hearing Children's Questions and Theories, Responding with Curricula*. New York: Teachers College Press.

National Research Council. 2001. *Classroom Assessment and the National Science Education Standards*. Atkin, Myron J., Black, Paul, & Coffey, Janet (Eds.), Committee on Classroom Assessment and the National Science Education Standards, Commission on Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.

National Research Council. 2000. *How People Learn: Brain, Mind, Experience, and School*. Bransford, J. D., Brown, A. L., & Cocking, R. (Eds.), Committee on Developments in the Science of Learning, Commission on Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.

National Research Council. 2000. *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*. Washington, DC: National Academy Press.

National Research Council. 1996. *The National Science Education Standards*. Washington, DC: National Academy Press.

Appendix

Snapshots of Children's Work: Conversations

The following conversations provide examples of first-graders actively engaged in the Cycle of Design Technology. Although class meetings were not recorded, opportunities to explain ideas and clarify goals within a group setting is also an important part of this process.

This transcript should be read by starting at the highest quote and then proceeding to the quote that begins the line below the first. The teacher's comments and annotations are in brackets. Concept and skill connections are in bold italics. These connections are made in an effort to provide evidence of children's developing scientific thinking and are not intended to demonstrate mastery. Additional observations would be necessary to determine the depth of the child's understanding.

The stages of the Cycle of Design Technology are presented separately in an attempt to clarify this cycle. In the classroom, these stages may blend together seamlessly.

Stage: Design Challenge 1

Context: Daniel and Joey are continuing work on their kicker machine.

DANIEL

"This is a kicker machine."

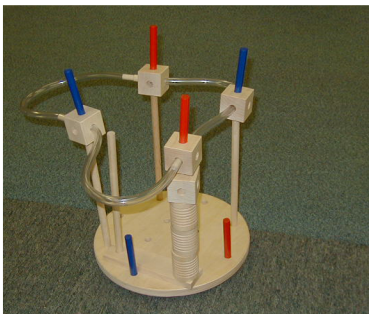
Using materials representationally.

"Here goes our kicker machine!"

[Daniel is getting ready to kick a "puck," a round attribute block, with the kicker—a slat attached to the turntable with a dowel.]

"We need something to hold them [bobbins] down. We need lots of weight."

A heavy object at rest requires a larger force than a light object to make it move.



[Daniel stacks three bobbins and two cubes on a long dowel and then adds a red dowel at the very top. A slat is on the bottom of this tower. Daniel starts moving the slat back and forth.]

"Tick, tock, tick, tock."

[As Daniel hits the dowels with the slat, it seems to remind him of a clock.]

JOEY

"Mine's going to be a kicker machine too."

[Talking about the same machine.]

"I'm going to keep on doing this, like a pattern."

[Joey is building a tower and making a pattern with cylinders and cubes.]

"Wait! Wait!"

MRS. F.

cont. on next page

Stage: Design Challenge 1 *(continued)*

DANIEL

Look at this. It [the slat] kicks it [the round attribute block].”

[The block goes flying through the air.]

A force is required to make an object change speed.

[Daniel helps Joey connect additional tubing.]

“That makes kind of a triangle.”

[As they look at the tubing from above, it resembles a triangle.]

“What do you want me to do?

Make another pole?”

[Daniel finds another pole to complete their kicker machine.]

JOEY



“Wait. I got a good idea.”

[Joey puts a long dowel into the empty hole of the slat and moves the slat by holding on to the dowel. He seems happy with this new version of the kicker machine and begins to put on additional blocks. He then connects pieces of clear tubing and slides the tubing through the center of two cubes. He smiles and shows Daniel what he has done. The cube is suspended in the air by the plastic tubing.]

“How can we attach this?” [Joey answers his own question. He slides the cubes onto two tall dowels that are supported by the turntable.] *Problem solving.*

“Yes! Got it! How should I do this?” [Joey wants to add more tubing.]

“How about let’s do just one kicker so we have more room. We don’t need these on.”

[Joey begins to simplify their machine. He is thinking about the essential parts.]

“We need one more pole.”

MRS. F.

“I wonder if there’s a way to kick the block off without touching the kicker [slat]?”

cont. on next page

Stage: Design Challenge 1 *(continued)*

DANIEL

JOEY

MRS. F.

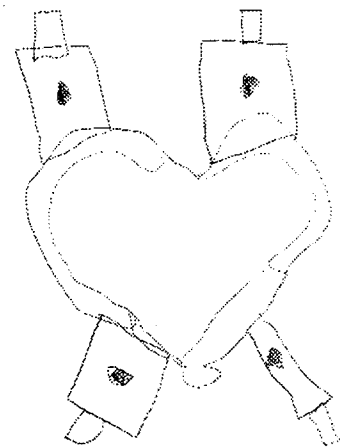
[Joey explains his invention to Mrs. F.]

"It's the 'Inside-Out-Heart Kicking Machine.' If there's real old, old stuff, then they just have to bring it over here and then we'll kick it off. Once it gets into little pieces then it goes down to the dump. It starts out big. This machine is strong. It can kick it off and then bust it into pieces."

Inventions can be developed to solve problems.

"Thank you for explaining your invention. It's almost time to clean up. Could you both draw a picture of your 'Inside-Out-Heart Kicking Machine'? If you draw a plan, then someone else could build your invention by following your plan." [Joey and Daniel decide to each draw a different perspective of their machine. Daniel draws the machine from above, while Joey draws what he sees from the side.]

Recording.



Stage: Design Challenge 2

Context: “The Inside-Out-Heart Kicking Machine” was saved so that Joey and Daniel could continue their work. Joey and Daniel use a copy of their drawings to add new details regarding their plans for today. They continue to refine their invention with the goal of propelling a puck through the air.

DANIEL

“I want to kick the puck really far.”

“I got a good idea. The tubes are wires with wraparounds, and the elastic bands are wires without wraparounds.”

[Daniel draws lots of wires to connect the dowels.]

Using materials representationally.

“The wires make the kicker work.”

“The wires will give it lots of power.”

A force is required to make an object change direction or speed.



“From these rubber bands. These are the elastic band wires. See how they stretch.”

[Joey and Daniel begin work on their invention. With adult support, they refer to their plan as they work.]

JOEY

“Me, too.”

“We’re going to kick the puck really, really far.”

“We’re trying to fill up any extra space with rubber bands. Can I have this really big one?”

[Joey and Daniel begin to stretch rubber bands from one dowel to another.]

MRS. F.

“Tell me more about these wires.”

“What would you like the kicker machine to do?”

“How do you plan to do that?”

“You need a lot of power to kick the puck far. Where does the power come from?”

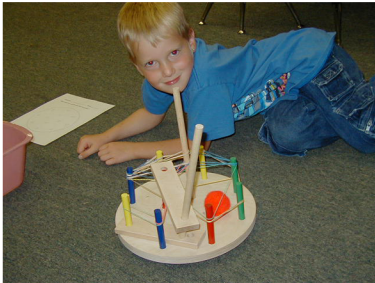
cont. on next page

Stage: Design Challenge 2 *(continued)*

DANIEL

[Daniel places the circular block by the kicker, and when Joey releases the dowel, the kicker block swings back and hits the block.]

A force is required to make an object change direction or speed.



"Connect it around here [dowel]."

JOEY

"Cool! It's like a trampoline."

[Joey drops the red circular puck on top of the stretched rubber bands.]

Using materials representationally.

[Joey picks up on this idea, connects the dowels with a rubber band, and then pulls the dowel connected to the kicker away from the other dowel. As he pulls the dowel, the rubber band stretches.]

"Awesome."

[Joey tries the elastic-powered kicker a number of times and observes the block's movement.]

Materials interact and behave in a predictable manner.

"It [the rubber band] needs to be shorter because then it will go faster. It could be like a hockey machine because you put the puck here, and it goes flying!"

Predicting.

"Yeah, that'll work."

[Daniel and Joey experiment with how the length of the rubber band affects the movement of the puck.]

MRS. F.

"What do you think would happen if we connected these two dowels with a rubber band?"

[She points to the dowel that controls the kicker and another nearby dowel. She's trying to focus attention on their original goal. She'll keep the trampoline in mind for another time.]

"How could we make the rubber band shorter?"

[She asks Daniel and Joey to compare their invention to their plan and include any changes. They can bring their plans along with their invention to share with the rest of the class.]

Stage: Return to Exploration 1

Context: Daniel and Joey are anxious to follow up on their trampoline idea and need time to explore possibilities with these materials.

| DANIEL | JOEY | MRS. F. |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|
| <p>[Daniel stretches as many rubber bands as he can find across the turntable from dowel to dowel. He seems to think more is better.]</p> <p>[Ignores Joey's suggestion.] "Now this will look cool! These little slants [of the rubber band] make it look cool. I have quite a few of those."</p> <p>"This is a kick and bounce machine. We're getting all of the rubber bands on." [Pompoms are getting stuck in the rubber bands.]</p> <p>"Put your goggles down! Send it!" [Joey and Daniel experiment with holding a pompom on a rubber band and pulling the rubber band back to send it through the air.]</p> <p>"Now we are going to need a couple of rubber bands to go across. Too small. Look for another band." [Daniel still wants to add more rubber bands. The number of rubber bands seems to inhibit their flexibility.]</p> | <p>"Let's take some rubber bands off."</p> <p>[Tries to bounce a pompom on the rubber band trampoline.] "I can't get anything to bounce on it. I got a floofy ball. How about if we pull these [rubber band supported by two dowels] back?" [Attaches pompom and flings it through the air.]</p> <p>"We can land in these holes." [Creates a target.]</p> <p>"Ready for fire? I can make it fly. I can make it fly even higher!"</p> <p>"I'm going to pull it back farther, and then it will go higher." <i>Testing relationship between amount of force and height pompom reaches.</i></p> <p>"Wait. Wait. It won't work."</p> | <p>"You can make it go even higher than before?"</p> |

cont. on next page

Stage: Return to Exploration 1 *(continued)*

DANIEL

"Let me try."

[Daniel has difficulty launching the pompom into the air. Joey and Daniel start to revise their invention. They begin removing rubber bands and short dowels. The short dowels are replaced with long dowels positioned in the outside circles on the turntable. They want to position cylinders at the top of the dowels. They discover that by positioning a rubber band toward the top of a dowel and stretching the band to another dowel, they can support a cylinder.]

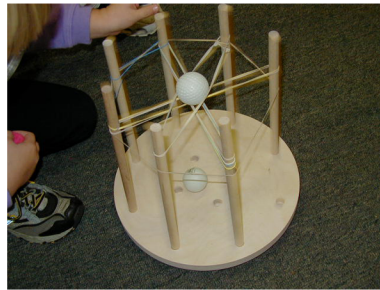
"Need a taller one [dowel]. There! It stayed up."

"Wow! It actually bounces now. Look at, look at what we can do. Wow! That was really good."
[Both boys are impressed by how high the ping-pong ball bounces off the rubber band trampoline.]

"Wow! Hey, look at this. Ah, cool!"

"It went really high!"

JOEY



"We could make a star [with rubber bands]. Cool!"

"Yeah. And put this ball right here."

"Try the middle now."

MRS. F.

"Would you like to see how ping-pong balls move on your invention?"

"I wonder how the ball will move if you drop it on the side of the trampoline?"

Stage: Return to Exploration 2

Context: Another child joins Daniel and Joey. The children return to exploration as they consider a different use of the materials.

JOEY

"Huh?"

"It's slowing down."
Friction is a force that occurs when objects rub together. Friction influences the way things move.

"It sounds like bees going through the air. When we go faster, it makes a louder sound."
Representational thinking.

"I can do the bottom."
[Joey helps to record today's work.]

DANIEL

[Dismantles work from yesterday.]
"Let's take it apart. We need something to make it 'eviborate.'"

"Eviborate!" [Vibrate.]

"We can make a band!"
[Devon, Daniel, and Joey build together and experiment with the sounds that are made as a dowel is held against the spinning outside edge of their structure.]

[Daniel decides to record his work. He begins drawing the design by looking at his work from above.]
"But you have to have the instructions from the bottom to the top because it always starts at the bottom and goes to the top."

DEVON

"Hey, I got a good idea. I'm using different colors [colored dowels]."

"I'm going to build a new one.
I need the green. I need the green."

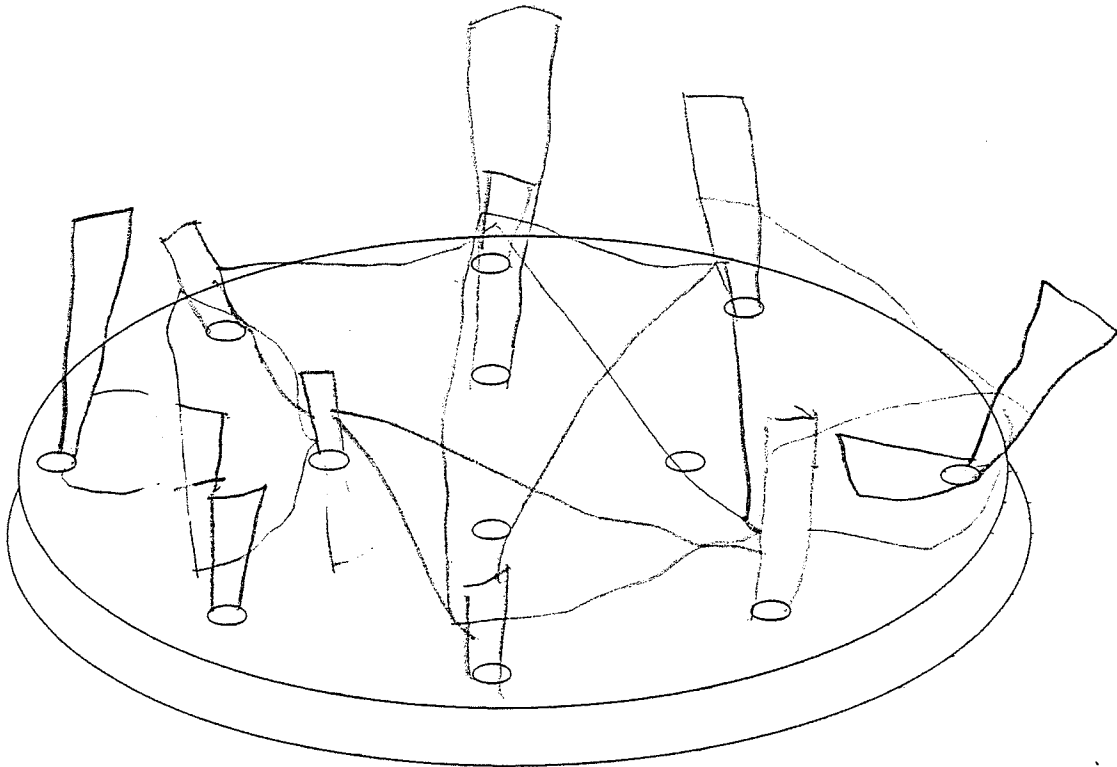


Snapshots of Children's Work: Inventions

The student recording sheets provide an opportunity for children to focus on details within their invention, share ideas with others, and create a lasting representation of their work. As students transfer an invention onto paper and attach words to thoughts, thinking is made visible and open for discussion.

Inventor: David Doherty Date: 1/20/01

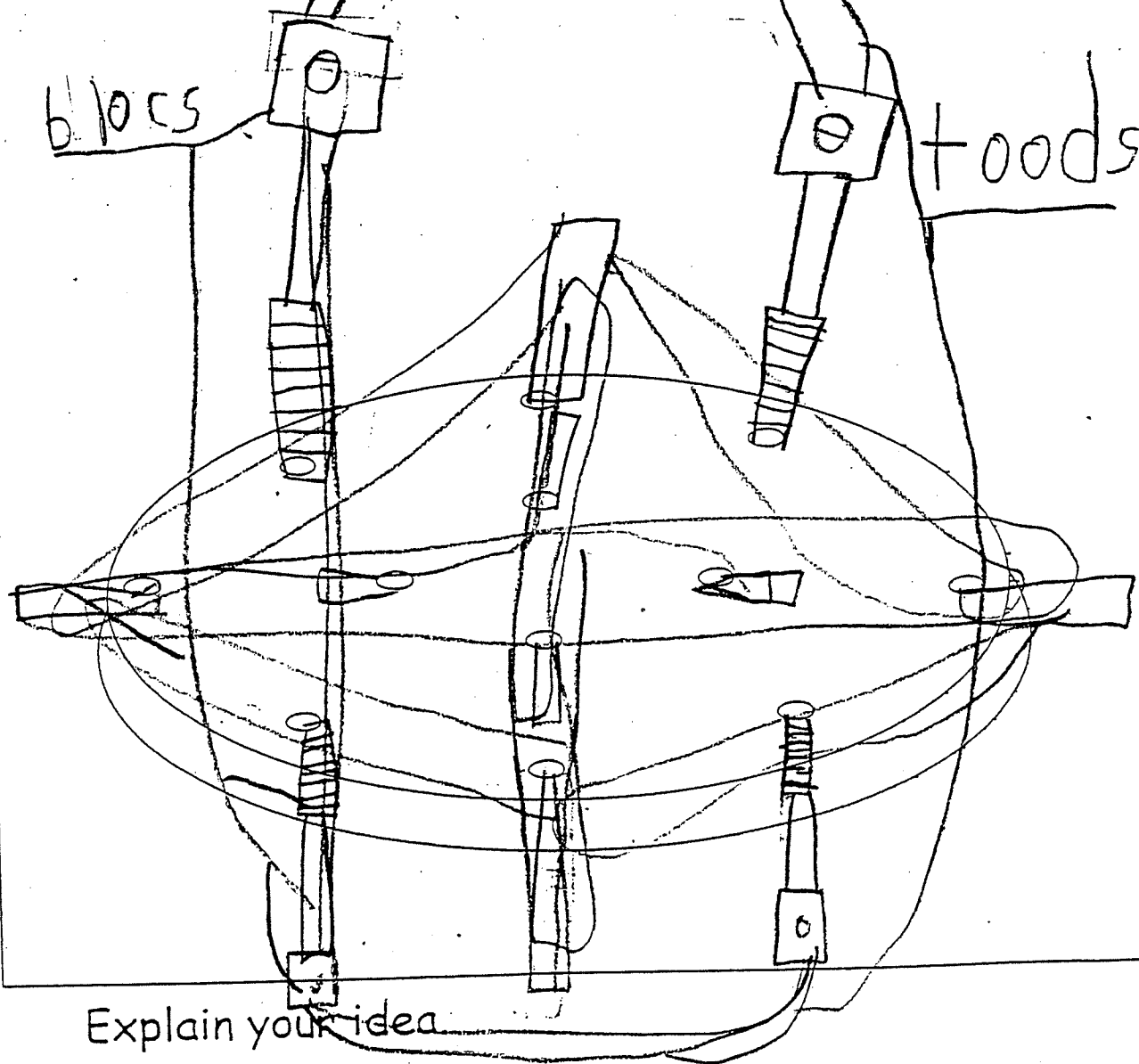
Draw your plan.



Explain your idea.

WE WATCH THE KICKING
MOMENT & KICK A PAM PAM

Draw your invention.

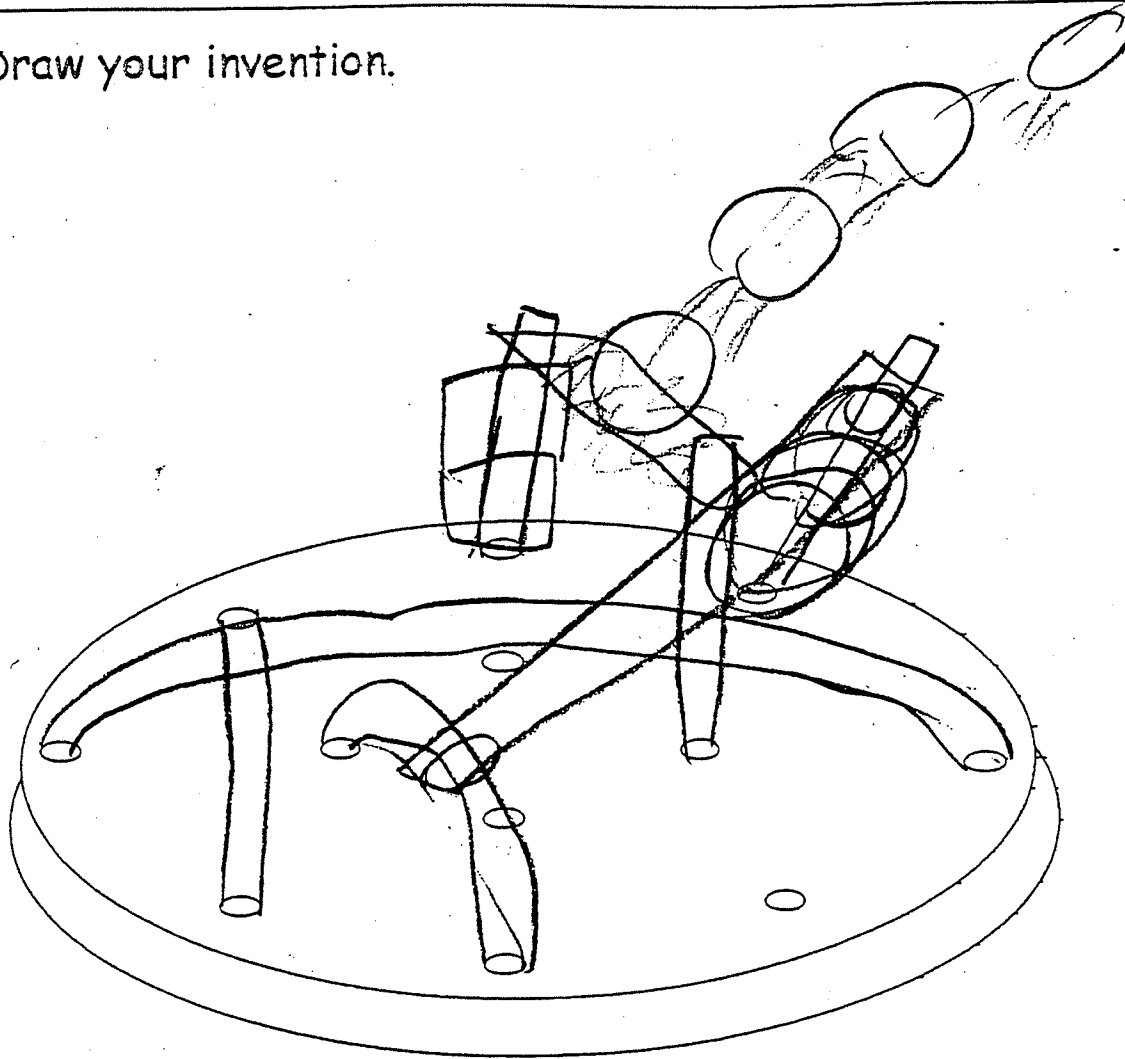


Explain your idea.

My spinning thing is a
dangerous because the

rubber bands could shoot off

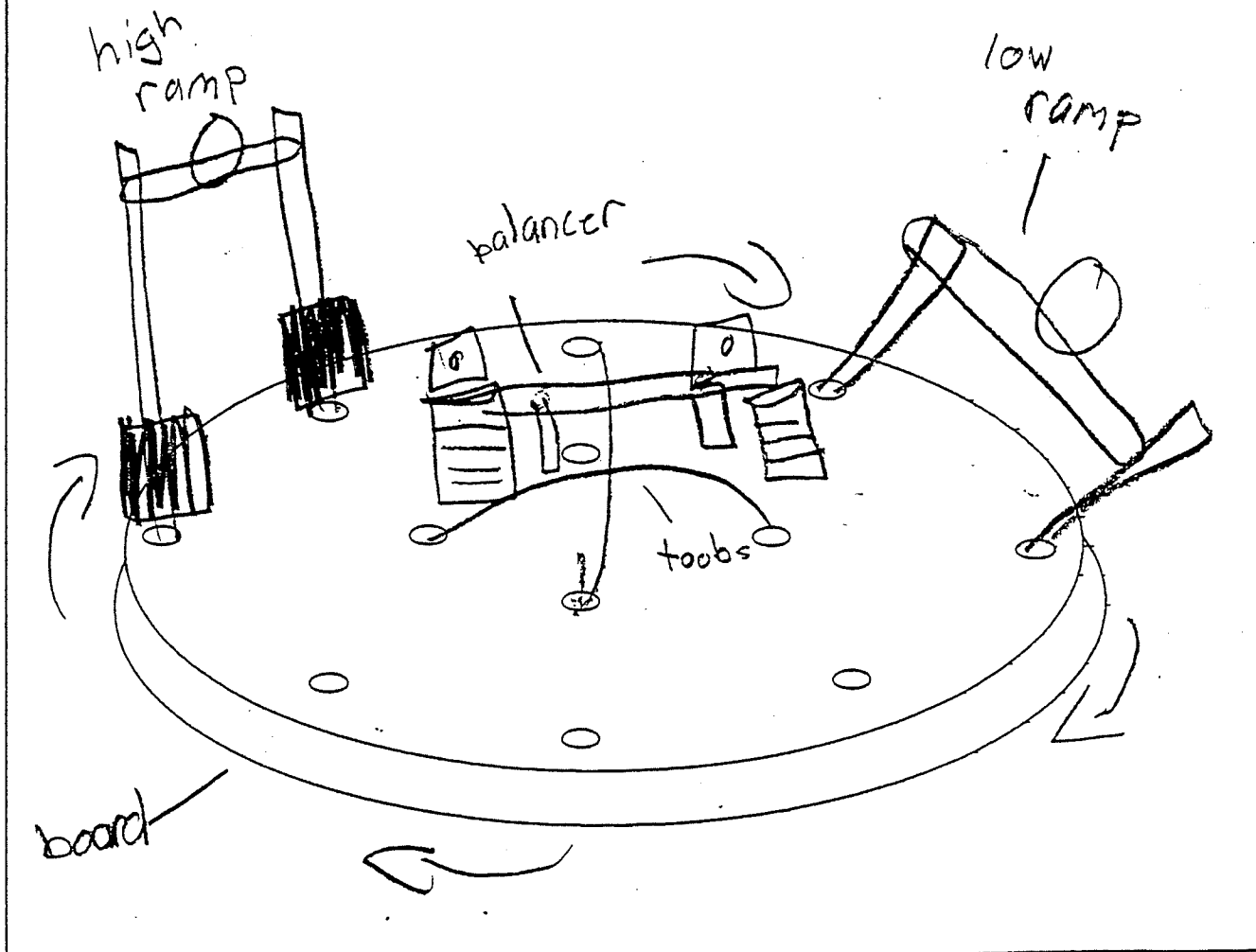
Draw your invention.



Explain your idea.

My contraption flings the ball. The ball is on the top of the roberband. When it spins the ball flings off the roberband.

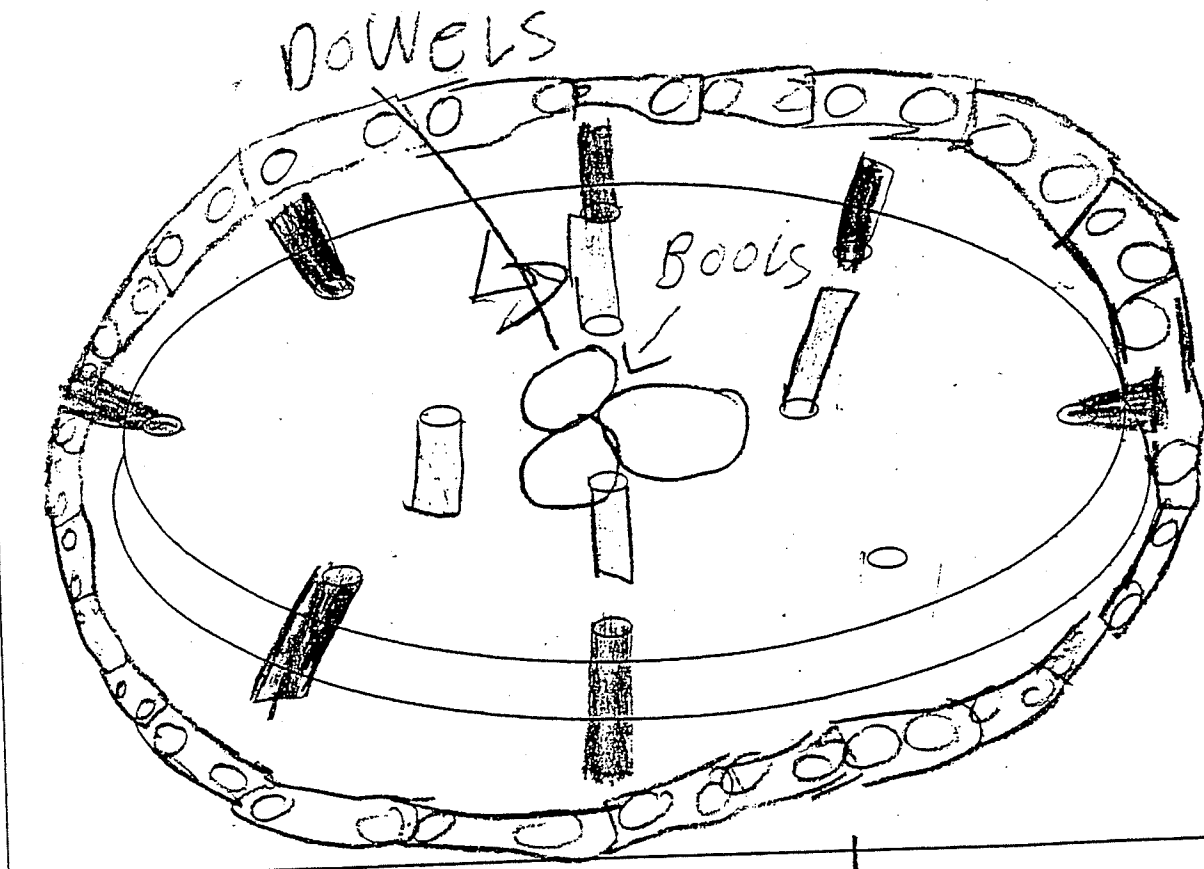
Draw your invention.



Explain your idea.

There are two ramps. One is high and one is low. The ball stays on the board when it's on the low ramp. But on the high ramp it rolls off the board. The balancer holds the ball and sees if it can balance.

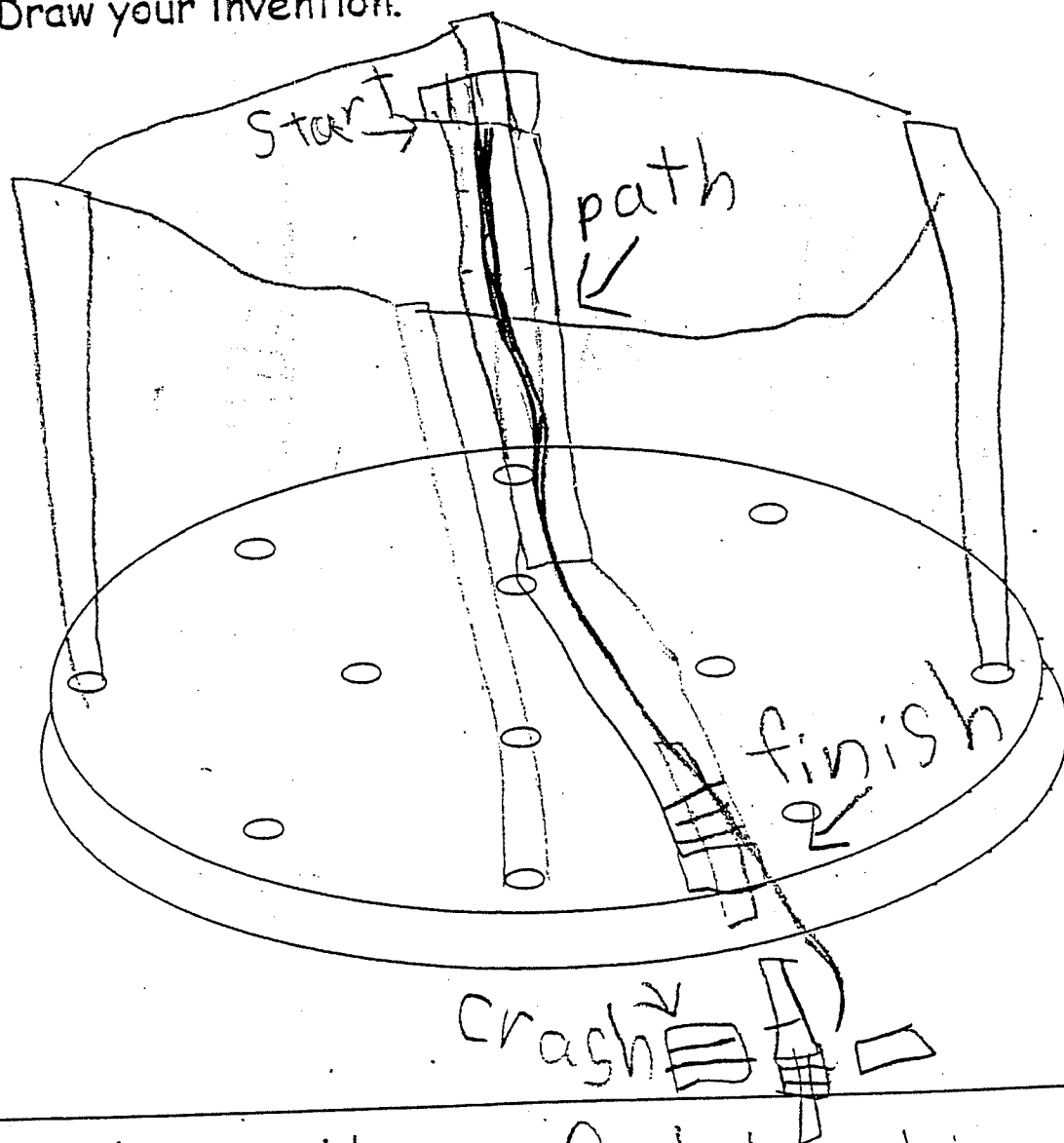
Draw your invention.



Explain your idea.

wan I spin The
 PLAT The BOLS
 fal off

Draw your invention.



Explain your idea.

It's kind of like the race

track but it isn't. First

I set four bars up, then I built

~~the~~ track. then I took this round

thing and set it on the track. It role

down the track and it made a big

Recording Sheets

The following recording sheets can be used to provide a framework for children's observations.

Inventor: _____ Date: _____

Draw a picture of your plan.

Explain your idea.

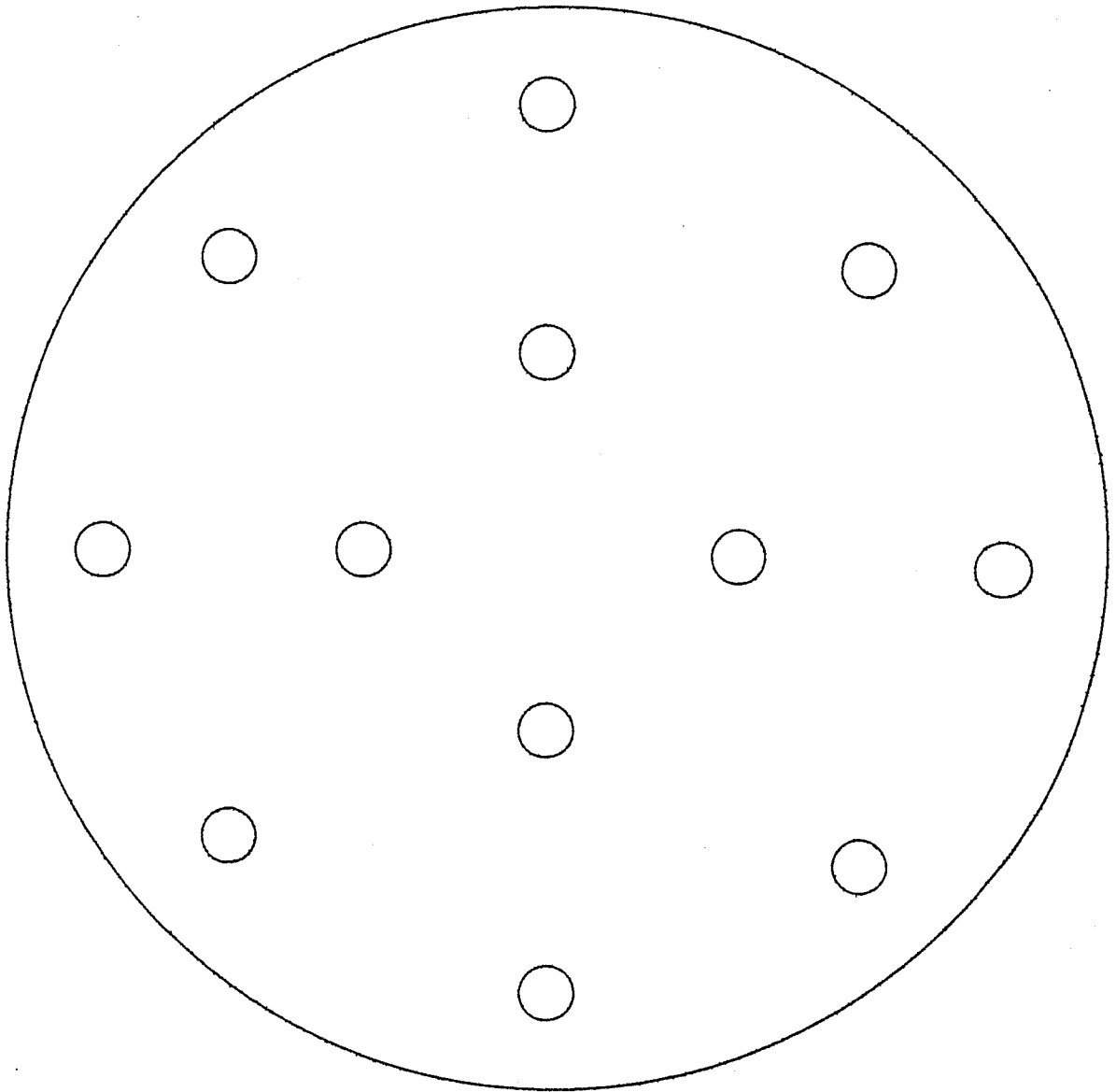
Inventor: _____ Date: _____

Draw a picture of your invention.

Explain your idea.

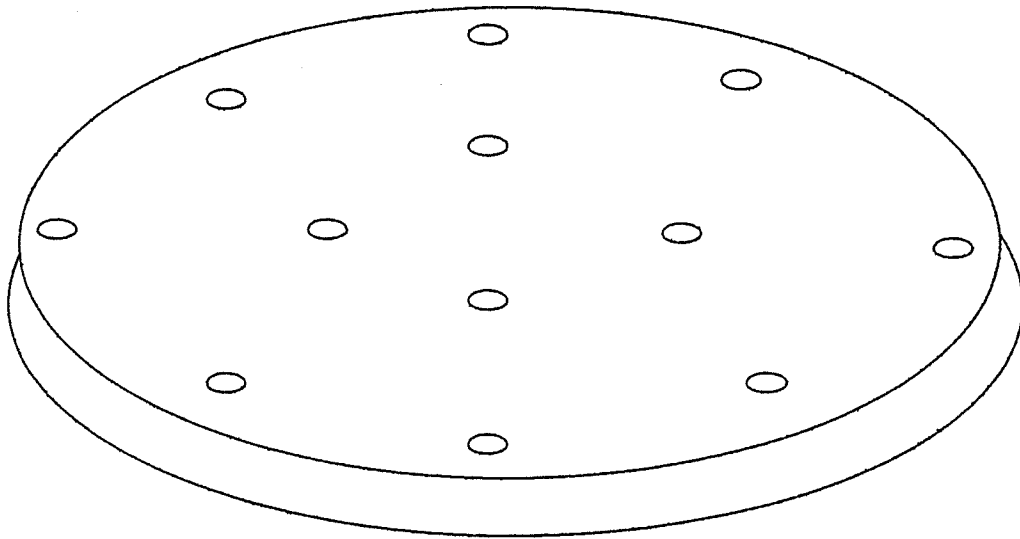
Inventor: _____ Date: _____

What does your invention look like from above?



Inventor: _____ Date: _____

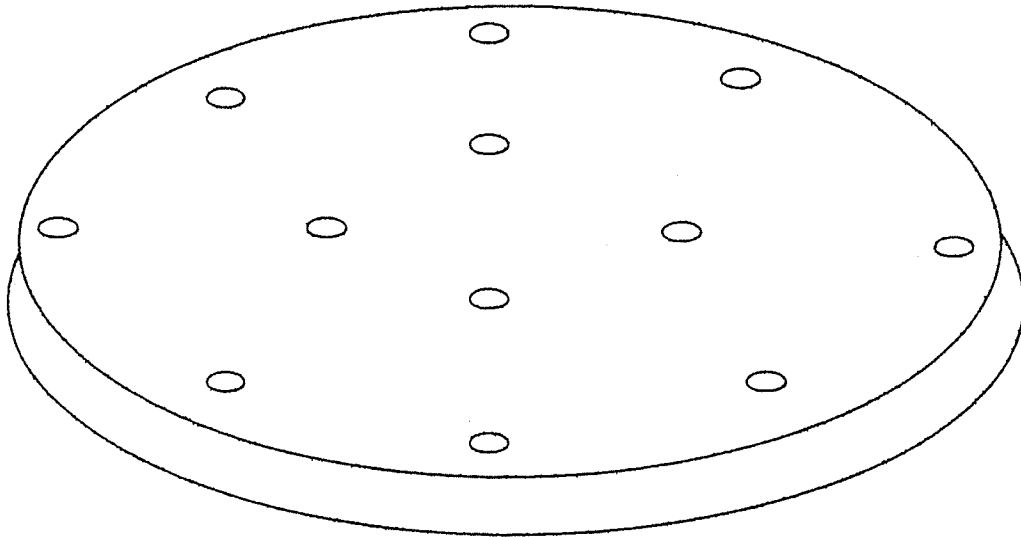
Draw your invention.



Explain your idea.

Inventor: _____ Date: _____

Draw your plan.



Explain your idea.

| | | | |
|--|--|--|--|
| | | | |
|--|--|--|--|

Setting: _____ Date: _____

| | | |
|---------------------|--------------|--------------|
| <p>Names: _____</p> | <p>_____</p> | <p>_____</p> |
|---------------------|--------------|--------------|

Concept/Skill/Disposition: _____ Date: _____

| | | | |
|--|--|--|--|
| | | | |
| | | | |
| | | | |
| | | | |