CHAIN REACTION

Chain Reaction is an activity inspired by the whimsical contraptions of 20th century cartoonists and inventors like Rube Goldberg, Heath Robinson, and Bruno Munari, which often revolve around devising an overly complicated way of accomplishing a simple task. Each participant is given space on a table and a collection of everyday materials and found objects to construct a series of events. Then, each individual contraption triggers the start of the one that follows, therefore becoming a component in a large-scale collaborative chain reaction machine across several tables. The relationship between cause and effect is an intuitively simple concept, but one that allows for an incredibly complex and deep investigation into something we experience every day.

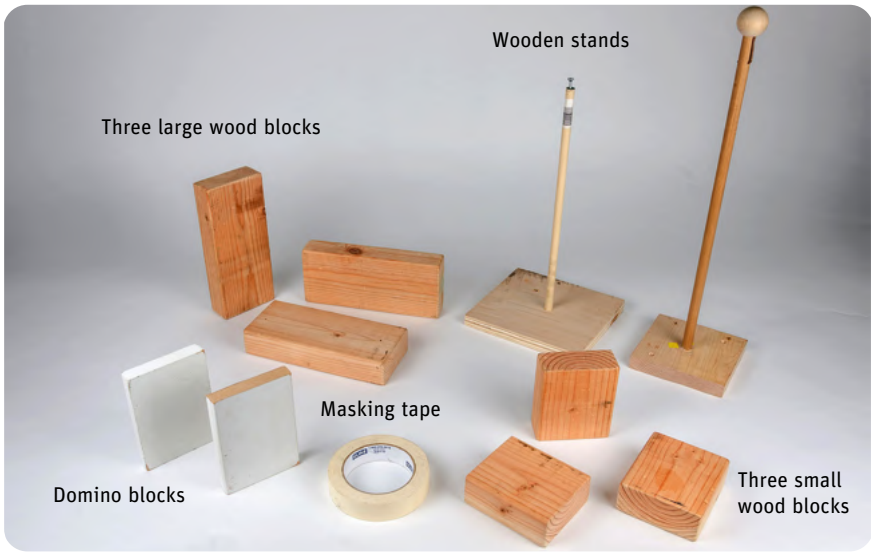
COLLECT THESE THINGS

Before you start building a chain reaction contraption, you need to collect or assemble a core set of materials to use (most will be re-useable each time you do this activity). In workshop settings, we have learners work in groups of two or three people per station. Each station will result in one contraption connected to the rest of the larger chain reaction contraption.

Note:
This is an extensive list of materials we found to be useful in large, workshop settings. It's a place to get ideas and be inspired to use everyday objects in unfamiliar ways. Whether you're working at home or in an informal learning environment the most important element to include are the large domino blocks to connect station to station. You don't need every item on this list to build a chain reaction contraption. Find what you can, and use materials that feel appropriate to your environment.

Objects to build with (per station):

Three small wood blocks (6-inch lengths of common 2x4)
Three large wood blocks (10-inch lengths of common 2x4)
Roll of masking tape
Two or three pre-built wooden stands
Two large domino blocks (1x4 blocks cut to 5")
NOTE: these blocks will act as connectors for each building station



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Objects to build with (in general):

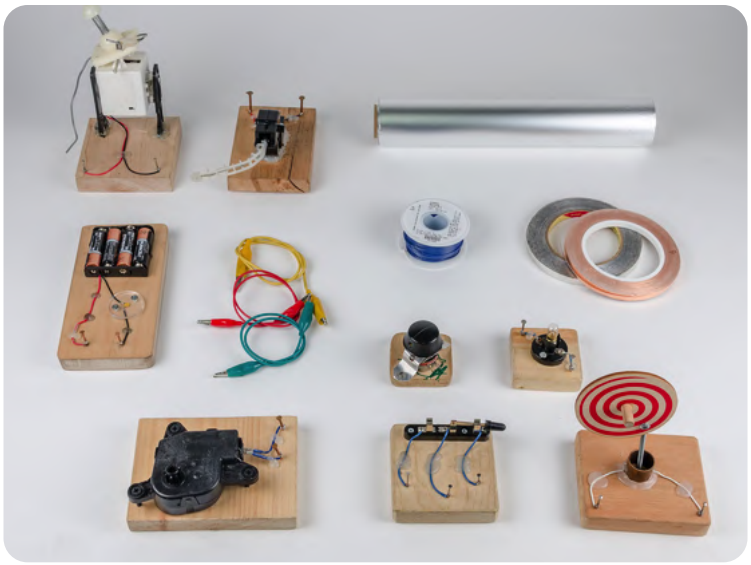
Scrap cardboard
Zip ties
Different types of string and fishing line
Electrical tape
Steel and copper wire
Rubber bands
Large paper clips
Wooden clothespins
Straws
Skewer sticks
Pieces of wood or scrap building materials
Screws, nails, thumbtacks
Variety of dowels
Many more large domino blocks
Weights (such as metal nuts, fishing weights, or washers).

Tools (in general):

Hot glue guns
Glue sticks, scissors
C-clamps
Wire cutters
Hammer
Drill and drill bits (range of small to large)
Driver bits
Standard and phillips head screwdrivers
X-acto knives
Box cutter knives
Hacksaw
Multimeter

Motorized and electric parts (in general):

A slow moving motor for each station plus extras
1 battery pack for each station (4x AA) plus extras
3 alligator clip leads for each station plus extras
Roll of hook-up wire
Dissected and working electric toy parts
Other circuit board components
Roll of tinfoil
Roll of copper tape and/or other craft materials that conduct electricity



Objects that roll, bounce, or move:

Wooden balls (various sizes)
pulleys
Kinetic toys and models
Balancing toys
Large and small marbles (5/8” to 2” diameter)
Plastic and wood ball tracks
Hot Wheels® tracks or Haba® wood tracks
Rubber balls
Tennis balls
Ping pong balls or Wiffle® balls
Metal ball bearings
Wheeled toys

Objects to decorate, embellish, or personalize:

Googly eyes
Pipe cleaners
Craft paper
Feathers
Fun fur
Markers
Pencils

Objects to inspire:

Flyswatter
Ping pong paddle
Marble toys
Balloons
Musical toys (like xylophones, tambourines, and small bells)
Short lengths of copper pipe
Magnets
Metal measuring spoons
Plastic spatulas
Funnels
...and any other unusual object that might be found in a kitchen, craft store, thrift shop, or garage

THE SETUP

Arrange your tables end to end so that each pair has space to work. (NOTE: we use 2.5'x5' tables where 2 pairs work at each table.) When working with a large group we create a snake-like table configuration across the workshop floor. Creating a varied shape with your table will keep the chain reaction dynamic and energetic. The stations on either end of your configuration will be the starting point and the finale.

Large, falling dominos trigger the connections between each station. Each contraption will result in pushing over a domino at the end of its station (the output), causing the start of the next contraption (the input). Place the large domino blocks in the input and output sections of each table so your setup can be introduced to participants

We found it important to provide a starting point that serves as initial inspiration and helps get ideas flowing at the beginning. It can be intimidating to walk up to an empty table and be told “make whatever you want!” Here are a few ideas that have worked well for us.

Carefully choose an inspiring object for each station to build into their contraption. These objects can be mechanical, electrical, or thematic.

Choose a general theme to drive the narrative of the chain reaction, like “love,” or “spring.” Encourage participants to interpret the theme as literally or metaphorically as they want, and think of narrative scenes that fit the theme. It is helpful if you provide materials that support expressing ideas about the theme.

Chain Reaction playing cards

We have created a set of illustrations of inspiring elements, and turned those into a set of playing cards. Participants choose a random card and then work in small groups to create a story linking their elements together. This special deck is available for purchase from the Exploratorium store.

We put extra building materials and tools around the perimeter of the room on separate tables to allow each team to utilize their station as the place to build, test, and refine their contraption. Tool stations include a place for using hot glue, a place to cut and score materials with knives, and a place for drilling and sawing.

Finally, create an example contraption at one station, triggered by the input domino. Try to incorporate ways to demonstrate the tinfoil switch, a slow-moving motor, a ball rolling down a ramp, and ultimately something that will set off the output domino at the other end. This example should indicate possible uses for the materials and objects, but not be so complex as to intimidate learners. The ideal example immediately suggests ways in which it could be improved!

TRY IT

Getting started

The path of every participant through this activity will be unique, so it's hard to give step-by-step guidance. Be open to the inspiration that comes from the quirky movement of a particular material or to trying an idea you've always wondered about but never tested.

Give yourself plenty of time to build and experiment. In the Tinkering Studio, we set aside 2-3 hours for learners to make individual contraptions at their stations, link them together, and set them off as one collective contraption.

Get familiar with your set up and materials. When working with a large group we start by showing the example contraption and setting it off, demonstrating the use of materials, the intended use of the input and output domino blocks, and the orientation of the room in terms of where the tools and materials are located.

There's no one right way to build your chain reaction. You can start with the input and work to the output, or vice versa. Some people start in the middle and build toward either end! Be patient as you build. Things will rarely work exactly as you expect them to on the first try. Iterate on your ideas. Test often as you build, and make observations and changes based on those tests.

As you build, here are some concepts you may want to consider incorporating into your chain reaction:

Height – are there ways to build vertical motion into your chain reaction? What could you build above or below your worktable?

Time – what can you incorporate into your chain reaction to slow down the progress from point to point? How can you use the space you have on the table to build tension between the connected elements?

Materiality – how many different ways can you use one object? How can you use objects in other ways than the "normal" usage? Can you use a book as a ramp? A spoon a catapult? A metal cake pan part of an electrical switch?

As time draws to an end, learners can finalize their contraptions, finish making and testing, and prepare to set off the chain reaction. Before it is set off, we usually walk around to each station and ask the makers to describe what they expect their contraption to do when it is all set up and running. After looking at everyone's individual stations, we give five minutes for everyone to get their contraptions set-up and ready to go. We count down from 10 ("10, 9, 8" etc…) and someone pushes over the first domino block in the chain, triggering the first station's contraption. It is almost guaranteed that everything will not work perfectly as the contraption starts to work. There will be times when you will need to offer some help to a reluctant mechanism or rolling ball by triggering a few things yourself. We try to pre-emptively take the sting out of this possibility by mentioning it in a lighthearted way and introducing the "magic finger," a helpful last-minute tool that everyone has to fix anything that might go wrong in the moment.

TAKE IT FURTHER

- *Themes:* It is fun to dream up themes for each chain reaction ahead of time in order to have appropriate materials on-hand for people to use in their contraptions. Themes that we have explored in the past have included TEXAS (for a group of teachers from Texas), LOVE (on Valentines Day) or Pi (for the annual Exploratorium Pi Day celebration).
- *Language:* We have also explored LOVE as a chain reaction theme using language as a starting point. We started the workshop by asking everyone to write down love-related nouns, verbs, and adjectives on individual index cards, and then pasted them around the room with everyone else's words. Each team chose three words that exemplify love, and built a contraption with that specific inspiration in mind. In the end, all of the LOVE themed chain reactions were linked together and set off. Machines included demonstrations of "Lovesick", "Humiliation", and "Passion".

EDUCATOR ADDENDUM

A note on our philosophy:

The Tinkering Studio is based on a constructivist theory of learning, which asserts that knowledge is not simply transmitted from teacher to learner, but actively constructed by the mind of the learner. Constructionism suggests that learners are more likely to make new ideas while actively engaged in making an external artifact. The Tinkering Studio supports the construction of knowledge within the context of building personally meaningful artifacts. We design opportunities for people to "think with their hands" in order to construct meaning and understanding.

Decisions and designs that support a tinkering experience

Tinkering Studio activities and investigations are designed to encourage learners to complexify their thinking over time. The variety of materials and variables available for experimentation allow for learners to enter at a point where they are comfortable starting, and then alter and refine their designs as they develop new ideas. Tinkering activities are often fun, whimsical, inspired, and surprising.

Rapid Prototyping: Chain Reaction is an activity that emphasizes the importance of "messing about" with the materials and challenges of the contraption. Ideas and constructions come together rapidly due to the informal nature of the activity and the time limit. Testing out a tentative idea, in the moment of discovery, is a value for the Tinkering Studio and a way to demystify the process of rapid prototyping.

Cross-talk and collaboration: Chain Reaction allows for collaboration at many levels; small teams form ideas for the individual contraptions, then collaborate at a larger scale when the individual contraptions are linked together. The idea of contributing your ideas to something larger than yourself contextualizes the elements in a holistic way, and allows learners to view a variety of different strategies and solutions to common problems.

Multiple starting points and outcomes: The whimsical and creative nature of the activity offers an entry point for people who might be nervous about building something from scratch. Likewise, learners who are naturally drawn to constructing objects that do something become interested in adding their expertise to the mix. It is often surprising how diverse the chain reaction events can be even when drawing from a similar palette of physical objects. This activity reinforces the notion that each learner develops their own path of understanding and exploration, while all are utilizing a similar set of materials. In the end, every chain reaction is unique to the group of makers who collaborated to build it.

Environment (the elements of the space that support tinkering)

Learners often work with us for an extended period of time, so we try to create a warm and welcoming workspace with comfortable seating, sturdy worktables, and good lighting. We often display exhibits, or examples from past projects and current activities throughout the space to seed ideas and provide an introduction to what is happening that day. Materials are easily accessible and in close proximity to the tinkerers, and we often work at large, communal activity stations to enable cross-talk and invite collaboration between participants, allowing them to look to each other for answers and solutions.

Set up tables for learners to build on in the order (and location) that each contraption will ultimately be set-off. The size and position of the tables are important to ensure that there is enough space to build at each table. The meandering design of all of the tables connected together is another way to connect all of the contraptions at the end, and make sure that everyone has enough room to move around the space without bumping into one another. The proximity of the individual elements (as they take shape all around the room) offers everyone a glimpse into the variety of what others are trying to build.

When we host a Chain Reaction workshop in the Tinkering Studio, materials and tools are offered at tables along the outer edges of the workshop space so learners are encouraged to move around the room and encounter other workshop participants searching for materials or using tools. Interesting conversations occur and solutions are often found during these moments. We also support tools and materials to be used at the individual stations so it forces participants/learners to look around the entire space, and sometimes ask, "where is the hand drill, roll of string, or other material?" that are currently in use by someone else. It is a natural way for everyone to move around the workshop space throughout the construction and allows ideas to cross-pollinate.

We play ambient music in the room while people are building their chain reaction contraptions to create an environment that supports the focused work of the learners. We often find that having background music on during the tinkering activities helps to create a pleasant environment that people want to spend time in, even when faced with challenging ideas and constructions.

Facilitation (the things we say and do to support learning through tinkering)

Facilitation is a way of teaching where you support the learner's own investigations, questions, and ideas within the framework of an activity. In the Tinkering Studio, we strive to practice a kind of facilitation that respects the individual path of the learner. As facilitators, we watch and wait until the precise moment to jump in and offer a hint, a material, or a new way of looking at a problem. As educators, we allow learners to feel frustration and encounter moments of failure as they work with real materials to try to solve their own challenges.

There are many ways that the facilitator can influence the interactions with participants in an activity. We help people get started with the activity by giving a quick sense of the goals. We invite them into the space, and introduce the materials and tools they might use. We spark interest and sustain learner's engagement by asking questions about their work and responding to their answers. We support multiple outcomes of the activity and are open to the possibility of new ideas, different solutions, and changing goals of the individual learners. We try to practice a style of facilitation where we are not teachers who transmit knowledge to passive learners, but rather are guides and co-learners on a path to understanding.

The most important first step for facilitating Chain Reaction is to make sure that you have spent some time experimenting with the materials and set-up yourself, in order to develop a basic understanding about what the components do, and how you can get them to work. You might try to build one or two connected chain reaction elements with friends or colleagues as a way to find out what it is really like as a learner.

Chain reaction facilitation is a combination of supporting everyone's ideas for what they want to build, and offering sound suggestions for how to make these things work. Facilitators of this activity are constantly on their toes because everyone tends to come up with a different challenge for what they want to make and how they might build it, so it's important to follow the learners path toward making something meaningful, without imposing your own ideas (as a facilitator) about how you might do this. It's important to let the mistakes, failures, and ultimately successes to come out of this process naturally, and allow the learners to own all of this for themselves. Learners will pay more attention to the things that do and do not work if their idea is being explained.

An example chain reaction station is helpful to have ready at the start of the activity in order for facilitators to demonstrate the possible use of certain materials. It's important to show a way of creating a switch from simple conductive materials (tinfoil or copper tape). We like to show the switch example with a slow-moving motor to show how it can create tension and ultimately trigger something else. We usually try to include an example of rolling balls, objects tied to string, or other elements that indicate innovative uses of these materials to trigger something else in the contraption. The example is only referenced at the beginning of the activity (because we often need to use the station for two participants in the workshop). We make sure to make the example simplee-nough to hint at the possible uses of the materials without creating a high bar that others might not be able to meet.

Placing a compelling object at each station and asking that they be included in the chain reaction elements is a way to offer each group a starting point to focus on, especially for those that might have a difficult time getting started with a "blank slate" (an empty table). We often facilitate teams to see what they can do to get this first object working, and then ask them how they might use other materials in the room to trigger that object to do its thing. This is a good way to facilitate the development of an understanding of how the materials in the room can be used in the chain reaction.

Sometimes the best early facilitation strategy is to be a helper. You might run and grab a specific tool or material for the learners, or you might give permission to cut, glue, or change an object or component. And often, your willingness to support the learner (in what are sometimes crazy ideas) will go a long way toward setting the expectation that you are interested in helping them think outside the box.

One technique that we use as facilitators midway in the page is to point out some of the interesting movements and accidents that you see happening. Asking about these things indicates that you are carefully watching what is going on and that you are interested in it. It also allows you an opportunity to talk to the learners in a way that helps you develop an understanding about what they know. If you ask for specifics about the construction or why a certain thing behaves the way it does, it helps the learner to articulate why they think it is working that way and how confident they feel about it.

When the time has come to set off the Chain Reaction, the facilitator's role is more like that of a master of ceremonies. We often walk through the entire chain reaction with the group, asking each team what they designed and how they expect it to work. This helps in two ways: 1) it helps to build an expectation in the rest of the group for what is about to happen, and 2) it helps you, as the facilitator, to refer to what is supposed to work as you the chain reaction is underway. Sometimes a component will fail or work more slowly than expected, so it is helpful for you to remind everyone what is supposed to happen at each stage.

Chain Reaction examples:

A large public event
https://vimeo.com/36385358

Professional Development workshop
https://vimeo.com/115017905

In the Tinkering Studio with visitors
https://vimeo.com/122596112

The "making of" a Chain Reaction
https://vimeo.com/102882775

After the chain reaction has been set off, it's time to get a few people in the group to say something about their process. What were the things that were tricky in this activity, and what did they do to get themselves past the tricky bits? What were some of the things that others appreciated about the elements, and what might some of them do next, if given another hour or half day? These types of discussion prompts can help start a conversation to reflect on the process of building the chain reaction contraption.

RELATED TINKERING ACTIVITIES

Activity Connections
Try these related activities to develop your own repertoire of tinkering experiences.

Toy Take-Apart: Collect discarded mechanical stuffed toys and dissect them to find battery packs, switches, sensors, and motor-driven mechanical elements similar to the parts used for circuit boards. You can use the circuit board components to test the things that you find inside, and some of these parts can even become new circuit board blocks.
http://tinkering.exploratorium.edu/toy-take-apart

Circuit boards: Tinker with electricity using common objects: batteries, lights, buzzers, motors, switches, and more. This activity provides an introduction to exploring circuits, especially using switches, before building a Chain Reaction.
http://tinkering.exploratorium.edu/circuit-boards

Light Play: Use common materials in unusual ways to create kinetic light and shadow vignettes. Individual vignettes, carefully constructed using point source lights and slow moving motors, are eventually combined into one large light and shadow play wall. Like Chain Reaction, the final result is collaborative in nature and unites the individual components that make it up.
http://tinkering.exploratorium.edu/light-play

ARTIST CONNECTIONS

inspiring connections to the Chain Reaction activity

Peter Fischli and David Weiss were an artist duo that had been collaborating since 1979. They were among the most renowned contemporary artists of Switzerland. Their best-known work is the film Der Lauf der Dinge (The Way Things Go, 1987), described as being "post apocalyptic", it concerned chain reactions and the ways in which objects flew, crashed and exploded across the studio in which it was shot.

http://en.wikipedia.org/wiki/Der_Lauf_der_Dinge

Bruno Munari was an Italian artist, designer, and inventor who contributed fundamentals to many fields of visual arts (painting, sculpture, film, industrial design, graphic design) in modernism, futurism, and concrete art, and in non visual arts (literature, poetry) with his research on games, didactic method, movement, tactile learning, kinesthetic learning, and creativity. His Machines drawings are whimsical explorations about making the mundane spectacular.

http://www.corraini.com/munari.php?lang=eng

PythagorasSwitch is a 15-minute Japanese educational television program by NHK, which aired since 2002. It encourages augmenting children's "way of thinking". During the beginning, ending, and between each corner (segment), there are Pythagorean Devices, known in the US as "Rube Goldberg machines", or in Great Britain as "Heath Robinson" contraptions.

http://www.youtube.com/watch?v=nAWnWGaOoWc