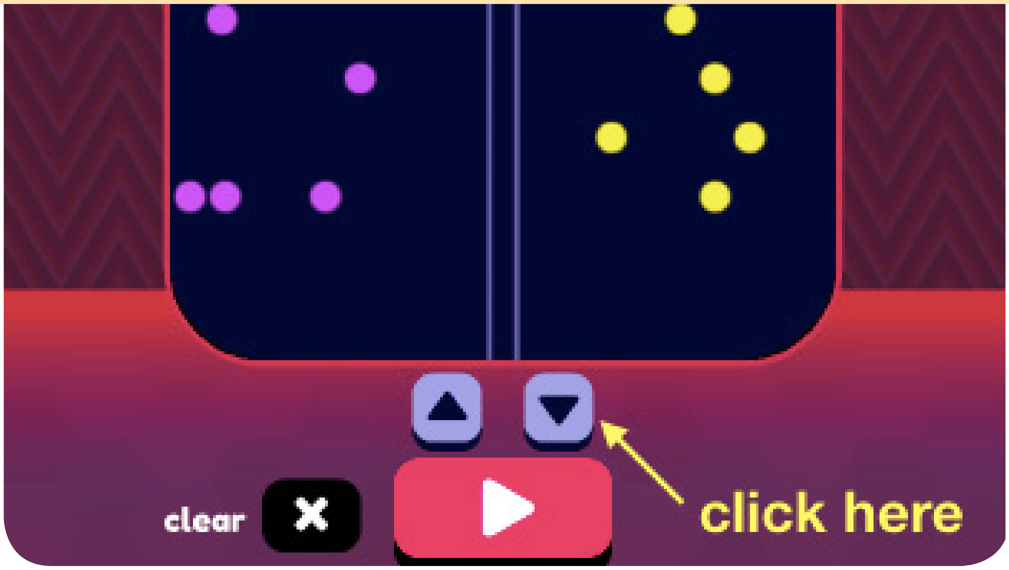
Thermonator: The Matter Maker

Thermonator: The Matter Maker is an engaging and educational app designed to help children see their own theories about how states of matter change from solids to liquids to gases. Using Thermonator to change the speed, bounce and attraction of small particles, children create different patterns of particle interactions to express their current understanding of how this micro-world work.



Getting to Know the App

Begin with the tutorial video at http://short.concord.org/88 that introduces how the Thermonator works. Stop the video at various points to allow children time to digest what they have seen or to ask questions. The video shows how the controls change the way the particles behave: speed, attraction, bounce, and gravity. The controls cannot be changed while the particles are moving. To change these settings, pause the simulation. These details will become clear after you watch the attached video.

What it Teaches

The Thermonator allows children to design animated events. Since the particles (yellow and purple dots) in the display can move according to the children's selections and input, the children can check out their assumptions about how the microscopic world of particles behaves and why it changes. Ultimately, the Thermonator can help children learn how physical variables such as gravity, speed, attraction, and bounce determine if a solid comes apart to flow as a liquid and likewise if a liquid become a gas.

Navigating the App

Allow the children to control the behavior of the particles. Calling the dots "particles" will reinforce that idea for subsequent lessons on states of matter and why states of matter change. At some point suggest that the children begin with two particles of each color.

You might say something like this, "Okay, now it is your turn to make the particles move and change. Try the controls, including dropping the barrier. In about 15 minutes I will ask you to show me some event that you have designed that you find interesting or fun or surprising. It can be anything. You have to make it happen a second time, so I can see it. So, in other words, I will ask you to erase what you have done and reset all of the controls to zero. Then I will ask you to make the particles do what it was that you liked."

Try not to set goals for the children during this free play. Just listen to what they are trying to do and give them suggestions on what might make the imagined event happen. Or, make a descriptive comment about an action that you see, such as "the yellow particles are moving faster than the purple particles."

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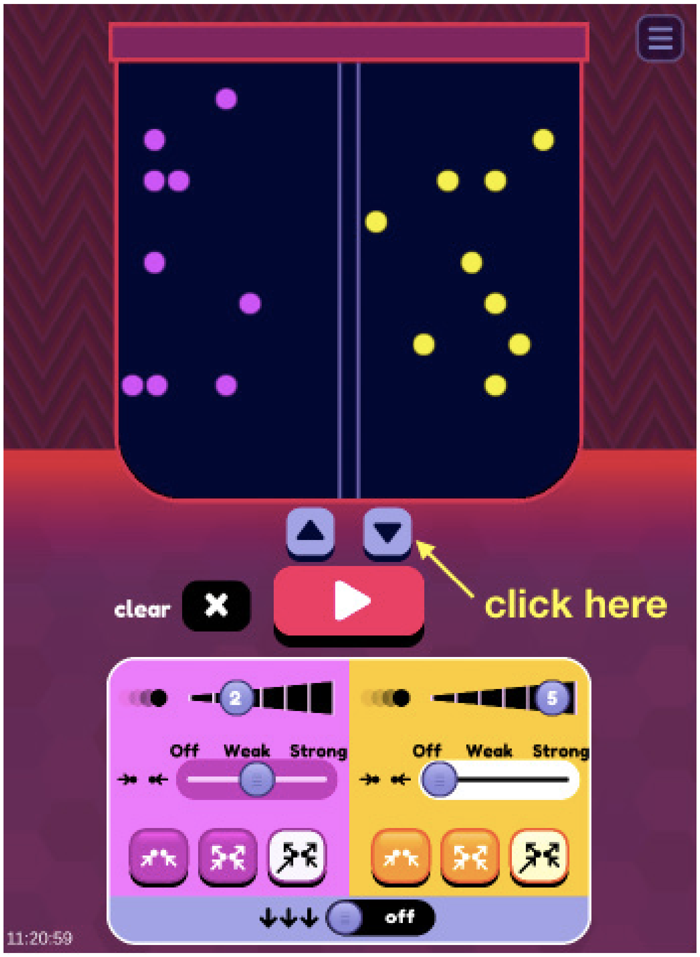
This free play session should help children develop a level of fluency with the Thermonator. Look for a shift from moving the controls without any expectations as to what will happen to reasonably accurate predictions. For example, children might predict what will happen to the particles if gravity is turned on or off. Look for statements such as, "I want the particles to ..." or "they are going to stick together when I do this." At first children may try all of the controls without any expectation about what actions the various settings control. Eventually they should make the shift to trying to make something specific happen. Keep a record of what they found interesting.

How it Works

The Thermonator works by tapping and sliding the icons on the touchscreen display. All action of the particles occurs within a container with a lid. The container is divided by a barrier that can be lowered at any time. Begin the animation with 2, 5, or 9 purple particles or yellow particles, or any combination with both purple and yellow particles. If two colors are selected, the yellow particles appear on the right side and the purple particles on the left. The behavior of each colored set can be controlled independently of the other set. The variables can be changed only when the animation is paused. The user can replay, edit, or erase an animation.



Encourage children to start with different settings for purple and yellow, watch what happens separately, then drop the barrier.

Talking About Discoveries

Select a few examples of sample experiments the children tried with the Thermonator and replicate them for the whole class to see. During this time, develop a way to talk about these kinetic events. For example, to describe how the yellow particles are flying around, rapidly bouncing off the walls of the container, you could say, "It looks like the yellow particles might escape from the container." In this one sentence, the event is framed as a gas in a closed space that would escape if not for the lid at the top. Use the following questions or comments to guide discovery and discussion:

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C: I made my particles go very fast.

T: Did you have any slow particles mixed in with fast ones?

[This yes/no question helps to initiate additional questions.]

C: My particles just hit and then stuck together.

T: Does anyone know what to change so they don't just stop when they touch each other? [The bounce button helps and the attraction should not be too strong.]

T: Did anyone play with just one yellow and one purple particle? What did you notice?

C: I noticed that after a while the fast and slow both moved at the same speed.

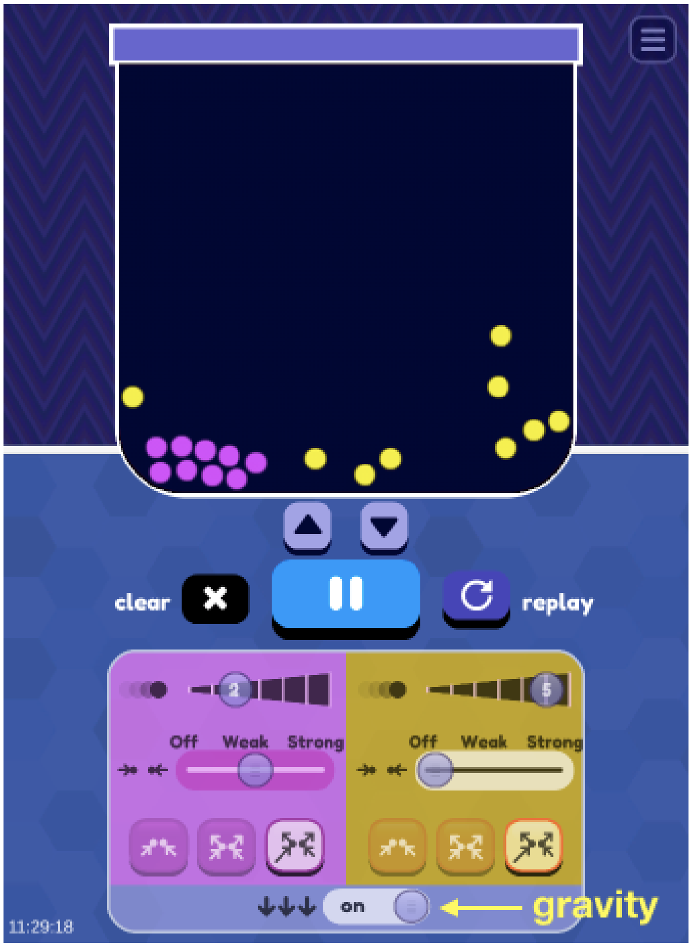
T: That's very interesting. Anyone have an idea why that happened? [This would happen only if the bounce button was set to "change speed after bounce," which is the third bounce button. This eventual equilibrium of speed becomes more interesting and visual when the child has added many particles, some fast, some slow.]

C: I like how my dots stayed close together but were still wiggling.

T: And what could you change so they would wiggle less? [Reducing the speed of the particles to zero would make particles wiggle less.]

C: I like it when the barrier keeps them apart.

T: Can you think of anything that you already know about that would keep fast particles separated from slow particles? [Children might mention clothes that keep the cold slow particles away from our warm body of fast particles. Listen for any comment that reveals the child's assumptions about mixing or not mixing hot and cold things.]



Before children hit the play button, ask them to predict, such as what will happen if gravity is turned on.

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Supplemental Activity: Melting at the Microscopic Level

What to Do

At this point we focus on how matter changes states, in this case, solid to liquid. Begin with the attached video showing wax crayons melting when a flame is place near them. Now show the attached video where Thermonator shows melting of a solid This video shows that the yellow particles (warm air) are moving fast on the right side. The purple particles (crayon) are clustered together and wiggling slightly as a solid on the left side. The settings of the Thermonator controls are hidden with a piece of paper. When the barrier is lowered the fast yellow particles start to bump the purple particles. The purple particles start to break apart and flow at the bottom of the container like a liquid. The fast air particles collide with the particles in the solid and make them break apart but they still stay near each other.

Show the video a second time and ask children to watch carefully because they are going to try to make this happen using Thermonator. If there is more than one child, have them work in pairs to increase the chance that they will think out loud.

Purpose of Activity

The Thermonator derives its power as a thinking tool from the fact that children can create events that are wrong from a scientific view. If children can create a clear representation of their incorrect assumptions, they are better able to spot inconsistencies. Thermonator makes their thinking visible so that children can reflect better on the implications of their assumptions. For instance, when a child says, "The particles did not cluster at the bottom when I turned on gravity," the child may think about other ways to cluster the particles, such as increasing attraction or decreasing speed.

What to Notice

Be alert to the difference between thinking skills and technical skills even though these overlap. If the child says, "I want the purple ones to be at the bottom," but does not know how to do that, the child is developing process knowledge. On the other hand, if the child says, "I want the particles to bounce and I don't remember which one makes that happen," the problem is technical, not conceptual. The first child is indirectly asking, "What process makes particles become a solid?" while the second is asking, "Which button makes the particles bounce?"

It may take a lot of trial and error to get the purple particles to cluster and become solid wax again. Children may understand that speed should be set to slow, but they will need to factor in the role of attraction. If attraction is too strong, the fast yellow particles will not be able to break the solid into a liquid. This is the purpose of the Thermonator: to help users understand that a single effect can be determined by multiple variables.

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This material is based upon work supported by the National Science Foundation under Grant No. DRL-1621299. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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