KENAN FELLOWS PROGRAM
FOR TEACHER LEADERSHIP

Dough! Stick with it - A Recipe for Success?

Description:
Students will explore the states of matter, and collaborate to design a recipe to make the perfect dough. They will need to use what they know about balancing solids and liquids to find the best recipe.

Quick Links within the Lesson

Introduction:
Through this week, students will explore their previous understanding of states of matter and take it to the next level. After discussing descriptive words and observable traits relating to liquids, they will have the opportunity to try and match their way to the perfect recipe.

Curriculum Alignment:
3.P.2.2 Students know that all matter exhibits properties. Students know that matter can be differentiated based on properties. Students know that gases, liquids and solids are all made up of particles, but the behaviors of these particles differ in the three states (gas, liquid, solid). Students know that solids, liquids, and gases (each) display unique properties characteristic of that particular state (phase) of matter. Students also know that the characteristics of particular states influence the functional applications of a given material.
3.P.2.3 When heat is applied to an object the particles in that object begin to vibrate more rapid. They also begin to move further apart. As the particles move further apart the object may change form

*Math and ELA content knowledge will be applied, but not assessed.

Objectives:
- Students will be able to explain the different behaviors of particles in the three states.
- Students will be able to explain the properties of various liquids.
- Students will be able to justify their reasoning and communicate their ideas.
- Students will be able to compare measurements.

Safety:
- Be aware of student allergies
- Discuss proper way to conduct a 1 finger touch of the materials

Time & Location:
5 x 45 min lessons (in classroom or lab)

Student Materials: for playdough
- Computer or Ipads - 1 per student to document process
- Miscellaneous liquids (lemon juice, corn syrup, molasses, dish soap, etc)
- Flour
- Salt
- Water

Teacher Materials:
- Laptop & projector
- Sorting Sheet (below)
- Recipe slips - cut up the recipe to have separate slips for each (below)
  - Numbered steps
  - Measurements
  - Ingredients

- Food Coloring - Plastic Baggies - Tupperware Containers - Spoons or popsicle sticks - Measuring spoons - Measuring cups - Student notebook - 1 per student - Paper plate If making gak, slime, ooblek, silly putty (see recipes links below for ingredients)	- Wonderopolis article (electronic or paper) *http://wonderopolis.org/wonder/who-invented-play-dough* - Self Assesmsent Rubric (below) - For reference: Making Science Make Sense - Spooky Slime

Student Prior Knowledge:
Students have learned about states of matter in 2nd grade and have background experiences. They can connect their learning to their weather unit with water changing between states. Students understand the phase changes, and have begun exploration of physical/chemical changes, as well as mixtures/solutions.

3rd Vocabulary:

- Solid - a state of matter with a definite shape, volume, and mass; it's molecules vibrate slightly but this lack of movement allows it to keep its shape
- Liquid - a state of matter that is like water, it has no definite shape, but definite volume and mass; its molecules are sliding past each other, allowing it to flow (although at different rates)
- Gas - a state of matter that is like air, and has no definite shape; its molecules are spread out, full of energy, and moving around in random directions
- Viscosity - The rate and nature in which a substance flows, this may vary due to temperature or pressure.
- Polymer - Natural and/or synthetic substances that has a molecular structure consisting of a large number of similar units bonded together; used in making plastics, concrete, glass, and rubber.
- Molecule - The simplest unit of a chemical compound that can exist, consisting of two or more atoms held together by chemical bonds.
- Mixture - combining any substances that can still be separated using a filter system, (i.e. sand in water, gravel of different rocks)
- Solution - combining substances that cannot be separated, typically involves dissolving, evenly mixed together. Solvent is the substance dissolving the other, solute is the substance that is disolved. (i.e. salt water)
- Physical Change - changes to the physical properties of matter (i.e. freezing, melting, condensation) typically can be reversed or separated. Phase changes. Classified by their physical characteristics (using 5 senses)
- Chemical Change - changes to the chemical properties of matter, forms a new type of matter (i.e. burning or rusting, vindegar baking soda, mentos coke)
- Energy - affects the state of matter. The more energy in the matter, controls the molecules and their movement. Determining factor of states of matter. Emphasize the transfer of heat energy.

Teacher Prep:
Organize materials in sample containers so that students may explore. It is helpful to set up trays to stay organized by group. Model for student notebooking to support student learning.

Desired Outcomes:

- Students understand the relationship between solids, liquids, and gases. This activity will challenge their definitions to encourage them to think about the real properties of each, and the interaction

between the different states. They will work together to support their ideas with fact and reasoning.

- Collaboration - Working in teams, they will need to come to a consensus as to how they hypothesize the recipe should be made. It will require them to speak and listen respectfully and find a way to compromise.
- Creativity - There isn't just one process for these recipes. Discussing failure and the need to improve and keep learning should be addressed, emphasizing that playdough was actually made by accident, a "failure" to begin with.
- Communication - Students will need to be able to communicate verbally and in writing to best convey their ideas. They will need to communicate their opinions and ideas, as well as writing a descriptive detailed recipe (how to writing).
- Critical Thinking - Depending on ability, this can be adapted for them to compare the different measurements, the ingredients, and possible outcomes. This allows for varied student outcomes, thus creating a need for reasoning, analysis, and evaluation - higher level thinking skills.

Student Roles
Project Manager - leader oversees
Data Analyst - records the results and reflections of the group
Communications Manager - only one who can talk to the teacher
Chemist - measuring and combining the materials

3rd grade:
Day 1: Ask & Imagine (Engage, Explore)

Teacher Learning Goal: Students will discuss and realize the differences between liquids, to better understand they have similarities on the molecular level, but can vary greatly. Students will focus on their descriptive conversation and observational skills.

(10 minutes) To begin, it is helpful for students to do a brain drain about solids, liquids, and gases to check and make sure there aren't any misconceptions and that we have a clear understanding of the properties for each. This can be as an entire class on the whiteboard, on student ipads, or in their notebooks. This may be in the format of a thinking map, table, lists, or venn diagrams.

(25 minutes) Students work in teams to begin to explore the mystery liquids. To begin, have each student draw a 3 column table in their notebook and label the top row: Sample A, Sample B, Sample C. This is where they will record their observations. To further support, have them divide the space to allow rows for each of the senses you are asking them to use.

To introduce this session discuss how students observe the different liquids using our senses (depending on the samples, determine which senses you can use). If students need additional structure, consider putting liquids in a clear sealed container to allow them to shake the liquid.
Sight/Look … What do you see? What do you notice? What color is the liquid? Is it transparent? Is it translucent? Is it opaque? How does it move in the container? Does it flow quickly? Does it flow slowly? What does it remind you of? Do the bubble stay in the liquid when you shake it? Does it leave residue on the side of the container when tilted? Is there variation in the color?
Touch/Feel … How does it feel? What do you notice? Is it sticky? Is it slimy? Does it stay on your finger? It is gritty? Is it hot? Is it cold?
Smell … What does it smell like? Does this help you make a hypothesis? How can you describe the smell? What does it remind you of? (this observation will give you great insight into their past experiences)
Taste… OPTIONAL depending on your samples. What does it taste like? Is it sweet? Is it salty? Is it bitter? Is it sour?

Hear/Sound … What do you hear? Does it make a sound when it is not moving? What do you hear when you shake it? Are there bubbles?
Learning Teams should spend about 5 minutes with each sample, and have the time to observe 3 different samples.
During this time, students will record their findings, while talking with their group, in their notebook. Students should display higher level of academic language to explain their observations. To modify, provide students with sentence stems to encourage those who need the additional support. You can provide sentence stems at varying levels of depth to structure their conversations.
Sentence stem options:
Sample ____ reminds me of _____.
I noticed _____.
I observed that _____ using my sense of _____.
I think this is similar to _____ because _____.
I agree with _____ that _____.
I respectfully disagree with _____ that _____.
I think this is different than _____ because _____.

(5 minutes) Students have quiet reflection to finalize their thoughts, and come to a hypothesis about each sample they explored. This is the time to complete an exit ticket, each student writes on a stick one of the samples they observed, two descriptive observations, and their hypothesis as to what that liquid sample is. This is also the time to clean up.

(5 minutes) Allow students to share their findings all together, comparing and contrasting the different liquid samples. Facilitate discussion to come to conclusions about each sample. Reinforce student usage of vocabulary and descriptive language.

Afterward - Teacher Action: Review their braindrains in their notebook to find commonalities and misconceptions. Prepare SLG sort, ingredient materials, and measurement mix up.

Day 2: Plan (Explanation)

Teacher Learning Goal: Students will communicate their ideas and opinions regarding the consistency and matching of measurements to ingredients for their recipe. Students justify their reasoning and find ways to persuade their team to find a consensus.

(20 minutes) Depending on students previous understanding (established during day 1) students may either complete the Solid Liquid Gas (SLG) sort, or write their combined knowledge with their team on a blank piece of paper. You may differentiate depending on the level of knowledge and writing skills of your students.
If sorting: As a team, they will discuss the various facts to determine which state it is referring to. Using the iPads, each team should create a slideshow of some kind and narrate their explanation of each state of matter. Extension: students give examples of the different states, and may discuss the changes that occur when going from one state to the next.
If writing: On the board, students should address their knowledge of these states relating to: shape, volume, mass, molecules, etc. As a team, they will discuss the differences and make a graphic organizer to connect their understanding of the different states of matter. Extension: Students provide examples of each and explain what processes occur when changing from one phase to another.

(5 minutes) Each learning team is given a tray of the ingredients in sample amounts. Provide time for the students to observe (as they did the day before) to discuss the different ingredients. For playdough, students should receive a small cup of flour, of salt, and of water (they do not need to explore food coloring). At the

lowest level, identify which state of matter each ingredient is in, at the higher level, predict what might happen when adding the ingredients together; do they predict a chemical or physical change? Will it be a mixture or a solution?

(5 minutes) *Scaffold for groups in need of more steps:* Provide each team the slips of paper with measurements, and measuring cups and spoons. As a team, they should put the measurements in order from least to greatest. This will require them to compare fractions, as well as comparing the units of measure. At this point, all responses should be the same. Discuss for a minute as a class the process for comparison. Extension: bring up conversations between the different units.

(5 minutes) Then provide each team the ingredient slips of paper. As a team, they will need to decide, when making playdough, what measurement will you need for each ingredient (may or may not explain that each measurement is only used once. Students discuss why they think they need more or less of an ingredient, support with sentence stems:
I think that we should use _____ of _____ because the recipe _____.
I respectfully disagree, because I think _____.
I agree with _____, because _____.
* This should not be a voting process, support conversation to reach consensus. Have students rely on past experience if possible. Students may realize with “1 drop” that this would match with a liquid.

(5 minutes) Then provide each team with the numbers, and have them consider the order in which they are combining their ingredients, as this will change the outcome. (This often allows you to see who has cooked or baked before.) Discuss sequencing, the process, and how to.

If creating more conversation, varied outcomes, and problem solving: You can provide all of the above at once, and have students sort it out. This choice depends on the classroom culture and level of need for support. Provide each team a set of measuring cups and spoons, specific to the measurements of the recipe, as well as the matching slips of paper for steps, measurements, and ingredients. Bring the discussion back together for writing.

(5 minutes) Quickly, have students write down their recipe in their notebook at the top of the page in list form.
i.e. 1. ¼ c flour
Class Discussion: As a shout out, have students share to make a collaborative list on the board of transition words, then verbs that might be used to combine the ingredients.
(transition words: first, second, then, next, after, etc.)
(verbs: mix, add, pour, combine, stir, fold, knead, etc.)
Students should then write their recipe directions, note the difference between a list of steps and the specific directions/procedure for making the recipe. Possible support, show a recipe on the board for chocolate chip cookies and note the transitions and verbs used to describe.

Optional: Share with students that another team will be following their recipe and assessing their directions.

Afterward - Teacher Action: Review their recipes, may use as an informal assessment of how to, sequencing, or procedural writing. Prepare set up for measuring ingredients (containers, stirring utensil in a tupperware, or in a plastic bag - label in advance for teams).

Day 3: Create (Elaborate)

Teacher Learning Goal: Students will collaborate and take turns to share in the learning. Discussions should include academic vocabulary as students observe what is happening as they create their recipe. Students will reflect, teacher may differentiate to support their reflection.

(15 minutes) Whole group: Demonstrate and discuss with your class the importance of accurate measuring. How do we measure liquids? How do we measure solids? Show students how to make sure that the measuring tool is level at the top and the difference between having holes and heaping. This inaccuracy will change the results of your product. May have students practice and connect to their math standards for measurement. Emphasize that we are measuring volume, and the units of measurement that are connected with volume. Discuss the difference between different units, i.e. tablespoons versus teaspoons. Might even share some conversions. *Playdough recipe requires ⅛ c, and standard measuring cups do not include this. Without accuracy, we could measure half of ¼ c, or convert it to 2 tablespoons.

(20 minutes) In teams: Students will open their notebooks to their recipe. May assign roles to the members as to which ingredient each person will measure and mix. To facilitate measuring you may:

- Have them take turns coming up to you to measure and add one ingredient at a time, then go back to their seat and observe what happened.
- Have each group with access to materials at their table and they can measure and progress through their recipe
- Have cups of ingredients pre-measured so that students can come up and get their specific recipe
- Prep trays to provide measured ingredients to each team according to their recipe, and they go through the directions to mix in a specific order

After mixing, students write a reflection statement about their recipe and their product. May support with sentence stems if needed:
Our recipe was too _____ because _____.
One measurement I think we had correct was _____ because _____.
One change we need to make to our recipe is _____.
Our team worked really well together by _____.
Our team can improve our collaboration by _____.
I can improve by _____.

Extension: Respond in their notebook or discussion with their team:
Is your product a mixture or solution, and why?
Was this a chemical or physical change, and why?

(5 minutes) Clean up

Afterward - Teacher Action: Observe each group's product and make note of successes and need for improvement. Make a table to show the class each team's recipe so that they can view it on Day 4 with the outcome.

Day 4: Improve (Evaluate)

Teacher Learning Goal: Class will have productive conversation about learning from failure and the importance of improving. Students will support their opinions with evidence. Teams will be able to plan improvements based on observations.

Arrange students in a circle with recipe results in the middle and/or an image of each projected on the board.

Teacher Notes before discussion: Emphasize in discussion that it is not the best and the worst, but direct

conversation about what worked well, and what did not give us the results we were going for. Correct the perspective that "we did it wrong" and "we got it right;" this is a scientific process, and if you are creating this for the first time, there is a learning opportunity with every result. As a class, each group may have done the recipe differently, which is very helpful to the entire class to learn from each group's product. If a group was completely off on their recipe, it is very helpful to explain their thinking and celebrate the learning opportunity. Do not celebrate failing, but rather celebrate moving forward and learning from the experience. We do not need students to strive toward failure or get excited about it, but failure only truly occurs if the students give up. This improvement process and evaluation may be the most important part of this lesson.
Option for a speaking and listening grade: have students facilitate the conversation as a padeia or socratic seminar - begin with the common samples, and allow for silent observation or pass around the samples and have them do a gallery walk. OR provide students this article to understand that playdough was an accidental invention. Track their comments/contributions, and frequency of speaking. Facilitate rather than control the conversation.

(25 minutes) Discussion: Who invented play dough? Provide students with the article or do a class read on the board of Wonderopolis article: Who invented play dough? Discuss briefly that this entire product was an accidental invention, and so as we look at our different recipes and different outcomes, we wonder, "maybe we have created a new product." That being said, there isn't a right or wrong answer, just more desired outcomes if we were trying to create a play dough product.
Questioning to facilitate conversation: (in no particular order)
What do you notice about each sample?
Comparing the recipes, what are the differences between? What are the similarities?
Is there a combination of steps, measurements, and ingredients that are the same?
These two were the same recipe, can you compare their results?
Is there a combination of steps, measurements, and ingredients that we did not try?
Thinking of your experience, what did you think worked well with your team's recipe?
Thinking of your experience, what would your team improve if creating the recipe again?
How might temperature have played a role?
Are these mixtures or solutions? Why?
Was this a chemical or physical change? Why?
What surprised you about your recipe?
What worked well in your recipe?
What did not work the way you had planned/imagined? (were they accurate in measuring?)
What about the dispersal of the food coloring? -- if time, demonstrate a drop of food coloring onto salt or floud versus a drop in water.
How do you think the process, or order of the steps made a difference?
Did anything dissolve?
Was any ingredient absorbed?
Why do you think Sample ____ turned out different from Sample ____?
Is your sample different today, than it was when you left class yesterday? Did anything happen to the samples over last night?

(15 minutes) After having this discussion, I want to allow your team to make changes or improve your recipe. Teams go back to their tables and on their next clean page, or on the iPad, write/record:

- The steps of your improved recipe
- Explanation of why you are changing the order or measurements
- Encourage students to document their process through reflection or drawing/taking pictures of their results

(5 minutes) Preview for tomorrow, teams will have the opportunity to make their improved recipe and see if they got closer tot he desired outcome. Take this time to wrap up and clean up.

Afterward - Teacher Action: prep materials as before for students to be able to create their new recipe.

Day 5: Improve (Evaluate)

Teacher Learning Goal:Teams will have another opportunity to collaborate and create the product. Students will be reflective, and able to articulate strengths and weaknesses of their collaboration, communication, product, and overall participation in this challenge. Students will act as materials engineers to evaluate their product.

(5 minutes) Ask teams to take one final look at their recipe and make any last minute changes to it or add to their reflection. Extension - may have teams write the directions emphasizing that they think about the process, how does that impact the product? How does the warmth of their hands or the stirring affect the recipe? How long should they mix?

(15 minutes) Teams follow their improved recipe to re-make the playdough. Make observations about team collaboration this time, versus the first time.
(5 minutes) Allow teams to take their product out of the container and place on a paper plate. Have them use observation and descriptive words to explain their product.

(10 minutes) Provide each team with a piece of commercialized Play Doh. Have students compare (with their team, as a class, or individually) their product to Play Doh.
What do you notice?
How do they smell? Alike & differet
How do they feel? Alike & different (wetness, dryness, stiffness, ability to hold its shape)
How do they look? Alike & different

Optional: Have students compare through materials testing:
- Shake in a container - what happens?
- Gravity/Stretch test - does it break apart or stretch?
- Shape - using a cookie cutter or form it into a shape, does it hold that shape?
- Container test - how long until it flows to take the shape of the container?

(10 minutes) Team discussion or individual opinion writing: Have students determine what state of matter playdough is, justify their answer with facts about SLG.
Student self-assess: Complete the rubric for self-assessment of collaboration, learning goals, and product outcome. Reflection statement.

(5 minutes) Close out the lesson. Keep products for extension learning, or allow students to divide into equal shares and take home. Clean up.

Variations:
- Have teams follow someone else's recipe, have them provide feedback about what the other team did differently and the clarity of their directions.
- May focus on ratios with their recipe rather than specific measurements (i.e. 1 part glue, 3 parts water, 2 parts flour)
- Multiplying fractions: Adjust the recipe to involve more fractions, have the students rewrite the recipe for a double or triple batch. What if we made it for the entire school? How many boxes or containers would we need of each ingredient?
- Observe your product 1 day later, 7 days later, 1 month later. What changes to you see? (evaporation, mold/chemical change, condensation, separation, etc.)

- Create a storage container to keep the recipe in, will it mold? Will it dry out? Will it separate?

Assessment: - Notebook entries/Written response - Exit Ticket (day 1) - Student Self Assessment/Reflection - Teacher observation	**Resources**: *you can use any of these recipes, the detailed plan was refering to playdough - Playdough -- need boiling water - Chapstick - Bouncey Ball - Ooblek - Silly Putty Wonderopolis - *Who Invented Play Dough?* *http://wonderopolis.org/wonder/who-invented-play-dough*
Kenan Fellow: Linnea Gibson Magnet & STEM Coordinator Conn Magnet Elementary School of Entrepreneurial Design Wake County Public School System 5 years	**Mentor**: Daneille Mayber & Casey Allen Communications Bayer Crop Science Division, RTP

Questioning:
Remembering: What are the three states of matter?
Understanding: How do they change states? What controls the state that matter is in?
Applying: What examples can you give of different phases of matter?
Analyzing: How were you able to improve your product?
Evaluating: In what ways is your product better or worse than the store bought? What worked well with the recipes?
Creating: What is the perfect recipe for your product? Justify your answer

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(solid liquid gas sorting sheet)

Solid	Liquid	Gas
Holds its own shape. Definite shape.	Takes the shape of the container	Takes the shape of the container
Has mass (you can weigh it)	Has mass (you can weigh it)	Does not have mass
Has volume (takes up space)	Has volume (takes up space)	Has volume (takes up space)
molecules are tightly packed, keeping its shape. Particles very close together.	molecules are able to slide/move past each other, taking the shape of it's container and able to flow.	molecules bounce off each other with complete freedom of motion. Particles are farther apart. A lot of energy.
Little energy.	Medium energy.	High energy.
Can melt to a liquid Can sublimate to a gas	Can freeze to a solid Can evaporate to a gas.	Can condense to a liquid. Can become solid through deposition.

(play dough recipe chart - cut along the rows and columns to have 12 separate slips of paper) You could do this with any of the linked recipes.

1.	¼ cup	water
2.	1 Tbs	Oil
3.	1 cup	flour
4.	⅜ cup	salt
5.	1 drop	coloring

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(student self assessment) *please note students are not evaluated on their outcome, but rather the process. Please adjust to reflect additional expectations or goals for your students.

Name: _____ Team: _____

Statement	1 Not at all	2	3	4 Model example
My team worked well together to create a product. - We did not argue - We were all involved - All of our voices were heard				
I worked well to collaborate with my team and participate.				
My reflections addressed multiple (at least 3) of the question prompts.				
I have shown I understand solids, liquids, and gases through my reflections and writing.				
I have participated in class discussions and shared my ideas, while supporting them with facts.				
My notebook entries are complete - I have both recipes written and the procedure written for our first attempt - I have pictures drawn				

What was the biggest challenge about this experience? _____

_____

_____

What is one thing you learned about states of matter? _____

_____

_____

What is one thing you, personally, would do differently? _____

_____

_____

What is one strength you demonstrated during this process? _____

_____

Anything else I need to know about your experience, please write on the back.