Nurturing Nanoscientists

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This curriculum unit is recommended for:
Science - Kindergarten through Fifth Grade

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Teaching Standards: See Appendix 1 for teaching standards addressed in this unit

Synopsis: Children come into science class expecting potions and magic, unfortunately, they never get the massive explosions, mad scientists and doves appearing out of nowhere. Luckily, we have the opportunity to show them the "magic" that explains our everyday world. Recently though my ideas for exploring matter have come up dry and mundane. Until I learned about nanoscience and realized that elementary aged science, concepts lay the critical foundation for explaining the unseen. This unit contains activities to be used as demonstrations, with small groups, cooperative groups or pairs depending on the age level. Each activity is directly linked to the essential standards for science in kindergarten through fifth grade. While the activities are the same I have given the direct correlation to each grade level that the nanoscience activity demonstrates. Remember to always assess the specific objective but encourage the critical thinking, guide them with questions to ask more questions and speculate answers. Encourage the out of the box thinking and thirst for more information. As their science teacher it is ok not to know all the answers to their wonderings, that is the nature of science.

I plan to teach this unit during the coming year to 80 students in Science Lab to 2nd grade.

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Introduction and Rationale

Facilitating science instruction for elementary aged students is a unique opportunity to nurture critical thinking. While science content is, what many believe is the most important part of science instruction, it is how we lead our young scientists to obtain and think about this information that far exceeds the facts. 21st Century Skills are a critical component to well-rounded science instruction. If we provide abundant opportunities for children to ask and answer their own questions in a safe environment, their self-confidence will develop to solve future problems and obtain whatever facts they seek. Year after year, I struggle with developing quality activities that reach these goals for my students to interact with the states of matter. They are engaging but students are not connecting to the lesson. Learning more about nanoscience has allowed opened my mind to alternative activities that connect our students to properties of matter.

Careers of the future are unknown but regardless of their nature, employees need to be critical thinkers with people skills. The potential that lies within the nanoscience world is still vastly unrealized. Current work in this field is very promising and exciting for our future but we have no way of knowing where it will lead us, or our students. Learning about nanoscience has made elementary science curriculum even more critically important to facilitate, it has opened my eyes to even more opportunities to share with my students. Building future Nano scientists begins before kindergarten and each year provides a necessary building block that changes their thinking and how they see the world.

This unit includes activities that to be used with any age level with direct connections to the specific grade level essential standards. Based on the grade level and students the activity can be a presentation, facilitated in small groups or partners. If needed for enrichment or support the teacher can look to the other grade level connections/vocabulary etc… provided to assist their learning. The activities are focused with science as the subject base but can be used to enhance critical thinking and practice interpersonal skills.

My unit will provide activities to foster critical thinking, interpersonal skills and the foundations for exploring/investigating nanoscience concepts. Due to the nature of Essential Standards for Science nanoscience spans across all grade levels. Refer to *Appendix I: Teaching Standards* for the detailed description of specific standards. I will provide strategies to be implemented across grade levels and activities written to support specific standards in each grade level.

Content Research

Nanoscience

Nanoscience begins with scale, think of the smallest thing you can think of and then break down even smaller. That may or may not be small enough to be categorized as a nanosized. The prefix nano- refers to one billionth. So when working in the field of nanoscience, materials are being investigated on a scale of one billionth of a meter. To help "visualize" that size, DNA is about 3 nanometers wide and one soccer ball is about a billionth the size of the Earth. (1) While this is difficult for adults to comprehend, it is almost impossible for elementary aged brains to fathom. Their ability to think abstractly is just developing in 4th and 5th grade. That is why educators need to be informed to better prepare their students for lies ahead. Providing multiple opportunities for students to see and manipulate matter gives them insight into the possibilities of the future, especially in nanoscience.

Working with materials on this scale may sound exciting but that is only the definition of the prefix. The most intriguing part is that once you have explored something on the nanoscale their properties can change! At first, this sounds bizarre but thinking of how the properties of solids and liquids change can aide in the acceptance of nanoscale changes, e.g. their structure can change with heat, color changes occur with mixtures and solutions, they can even appear to disappear. Nanoscience is the wonderful world of exploring and benefitting from manipulating matter at that size. There are four big ideas of nanoscience that help us to understand this small world among us, structure of matter, size dependent properties, forces and interactions and quantum effects. (2)

Structure of Matter

All matter is made of atoms and a nanoparticle is slightly larger than an atom. It is these pieces that we move around and observe the changes. At the elementary school level, students are introduced to particles in third grade. This is an abstract idea for them because they are unable to see the individual particles of matter. The third grade foundation provides the basics for the structure of matter in general and their organization as it relates to energy.

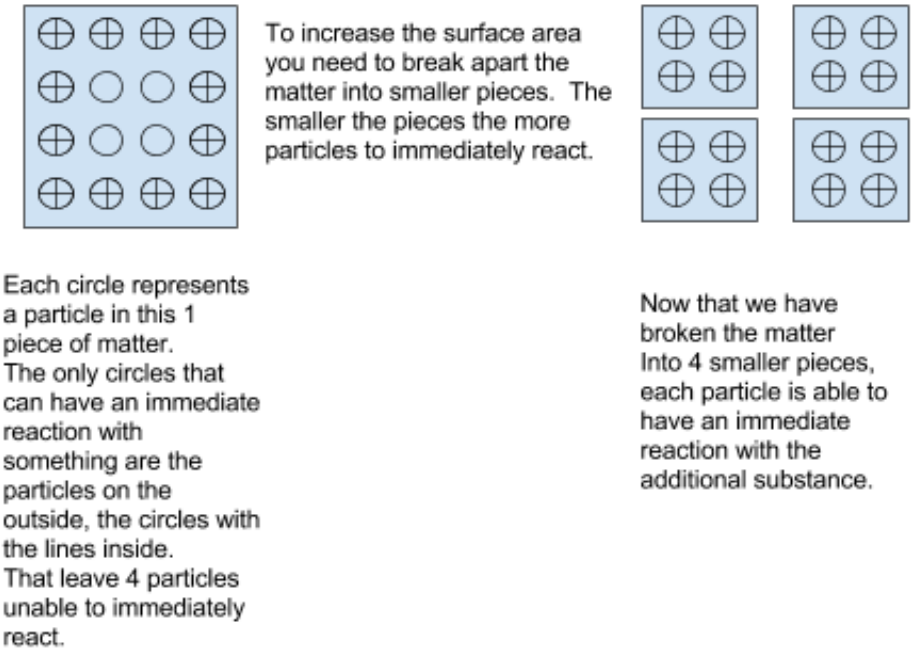
A common misconception among students is that solids are hard; how are you able to determine a solid from a liquid? They believe that if it is hard then it is a solid. We have not provided enough experiences for students to examine the similarities and differences among a variety of solids. Comprehending the structure of matter allows for a solid foundation for understanding our world. Luckily, structure can be seen and manipulated as models and drawings. Facilitating hands on experiences with blocks and other materials is a great way to start.

Carbon is one of the best examples of changing the Nano level structure at to adapt their behavior. When carbon is rearranged into tubes on the nanoscale the strength and conductivity is exemplified. This strength can one day be used to make stronger cars and ability to conduct electricity can be used to protect airplanes from lightning strikes. (3)

Size Dependent Properties

Exposure to a variety of solids must include size differences. This can begin as early as kindergarten. Describing a boulder compared to a rock that fits in your hand and a grain of sand allows the child to evaluate how size affects the properties of matter. (You can pour a cup of sand much easier than tossing boulders around the yard.) Providing them with language to describe these experiences opens their minds to possibility while laying the foundation for scientific thinking.

As mentioned before the excitement for nanoscale science lies in the ability to change how matter behaves. Perhaps the largest benefit of working on the nanoscale is the increase in surface area. Having more area to work with/on allows for more interactions of materials and an increase in certain behaviors. There is an activity to demonstrate this in the Instructional Implementation section.



(4)

This property is very important for making solar cells that are more efficient. The purpose for one of the materials, TiO2 (Titanium Dioxide) is to absorb the dye which will absorb the energy from the sun. TiO2 is used on the nanoscale to ensure the maximum amount of surface area, which will absorb the most amount of dye.

Forces and Interactions

Understanding energy and its effects is critical for this part of nanoscience. The mention of energy begins in first grade with living things needing energy to grow. Second grade allows students to explore the energy of the sun and how things are on Earth are affected by its heat. Third grade is the first time energy is explored as being around us at all times in various forms. They also are given time to realize that energy is transferred from one thing to another. Fourth grade focuses on electrical energy and shows them the movement of electrons with static electricity. This directly links to interactions on the nanoscale.

One of the most predominate world problems revolves around energy. Solutions can come from nanotechnology. Enhancing the ability to harness the sun's energy for our benefit is found by working with gold nanoparticles. Scientists have discovered how to use gold on the nanoscale to increase the efficiency of solar cells.

Quantum Effects

When describing scientific events, the materials can either be limited to a certain value (quantized) or have the ability to possess any value (classical). In nanoscience, this is important because electrons play a crucial part in manipulating matter. As electrons move the energy in the atoms is affected and this change in energy changes certain properties. The energy level in nanoparticles are quantized because they are confined. (5)

Luckily, for the purpose of teaching elementary school it is sufficient to focus on the basics of energy in order for the students to one day be able to begin understand quantum mechanics.

Examples of Nanoscience

Nature is a wonderful source of ideas for how to use the nanoscale help improve our lives. After observations on the nanoscale of living and nonliving things new ideas were developed due to the possibility of manipulating matter to change its properties.

Lotus leaves have been investigated at the nanolevel, which has lead us to better water replant / stain proof surfaces. (6) The lotus leaf is a superhydrophobic surface, which means that while water will minimize contact with its surface at there is an increased roughness at the nanoscale so that water and other liquid just roll right off the surface. (7) There is a beetle in the Namib Desert that was seen crawling to the tops of dunes and then standing on its head early in the morning. This process was performed in order for the beetle to drink a few drops of life sustaining water. The exterior shell of the beetle is superhydrophobic and as they stand on their head dewdrops can form on their back and roll straight into their mouths.

Spider silk is constructed out of nanoscale crystals, which provide super strength in a lightweight package, useful for in transportation and the sports industry. (8)

Currently, we use nanoscience in our everyday lives. Sunscreen was developed using nanotechnology, stain and water resistant clothing, cosmetics and paint contain nanotechnology. One of the most exciting uses is in the field of medicine. Scientists are using their knowledge of nanoparticle properties to develop cancer detecting agents and transportation methods for

medicine to exact locations within the body. Nanotechnology has also found its way into forensic investigations, detecting certain chemical and drugs on people and objects. There are many more ways that people are looking to use this technology and those that have not even been imagined yet. Use the following activities to spark the imagination of our future.

Instructional Implementation

Activities

Surface Area Reaction Time

This activity will demonstrate the relationship of size and reaction time. As referenced before when you break down matter into smaller pieces it increases the surface area, which allows more particles to interact with a substance.

Materials
Alka Seltzer tablets
Transparent cups
Water (add a few drops of vinegar)
Stop Watch

Procedure

1. Provide students with materials - either prepared or 3 whole tablets.
2. Allow students to observe the physical properties of a whole tablet, a tablet broken into 4 pieces and a crushed tablet. Discuss the similarities and differences between them. Place the 3 different sized tablets into separate cups.
3. Explain that when you add water to the tablet there will be an observable change.
4. Provide students with a table to record their results in an organized method.
5. Have students add water to the whole tablet first and record the amount of time it takes for a reaction to occur. Students will also record changes.
6. Add water to the tablet that is broken into 4 pieces while a student records the time. Students record changes. Take time to share how the reaction was similar and different to the whole tablet.
7. Students can crush the final tablet a little more just to make the pieces even smaller. Have the students add water to the smallest pieces and record the reaction time in their chart. Students will be excited and very vocal about their findings. Allow this time for spoken language to occur while reminding them that they also need to write/draw their observations.
8. It is important for scientists to share what they have discovered, encourage them to use their notes when they speak to another scientist.
9. Bring them to discover the relationship between size and reaction time - as the size decreases the reaction time decreases.

Kindergarten P2.1

Observable physical properties are the focus here for science content. When scientists observe they use their five senses, in the activity they are able to use their sight, hearing, touch and possibly smell. To engage a sense other than sight begin the lesson without showing them the reaction, add water to a tablet and allow them to listen carefully. Have the students describe the sounds they hear - plop, sssssss, zzzzzz etc… and what they think you were doing. Depending on the time of year and your students you may want to do this as a class demonstration however, call students up to interact with the materials and complete the activity. Create class anchor charts to record their observations from each sense and time.

First Grade E2.1

As always reinforce content from the previous year but focus on the tablets being a solid and hold their shape no matter what container they are in and the water is liquid which takes the shape of the container it is occupying. This is critical for all future content on matter that students do not retain from first grade. A very common misconception is that matter is solid if it is hard. Take time in this activity exploring the tablets and how the solid's observable physical properties change when you break them. This is where most of the time should be spent in this lesson. Provide a structured way to gather their information and allow them time to reflect and write their own thoughts/drawings. Again, their observations should include more than sight, texture is a big change and the sound the pieces make when dropped should change dramatically.

Second Grade P2

This is the first grade where students are focusing their attention on specific properties of matter. Allow students to take their time with analyzing the solids and how their properties change when they are broken into smaller pieces, are they easier to pick up, did their color change, analyze their shape, are the pieces still a solid? Scientists have the responsibility of looking for changes. This allows for mixing of solid with a liquid and recording the changes. Specifically, with second grade allow for the containers to remain open for a few days, the liquid will evaporate but the solid will remain.

Third Grade P2.2

This is the first time students are formally introduced to the third type of matter, gas and the fact that matter is made of particles that we cannot see. These particles behave different in each type of matter. This reaction involves all three type of matter and each should be focused on in terms of their observable properties and how the particles behave. The bubbles that are produced are made of gas. This can be used to reinforce particle behavior or introduce and illicit questions and predictions.

Fourth Grade P2.1 E2.3

One section of this objectives mentions reactions to water. These reactions include but are not limited to creating a mixture, solution and in this activity producing a gas. Students can observe

the tablets for other physical properties before starting the procedure to fulfill more of the objective but this can be used as a great conversation starter or connection to the rock cycle and breaking down of Earth materials by nature. Each time students test other minerals this can be part of their predictions and if no other mineral is found to react to water in this way, they can speculate why the tablet reacts this way.

Fifth Grade P2.3

This activity is very helpful for practicing accurate measuring, data collecting and recording of observations. Students should be encouraged to make a claim about the effect the size may have on the reaction, if any. As they follow the procedure, they will collect the necessary evidence to support or refute their claim. Students can also record the physical changes versus the chemical changes and provide evidence for their thinking. If these concepts have not been taught before this is an excellent way to engage their minds on the differences between these changes and develop an understanding of how physical changes can affect chemical reactions.

Size - Sneaky Small

This activity provides students with an opportunity to question what properties are they able to see. The plastic baggie appears to be one flat piece of solid but upon an interaction with liquid, they prove that there are small holes that allow small enough pieces of matter to travel from one side to the other.

Always let students to interact with the different types of matter before beginning the experiment and share their observations. Powders are an interesting solid that most students do not realize are small solids.

Materials

Iodine
Plastic sandwich baggie (cheap)
Cornstarch
Water
Bowl
Measuring spoons
Dropper

Procedure

1. Place 1 tablespoon of cornstarch in the sandwich bag. Fill about half full with water. Mix the two and make a knot to tie the bag shut.
2. Mix about 15 drops of iodine with 1 cup of water in a bowl.
3. Make sure the outside of the sandwich bag is clean and dry before placing it in the bowl. Keep the knot outside of the liquid in the bowl.
4. Wait at least 15 minutes. Take the bag out and observe.
5. Record and share results.

A property of iodine is its color, originally it was brown and when it interacts with starches it changes to purple. The sandwich bag has tiny holes that we are unable to see without a

tool. Since a piece of iodine is smaller than a piece of corn starch, iodine can travel through those holes and the cornstarch does not fall out. (9)

Kindergarten P2.1

Observable properties continues with this experience and ideas can be added to your anchor charts. It is a good idea to mention how scientists watch for changes. A new anchor chart can be properties before and after, including properties that did not change at all.

First Grade E2.1

Size the physical property of importance in this activity. Students can examine a small amount of cornstarch, water, and the plastic baggie separately. They will record a picture and decide how to classify each in terms of solid or liquid. Have the students verbalize why they believe in their classification. Challenge the students to pick up one piece of each and discuss the differences. Allow them to struggle a little bit but then lead them to pushing 1 finger into the cornstarch and observing how small solids can stick to our fingers. Encourage them to try that with the water and make a claim as to why it worked or did not work with water. Once the experiment is concluded ask them about the size of the matter. Connect the size with other types of soil and order soils by the size of one piece, sand, clay, loam, humus, rocks, pebbles etc…

Second Grade P2

Similar to the last activity allow students to discuss and record their observations of the two types of matter. Refer to the first grade focus and have discussion. Have students make predictions about what will happen if you leave the baggie open? Will the cornstarch return to its original color? Why or why not? Is iodine truly just a liquid or is the color tiny solid pieces? How can we find out?

Third Grade P2.2

Continue to focus on the behavior of the particles in each type of matter. Challenge the students to evaluate what about the behavior allows this to happen? Do the particles of the baggie differ from those of the cornstarch? What differences can you observe and do you think the particles cause those differences? In third grade they need to understand that solids have particles that do not move from place to place, this is why they retain their shape when moved from one place to another. This activity is an effect of the size of the solid and not the behavior of the solid particles. Liquid particles move and slide past each other. Since they move more freely, they can fit through the small holes in the baggie and interact with the solids.

Fourth Grade P2

The important idea from this activity is that we are not able to observe all the properties of matter with our eyes, we are not even aware of certain properties until a reaction occurs. Either this can be used as a scientific inquiry activity or it can be used towards the end of the matter unit. Students can link their findings – the baggie must have very small holes for the liquid to travel

through and this causes the interaction between the liquid and solid – to natural processes in the Earth. Now that they know that solids can have small holes how could this knowledge be applied to how rocks form. Encourage creative thinking but make sure the scientific facts of the rock cycle are correct.

Fifth Grade P2.2 P2.3

If you chose to use P2.2 have the students very carefully measure all the materials before beginning and afterwards. This can be used as evidence that the liquid truly travelled through the baggie because the weight of an object is equal to the weight of the sum of its parts. As for P2.3, encourage discussion between physical changes versus chemical changes and providing evidence to support their thinking. To extend their thinking ask them how this information can help them to solve possible problems in the future.

Light

During this activity, students will use a thin film to bend light and create surprising colors.

Materials
Shallow container
Black construction paper
Clear nail polish
Water

Procedure
1. Fill the tub with no more than an inch of water.
2. Slide the paper into the water.
3. Apply one drop of clear nail polish over the center of the paper, make sure the brush does not touch the surface. Allow the drop will spread out on the surface of the water.
4. While pulling the paper out, slowly, it is critical that the film sticks to the paper for the necessary result.
5. Allow the paper to dry then observe and describe what you see.

Students are able to observe 2 liquids with different viscosities interact and then interact with the solid. Interactions are very important in nanoscience so it is important for students to observe each interaction and the effect it has on the matter.(10)

Kindergarten P2.1

Continue with adding to observable physical properties. This activity focus can be on the property of stickiness or viscosity of liquids. Students can also take the time to observe the different colors that show when directed to varying amount of light.

First Grade Science as Inquiry

While there is not a specific objective that this reaches, this activity can be used at the beginning of the year to encourage inquiry and scientific thought. Before the objectives there is a paragraph written about "Science as Inquiry". Use this as a way to establish cooperative group expectations and safety skills.

Second Grade P2

Students can measure the amount of water to be used in the shallow container. Record their predictions of what will happen to the paper once it is submerged, will its properties change? Analyze how the nail polish is a different liquid than water, texture, viscosity, color, smell (do not directly inhale) etc… The end of the procedure allows the paper to dry, make sure the students know what is happening when the drying occurs. Should they put the paper inside something to speed up the drying?

Third Grade P2.2

Students should record their observations in picture form of what they are able to see and what they believe the particles of each material to look like. Where did the liquid particles travel when introduced to the solid? Focus their attention to the particle behavior after the paper has dried, what does dried mean in terms of the particles? Where did they go? How did they change? Heat was added, which changed the liquid into a gas. This is a great way to encourage critical thinking and ensure that they have the basic understanding of how particles behave in each of the states.

Fourth Grade P3.2

There is not much to this standard, it is very brief but full of vocabulary, refracted, reflected and absorbed. This means that it is our job to provide a variety of instances where light behaves differently. Students do not think of seeing colors as related to light. When the paper is dry and the colors emerge, guide them with questions about how to change the colors, where the colors are appearing and why they think these things are happening. This can be used as an engage activity before light is taught and then taken out again at the end for them to apply their learning.

Fifth Grade P2.3

This can be used as a scientific inquiry activity to establish norms for your science time/cooperative work and/or it can be used to further investigate changes in matter. For some ideas refer back to the second grade focus. Encourage students to account for all matter before and after and explain what happened to each material.

Size

This activity allows students an opportunity to be introduced to scale, the effects of mixing and encourages the use of their sense of smell as an observable property of matter. This is a great opportunity to teach wafting, the safe way scientists smell objects.

Materials
10 plastic cups
Marker
Tablespoon
Imitation vanilla
Water

Procedure

1. Label each of the cups 1- 10.
2. Add 2 tablespoons of vanilla to cup 1.
3. Fill cup 2 with 1 tablespoon of liquid from cup 1, plus 9 tablespoons of water. Stir.
4. Fill cup 3 with 1 tablespoon of liquid from cup 2, plus 9 tablespoons of water. Stir.
5. Continue this pattern until all 10 cups are filled.
6. Use a white piece of paper as a backdrop. How far can you see the color? Now smell each cup. Begin with cup 10. Record and share results.

Cup 10 contains one part per billion of vanilla, 1 piece of vanilla for every 999,999,999 pieces of water. Your nose is more sensitive than your eyes and can detect some scents to parts per million (cup 7). However, it is an even greater challenge for your nose to detect parts per billion. You can do this experiment again with different liquids like vinegar, mouthwash and perfume. Compare how well your eyes can detect small pieces versus your nose. (11)

Kindergarten P1.1

Sense of smell and position words will be the focus of this activity. You can also tie in comparative and superlative language when describing the smell. When asking the students to describe the strength of smell they can describe the cup position in relationship to another object. Place a stuffed animal or engaging object among the cups to practice words such as; in front of, behind, between, on top of, under, above, below and beside.

First Grade Science as Inquiry

Use this activity for scientific thinking, encourage asking questions, take your time with measuring accurately, compare their thinking with other students, drawing what they see and drawing how the smell is different. Take time to reinforce conversations that refer to observations and not about who is wrong or right.

Second Grade P2.2

This activity is great to reinforce measuring and comparing the volume. It is very important for scientists to measure accurately. Encourage questioning throughout, specifically comparing solids and liquids. Why is it easier to smell liquids than it is solids? Or is it harder? When is it easier to smell solids? Think about the size of the liquids and solids and if heating and cooling affects how well we can smell matter.

Third Grade P2.2

Again, use this as another way to observe matter while focusing on particle behavior. They should draw pictures of the different liquids and how they believe the particles are acting. Should each picture look the same? Why or why not? Why is it easier to smell one cup over the other cup? What is happening to the particles that makes it easier for us to smell/see them across the room?

Fourth Grade Science as Inquiry

Scientists measure accurately and use math throughout their investigations. Students struggle with place value and wrapping their heads around larger numbers because they are a challenge to represent. During this activity, students will be using matter that is so small that they can actually represent these large numbers. They can practice making claims and providing evidence with what they see compared to what they smell and then share their ideas with others. To conclude it is important to make sure the students have made the connection with math and the scale of the matter.

Fifth Grade P2.3

Similar to the fourth grade focus, intentionally guide students to think about the amount of matter being used and the ratio of water to vanilla. How does the ratio affect our observations? How could you model/draw the amount of water to vanilla? Remember to focus your note taking to be connected to the objective of making qualitative and quantitative data records and creating before and after representations of materials.

Strength

The strength of a material can change the way it is used in the world. There are current products that would be more valuable if they were stronger and nanoscience can help. Some of those products include cars, helmets, protective clothing etc… Students will evaluate the strength of bones and how interactions with liquids can affect how much force they can withstand.

<u>Materials</u>
3 chicken bones per group
3 cups
Water
Vinegar
Bleach

(Do not allow students to handle or smell in close contact)

<u>Procedure</u>

1. Clean 3 chicken bones and have students record their observations in an organized manner such as in a

table. Examine their flexibility without breaking them.
2. Place one in each cup.
3. Label the cups and add vinegar to one, bleach to the other and water to the third (this is your control). Make sure the liquid covers the entire bone.
4. Wait 24 hours. Remove the bones and rinse with water. Observe and record what stayed the same and what changed.

Bones are made of collagen (a protein) and minerals (calcium). Collagen is a nanosized molecule that gives bones their flexibility. The minerals give bone its strength. The vinegar removed all the minerals and left only the collagen, which is why the bone could bend. The bleach removed all the protein and left only minerals, leaving it very brittle. You can see we need both parts for our bones to work properly. (12)

Kindergarten P.2.1

Students can observe the different smells of the liquids, however do not allow them to smell these directly nor allow them to handle them. The physical property that will be brought to their attention will be the flexibility of the bones before and after. Scientists are responsible for observing changes and as scientists they will record how the flexibility changes.

First Grade P1.1

Examine how the observable property of flexibility changed and not the force. First grade is the time when students analyze the amount of force and its effect on motion. Have the same student demonstrate the flexibility of the chicken bone before and after they are saturated. Impress upon the students that each time the student is using the same amount of force and observe what changes occurred to the bones.

Second Grade P2.1

Students will take the time to analyze the changes in the physical properties of the solids and what caused the changes. Why did the solid not behave the same? What is different about the two liquids that caused these changes?

Third Grade P2.2

This can be done to reinforce two separate objectives. If done during the physical science objective continue with how the particles change in their behavior when the liquids are added to the solids. When it comes time to teach life science this is visual of the function of the skeletal system and how bones support and protect our body.

Fourth Grade L2.1

Students need help to make connections across material. Use this activity to connect their careful observations and note taking to discovering how this helps understand the role of vitamins and minerals, and exercise have in maintaining a healthy body. Explain that chicken

bones are very similar in make up to human bones and if you deplete the bones of their needs they are unable to function properly. This can lead to further lessons on how to provide our bodies with the proper vitamins and minerals to ensure healthy bones.

Fifth Grade L1.2 P2.3

Either objective is fine to use with this activity or it is more than ok to weave the concepts together to help students make connections between content. Make sure that your assessment is aligned to the specific wording stated in the objective.

Absorption

Sunscreen is nanotechnology, we needed something to protect us from harmful ultraviolet rays and at the nanoscale these particles can scatter light. Students will evaluate the effectiveness of different amounts of sunscreen.
Photochromic paper is coated with a chemical that will react with light.

Materials

Photochromic paper -
Transparent plastic sheets
Light sources - sunlight, black light, lamp
Solution rinse tray
Glass or plastic microscope slides

Several samples of chemical-based sunscreen with different SPF values
At least one sample of nanoparticle based sunscreen
Warm water bath (to warm sunscreen if necessary)

Material Preparation

Make the solution rinse with a small amount of vinegar or lemon juice (1 Tbsp. per qt.)
Prepare the microscope slide applicators by wrapping a small piece of aluminum foil around the end of the slide, so that it covers about ⅓ of the slide at one end and secure with tape. Do this to both ends, leaving approximately 1 cm gap between the two foil sections.

Procedure for activity 1

1. Select a light source. Place a piece of the photo paper 8 cm under the light source and place an object on the paper.
2. Turn on the light source and expose the photo paper for a set amount of time.
3. After exposure, develop your photo paper by placing it in the solution rinse. Swish around for 1 minute.
4. After exposing and developing your paper samples, dry them on paper towels.
5. Compare your exposed photo papers to those of other groups who used other light sources.
6. Determine the light source that produced the most UV energy.

Procedure for activity 2

1. Select a chemical sunscreen, record the brand and SPF.
2. Warm the sunscreen bottle in warm water to make the liquid easier to spread.
3. Place a small amount of sunscreen on a piece of transparent plastic.
4. Using the slide applicator, spread the sunscreen thinly across a 1 cm X 1cm region on the plastic sheet. Do this by slowly drawing the applicator across the drop of sunscreen. This should leave a uniform layer of sunscreen behind. The thickness of the layer is dependent on the thickness of the foil or plastic. The goal is to have it uniform.
5. Place the sheet of plastic covered in sunscreen on top of a piece of photochromic paper, with sunscreen facing up.
6. Immediately expose this to the light source. Use the most effective time determined in part 1.
7. Remove the paper from underneath the plastic.
8. Develop the photo paper in the solution rinse.
9. Take the paper out and lay on a paper towel, letting it dry a bit.
10. Compare your results with other sunscreens and SPF values. (13)

Kindergarten P2.1

This would be a great experience to demonstrate lightness and darkness of colors that develop because of using the sunscreen and light sources. After their design has been developed students can evaluate who has the darkest color vs the lightest color. Most importantly is the discussion of why, no need to get too technical but reminding them of using different types of sunscreen affect how much light gets through. Continue to develop the language for scientific thinking, before and after, because, I wonder etc…

First Grade Science as Inquiry

Continue to develop language and scientific conversations by providing sentence starters and appropriate vocabulary. Revisit kindergarten standards to ensure mastery with observable properties. Evaluate behavior in cooperative groups.

Second Grade E1.1

Students are used to the sun being out every day but it is our job to provide them with experiences to really think about what happens as a result of the sun. They are completely unaware of the fact that the sun effects everything it can reach. Focus on the energy of the sun with this activity. As a part of this objective show how engineers have created sunscreen to block some of that energy from influencing our bodies.

Third Grade L1.2

Skin is a challenging objective for hands on opportunities. Skin is the largest organ that protects our body. While the sun provides warmth there are harmful effects from the sun and this is why engineers developed sunscreen. Before they begin students will develop a claim for which sunscreen is the best protector and why. Explain how scientists conduct experiments like this

and the scientific thinking behind each step. In the end, they will have evidence to support or refute their initial claim.

Fourth Grade P3.2

Again, this objective is open as long as the students have an opportunity to observe light and use the proper vocabulary to describe what is happening. Encourage scientific thinking by having the students make specific claims and providing evidence with light vocabulary. Where was the light absorbed? How do you know?

Fifth Grade P2.3 P3.1

When providing opportunities for students to investigate heat transfer this allows for an in depth look at radiation and how engineers provided a solution to potential problems. When they developed their solution they used their knowledge of matter and the properties of original materials versus a new material to create multiple types of sunscreens. Other concepts can be connected to this but make sure your always bringing the students back to the objective that you have chosen for the focus.

Forces

Nanoscience depends a lot on interactions of materials and forces that are unseen. At this level students need to be introduced to the relationship between forces and motion.

<u>Materials</u>
Magic sand
3 pieces of paper
Dropper
Water resistant glue sticks
Various liquids

<u>Procedure for Activity 1</u>

1. Set aside 1 piece of paper that will be the control. Apply a layer of glue to the second piece of paper and set aside. The third piece of paper requires a layer of glue and a layer of magic sand. Make sure the layer of sand is uniform. There should be no paper showing through. Make in large sheets and then cut smaller pieces for each group to conduct the activity.
2. Make a prediction of the results for the 3 tests. What will happen when several drops of water are applied to each surface?
3. Use a dropper to place several drops of water onto the surface of each site, record observations on a data sheet.
4. Repeat using other liquids. (oil, alcohol, salt water)

<u>Procedure for Activity 2</u>

1. Remove any water drops from the sand covered surface.
2. Sprinkle a small amount of pepper flakes over the surface of the sand.
3. Use the dropper to place a drop of water on the pepper sprinkled sand coated surface.

4. Roll the water droplet over the pepper flakes and observe the interaction of the pepper and water.
5. Roll the water droplet off the sand covered surface and observe the response. (14)

Kindergarten P1.2

Students will evaluate the movement of the water as it travels across the sand paper. Making predictions is very important as well to develop their scientific thinking. Compare their predictions with the results and reinforce that scientists are not focusing on being right but learning something new. Encourage mistakes and failure as an exciting way of learning. The texture of the different sand papers can be used as reinforcement of observable properties and added to the anchor chart.

First Grade P1.3

Allow students to observe the force and motion of the water on the plain paper. Have them record their thoughts in labelled pictures and sentence with proper vocabulary, push, pull, gravity etc… Provide the other paper to the students and encourage discussion about their predictions on whether or not the motion will change and why? Collect their responses on an anchor chart to allow of analysis at the end. Evaluate how the paper changed, if the water changed and what might be forcing the movement to change. Encourage rich description of the motion.

Second Grade P2.2

Second graders can measure the amount of water to be poured over the paper before and after the activity. They can guess how the interaction between the different solids affects how much of the water made it to the end of the paper.

Third Grade P1.1

This activity will be helpful to analyze forces and the motion as a result of the sand pushing the water in different directions. Show students how to draw force arrows, longer shafts represent more force and shorter shafts represent less force. When pushing on the dropper the arrow will be larger than a grain of sand shifting the direction of the water. Scientists must be accurate with their drawings to share what they have observed.

Fourth Grade P3.1

Introduce energy with activity. Use it as a pre-assessment to evaluate their understanding of energy and its effect on motion. This background is essential before moving on to electrical energy, which they only see the effect and not the actual energy movement.

Fifth Grade P1

Quite often this standard is taught with marbles, cars, blocks etc… This narrows the students' focus for force and motion to be only with solid matter. Connect their background knowledge of

force and motion to this activity and introduce new vocabulary. Their attention will be held because of the various materials and it will stretch their thinking about water in their everyday lives. Create questions formed from each objective to guide their thinking after the initial activity is completed. This can be used an ongoing center during science time.

Absorption

These activities continue to reinforce interactions among different types of matter, the basis of nanotechnology. This is not redundant but necessary because each activity shows drastically different materials behaving in different ways.

Materials
Petri dish
Water
Other liquids
Cross-linked polymer
(sodium polyacrylate)
Dropper

Procedure
1. Place a small amount of polymer in the petri dish - feel it and observe its physical properties.
2. Using a dropper add some water or other liquid to the material.
3. Observe what happens.
4. Now feel the resulting material - how have the physical properties changed?

Materials
Ring polymer - diaper stuffing
Petri dish
Water
Other liquids
Scale
Small beakers
Droppers

Procedure
1. Measure out about ¼ teaspoon of ring polymer
2. Place the polymer in the petri dish and measure its mass
3. Using the dropper begin to add drops of water to the polymer
4. Keep adding water until it can no longer be absorbed by polymer
5. Weigh the polymer, petri dish, and water to determine how much water was absorbed. (15)

Kindergarten P2.1

Observing and recording the physical properties before and after the interactions. Record the color shape and size of the polymer before and after. Students should be given an opportunity to feel the polymer before it changes, try to separate one piece from the rest to examine. The temperature change is also important, temperature is something we feel with our skin and can measure with a thermometer. Compare the changes between the two different polymers. The measurement can be helpful for examining value of numbers.

First Grade E2.2

When students are asked to observe the properties of soil it can be a challenge for them to understand the retention of water. These activities give visual representation of solids retaining water and changing as a result. This can be done as a way to show how solids can retain or absorb liquids and then extended to physical properties of Earth materials. They can examine color change and look to see if the size of the soil changes when water is added.

Second Grade P2

The observations the kindergarteners made in this activity are important for them to make at this age as well. Their vocabulary and observation skills have developed so that their understanding will be different at this age. Students can analyze the changes and make predictions of how to remove the water from the solid. The measuring is also of large importance in this grade level.

Third Grade Science as Inquiry

This activity would be best suited for students to focus on critical and scientific thinking. Begin by observing and asking questions about the two materials. Encourage accurate measuring and making predictions about what they are used for and how they will react when mixed.

Fourth Grade P2.1

Compare the physical properties of the polymers before and after the interaction with the water. Measure, observe and record accurately. Encourage students to use various tools, hand lenses, balance scale, tweezers. Have the students make claims about what they think will happen after the reaction with water. Perform all the same observations after the interaction and compare the results. Allow time for students to share their findings and listen to others.

Fifth Grade P2.2 P2.3

Similar to fourth grade focus compare the properties before and after but make sure the students realize that the weight of an object is equal to the weight of the sum of its parts in a closed system. Students should organize their observations be qualitative and quantitative data.

Appendix I: Teaching Standards

Standards

Science as Inquiry is a paragraph at the beginning of each grade levels' specific content standards. Here is where the teachers find the critical thinking and interpersonal skills that are facilitated in their classrooms to foster well-rounded scientific thinking. The content standards I have chosen are directly linked to "the big ideas of nanoscience 1) structure of matter 2) size dependent properties 3) forces and interactions 4) quantum effect" (Stevens Shin, pg 8) Hopefully the word "quantum" isn't too discouraging. There is more of an explanation in the background section of nanoscience.

Younger elementary aged students, kindergarten through second grade are already so excited to investigate their world as educators we need to harness that energy toward critical thinking, observation skills, proper vocabulary and developing conclusions. We need to give them opportunities to think like scientists and notice changes, record before, after, make careful observations, communicate, and work with others

Kindergarten standards focus on observable properties. Students practice using all their senses to investigate objects and have a better understanding of the world around them. Vocabulary development is key here, use anchor charts every day to reinforce specific properties. P1.1, P1.2, P2.1

First grade takes their observations towards Earth materials, similar to kindergarten they will evaluate the observable properties, but it must circle back to where these can be found in our natural world. While these activities do not have an Earth material focus they are great ways to introduce a concept/vocabulary and then have the students apply this knowledge to soil, rocks and water. E2.1, E2.2, P1.1, P1.3

Second graders begin their investigations into matter by evaluating the properties of solids and liquids. They need many opportunities to see how matter reacts, the various properties of each, how to measure solids vs liquids and changes they may occur. P2.1, P2.2, E1.1

Upper elementary students still have that curiosity but they need a little more of a push to allow it to surface. With these grade levels I may open the unit with engage activities that show them the world of nanoscience and how it is linked to our everyday lives.

Third grade objectives focus on the physical science objectives, specifically modeling what particles look and act like in the different states of matter. These activities will have your students thinking critically about the changes in matter and how particles behave. This grade is the only devoted time in elementary school that allows students to investigate the unseen differences in the states of matter. If your students do not have a firm grasp on the observable properties use the objective focus from K-2 before introducing the unseen. P2.2, P1.1, L1.2

These activities cover a variety of objectives in fourth grade. I would recommend using these as supplemental, pre-assessment or culminating activities, to understand what they need to know or what they have learned. P2.1, P3.1, P3.2, E2.3

Fifth graders should show their critical thinking and vocabulary development through these activities. The essential standards are taking all of their previous science instruction and connecting the content to global ideas. P1, P2.2, P2.3, P3.1, L1.2,

Assessment

K-2 Science	Below Expectations 1	Meets Expectations 2	Above Expectations 3
Observations	Uses only 1 sense to safely make observations	Uses more than 1 sense to safely make observations	Uses more than 2 senses to safely make observations
Collaborating	Remained silent, did not complete their task, did not share materials or was not responsible with materials	Waited for their turn to talk and touch materials, completed their task and was responsible for materials	Helped other teammates take turns, be responsible, explained directions, and used materials responsibly
Using Vocabulary	Did not use any vocabulary from the anchor charts	Used more than 1 word from the anchor chart in conversation or written	Used more than 3 words from the anchor chart in conversation or written

3rd Grade P2.2 Particle Behavior	Drawings without labels – or only 1 type of matter modelled correctly	Drawings with labels, all 3 types of matter modelled correctly	Explanations provided for each model, used vocabulary correctly and made logical predictions and conclusions based on the activity
4th Grade	Use the activities to analyze what students already know about the content.		
5th Grade P2.3	Made simplistic observations without details, unable to explain how the matter changed	Accurately describes matter before and after the interaction, uses qualitative and quantitative data as evidence, create before/after representation of materials	Applies information to real world, asks questions to extend learning, connects the activity to other content in science
Collaborating	Remained silent, did not complete their task, did not share materials or was not responsible with materials	Waited for their turn to talk and touch materials, completed their task and was responsible for materials	Helped other teammates take turns, be responsible, explained directions, and used materials responsibly
Notebooking	Wrote in incomplete sentences, did not label pictures, wrote illegibly	Supported claims with observed evidence, wrote neatly, organized information into charts, explained using vocabulary	Asked further questions, made connections to the real world

Notes

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United States National Nanotechnology Initiative . 2016. National Nanotechnology Initiative . Accessed October 29, 2016. http://www.nano.gov/nanotech-101/what#content#content. This website holds a lot of information about where nanoscience has been and where it is going. This is useful for activties, other websites and articles.