

Paper, An Innovation?

Introduction

Paper, an innovation? The idea may sound preposterous to us today; however, the invention of paper significantly impacted the world. In this lesson students will begin by making historical connections; as well as, how the process of making paper has changed over time. Students will then explore potential problems caused by the excessive use of paper by analyzing the three components of sustainability: economic, societal, and environmental. On day two, students will use this knowledge to create their first science experiment centering around the idea of recycling paper.



Process Goals

- Students will develop an initial understanding of key innovation concepts including: making connections, inquiring, analyzing problems and anticipating possible solutions.
- Students, working collaboratively, will create an experimental research plan to a teacher posed question. Plan shall include procedures, additional questions, and plan for data collection.

Content Goals

- History: Students will be able to analyze innovations of the past, in this case paper, examine its change over its time, and describe logical solutions to unintended consequences.
- Science: Students will be able to defend their hypothesis by discussing properties of cornstarch.

- **Math:** Students will be able to select appropriate measurement tools while designing an experimental research plan. Students should also be able to justify their selection by explaining why they feel each tool is necessary.

Instructional Strategies

- **Partner/Table Talk**
- **Agree/Disagree**
- **Poll/ Survey**

Vocabulary/Important Ideas

Innovation

Students will work to create their own meaning of this word during class discussion. It may include the following ideas: new approach to a solution of a current problem, can occur in any content area (not just math and science), is often seen as a creative solution, an innovation of the past can sometimes cause an unintended consequence in the future.

Sustainability

Sustainability is the ability to continue. Students will examine this by taking a look at the economic, environmental and societal implications of our every day choices.

Experiment

A process of conducting research by way of testing the impact of a variable against a control.

Variable

The substance, material, tool, etc. that you are changing in an experiment. In this experiment we will use baking soda as the variable.

Lesson Two

Materials

- Innovation Model
- laptop, interactive white board, or some other method for sharing internet videos (optional)
- various paper products (newspaper, classroom scrap paper, paper plates, paper towel, etc...)
- student note making sheet: anticipating challenges and future problem solving

Innovation

An Understanding

- Ask students to think about the following questions:
 - What is creativity?
 - Who is creative?
 - When are you are you creative?
- Students will generally answer the questions above by focusing on the humanities (ex. art or music) or out of school activities (dance, guitar lessons).
- Ask students if they are ever creative in math, science, social studies, etc. Tell them that often creativity in these areas is referred to as innovation. Have students pair share or discuss at their tables to develop a class understanding or definition of the word innovation. Students can write this on their note making sheet.
- Finally ask students to share examples of innovative ideas or innovations that they know. (Ex: Web 2.0/social networking, video game systems like Wii, solar power, 3d TV, ebooks)
- You may want to ask students how/if innovation impacts society, economy, and the environment. This would be a good opportunity for students to partner or table talk their ideas.

Connect

Building Historical Connections

- Show the students a couple of products made from paper that you have around the classroom (books, journals, posters, etc.) Make a statement similar to the following: “Paper is one of the greatest innovations of all time.”
- Have students discuss this opinion in partner or table groups. Ask them agree or disagree with the idea and justify their answer by telling why. Remind them their justification should be based on the class understanding of the word innovation.

- Model for students the following wondering questions:
 - I wonder how our life would be different if there was no paper?
 - I wonder what people used to communicate prior to paper?
 - I wonder how or if the invention of paper changed the lives of the people living at the time it was created?
 - Encourage students to add their own wonderings to the list
- Share with students information on the history of paper using the websites below or another resource of your choice. Any media/print format is fine as long as they learn information of when paper was invented AND how it is created.
 - [History of Paper Movie](#)
 - [Papyrus Video Cartoon](#)
 - [History of Paper Cartoon](#)
- After viewing the videos (or other media) discuss how the process of making paper has changed over time. (equipment, mass production, etc.) It is also a good idea to discuss components of the paper making process that have stayed the same (need for plant fibers, water, heat, etc.). Note: There is a section on the note making sheet for students to jot down their ideas as you have this discussion.
- Poll students using thumbs up/down or other quick survey to see if they feel that paper is an example of an innovation. Many students will likely come to the agreement that innovation was innovation in the time it was created.

Analyze

Anticipate: Future Problem Solving

- Though paper was once a very valuable resource, some would argue that is no longer true. Agree or Disagree? Why?
- Give students one minute to list as many products as they can think of that are made of paper on the “Quick Write” section of their note making page. Then, generate a class list of as many products as possible. You may want to have some of these materials already to lay out for the students as a visual image of the many uses of paper. (See materials for suggestions of materials.)
- Ask students what are the positive impacts of paper in our life. This discussion could lead to an understanding that one invention often paves the way for another new idea. For example: the invention of paper eventually lead to the printing press.)
- Have students generate ideas on their organizer any unintended consequences of this innovation.
- Encourage students to share their ideas. As you discuss the two previous questions you may want to refer to the Venn Diagram of sustainability, acknowledging that students are discussing society, economy, and environment. Please see the following examples:

- **Society & Economy:** Although it may have been an unintended consequence, paper eventually impacted the area of literacy. As paper became a resource that was more readily available to everyone and less expensive to create, it led to more children being taught to read. There was no longer the reason to only share the resource with the wealthy or royalty; therefore, others were given books and printed materials.
- **Environment, Economy & Society:** The environment has seen a negative impact due to the excessive use of paper (ex. junk mail, food wrappings, etc.). Society now has a responsibility to make sustainable choices with their 'trash' by recycling as much as possible. Although, there is still an environmental cost to recycling by way of factory pollution and the energy required to do so.
- Have students work either independently or in partners to generate a list of possible solutions to this problem.
- If students have not already thought of an idea such as electronic documents, advanced recycling techniques, etc... guide them to the idea through problems comes the opportunity for new innovative solutions.

Inquiry

Wondering

- Give students to write down and share any additional wondering questions they have about today's lesson. Topics may include sustainability, innovative solutions, innovations of the past, etc...
 - Finally, ask the students the three L's What is something that... you Learned OR you would Like to do again OR Lit your fire about today's lesson?
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PAPER, AN INNOVATION?

Note Making Sheet

Quick Write:



Describe the paper making process in the space below.

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I Wonder...

What is INNOVATION?

In the space below create your own definition of the meaning of innovation. You may want to list specific examples of innovative products or ideas.

Lesson Three

Materials

- Innovation Model
- Student Note Making Sheet: Innovative Scientist
- Chart Paper (Recording Class Experimental Research Plan)

* Note: It is suggested that you use chart paper rather than a marker board or smart board; therefore, the experiment plan can be posted in the class until the end of the unit. It is often easier for students to make connections to previous lessons if that have a visual reminder of their thinking, such as a poster.

Suggested Materials for Experiment:

- Scrap Paper (newspapers, flyers, magazine, shredded paper)
- Scrap Construction Paper
- Baking Soda
- Pan, Plastic Tub, or Large Bowl
- 5 Gallon Bucket
- Sponges
- Blender
- Deckle (instructions below)
- Measuring Cup with milliliters
- Measuring Spoons with milligrams

Teacher Research Notes:

In this lesson students will be researching the question, “Does adding corn starch to a recycled paper mixture produce a more durable paper product?” Designing, conducting and analyzing the experiment will likely take two-three class periods. One of the most important components to this lesson is guiding the students to think critically in order to design (create the steps/plan) the experiment. However, it is always helpful if you, the teacher, have researched a successful plan for the experiment. It will help you effectively provide guidance as needed. Therefore, a list of instructions for making recycled paper is included below.

Step 1: Making A Deckle

- Bend a metal coat hanger into desired paper shape
- Wrap coat hanger in aluminum foil
- Poke small drain holes in deckle

* Note: The deckle can be made in advance, as it is not a part of the variable in this research experiment. Or you could give the students the materials for the deckle and let them decide how to create it. The choice is yours. A deckle can be made in many different ways. One advantage to this method is it uses reclaimed materials, the coat hanger.

Deckles can also be made with the following substitutions: using nylon hose rather than aluminum foil, and by using an old picture frame rather than the coat hanger.

Step 2: Blending Shredded Paper

- Tear paper into small pieces
 - Fill blender half way full with paper
 - Add 800 milliliters of water
 - Add 5 milligrams of corn starch (*Variable Batch ONLY*)
 - Blend until consistency of oatmeal
 - Add scrap construction paper to adjust color
- * Note: As the paper dries the color will lighten.

Step 3: Separating Water from Pulp

- Cover deckle with mixture
- Hold deckle over bucket
- Gently press pulp with sponge allowing water to drain into bucket
- Dry paper in sun for several hours
- Carefully peel paper off deckle when dry

The following experimental design lesson is set up in a unique format to encourage student engagement and higher order thinking. Students will be given a list of materials they must use for the experiment: scrap paper, corn starch, blender, and sponge. They will then be required to request any additional materials or tools they will need. For the student's first experiment with this type of science experiment, you may find that you need to guide students to think of certain materials or tools. This is a normal part of teaching students to think in this way. The more experience students have with this type experiment, the better they will be come at planning and requesting needed materials.

Connect

Relating to Prior Knowledge

- Give students some time to review previous lesson's note making page and the innovation model. Tell them we will be using both the model and what we learned the last lesson to design a science experiment.
- Have students answer the first two questions in the "Connect" section of the Innovative Scientist note making page either independently or in pair groups. These questions will review why paper is an innovation of the past; as well as, the unintended consequences of the use of paper in society today.
- Review the solutions students generated in the previous lesson. Be sure that recycling paper is listed because this is the lead into today's science experiment.
- As you are reviewing you may want to discuss again the steps to making paper that were found in the videos you watched yesterday.

- Be sure students remember the following steps, as it will help them develop the steps to their science experiment to come.
 - Paper (and other plant fibrous materials) cut into small strips
 - Paper mixed with water to create pulp
 - Pulp is strained using deckle,
 - Sun or other heat source is used to dry paper

Inquire

Student Engagement through Wonderings

- Tell students as you were researching to learn more about creating recycled paper you noticed that various websites/articles listed different ingredients. Some required only paper and water to make pulp while others stated that adding corn starch would make a more durable paper.
- You can either model the following wondering question for the class or ask them what they wonder now that they knew some recipes call for corn starch and other's don't.
 - "Does adding cornstarch to recycled paper mixture really make a more durable paper?"
- Some students may also wonder why adding corn starch could change the durability of paper. If this wondering occurs, it may be helpful to make a brainstorm a list of products that use corn starch or other starch. Therefore, students will understand that cornstarch can be used like a glue in cooking or crafts.
- There is a spot on the student note making page for students jot down any wondering questions they have before, during, or after the experiment. Tell students they are welcome to write any questions they wondering throughout the course of the experiment. It is a good idea to periodically invite students to share these wonderings.
- Have students write their hypothesis to the question "Does adding cornstarch to a recycled paper mixture make a more durable paper?"
- Ask students how you can find the answer to the wonder question "Does adding cornstarch to a recycled paper mixture make a more durable paper?"
- Some students may suggest to research the answer. Explain to them that today you will be working with a special type of research called Experimental Research. Like traditional paper pencil research it is used to solve or find answer to wondering questions; however, it is not done using books, magazines, or the internet.
- Experimental research is done by testing a variable. Ask students if they can find and underline the variable in the wondering question listed on their Lab sheet. (Cornstarch)
- Have students explain how they know that this is the variable. (It is what you are testing.)
- Lay out the following ingredients on a table: Cornstarch, Scrap Paper, Blender, Deckle, and Sponge.

- Tell students these are their required materials for the experiment. In other words they have to use these items as a part of the experimental research. Tell them they may request as many additional materials as they need.
- You may want to give students the hint that you have intentionally not included any tools because you want them to determine what they need. If students do not already have an understanding of tools that scientist use (measuring cups/beakers/spoons, thermometers, rulers, scales, etc...) you may want to discuss with them the value of using tools in experiments. Tools **MUST** be used as a form of control in the experiment. For example would it would not be a fair test if you used two cups of water in the batch with corn starch yet only used one and a half cups of water in the non cornstarch batch.
- Give students time to work in pair groups or at their table to make a list of additional materials they will need. Examples include: Measuring cup to control the amount of water included. A timer to insure you have given both batches of paper (cornstarch and non cornstarch) the same amount of time to dry.
- If students are having a difficult time coming up with additional materials you may want to have a table set up with “materials available upon request”. It should include materials/tools you will need in the experiment and things that are not needed.
- For each material students select have them explain to you why they feel it is necessary in the experiment.
- Record the materials on chart paper that the class agrees you need for the experiment.
- If at the end of this portion of the lesson you feel students are missing an important material, it is okay. As you plan the experiment they will likely remember and include it in a step. If students do this point out them they have listed a material/tool that the class had not planned for and ask if they would like to add it to the chart.
- While this step of not telling students all materials they need may seem trivial, it is an important component of experimental design. Requiring students to think critically about how to test only one variable (cornstarch) and the tools required to control the other materials is key in developing their understanding of how to conduct experimental research.

Create

Designing a Research Plan

- After students have generated a list of materials they will need for the experiment, it is time for them to begin designing the procedural steps to the experiment.
- The section on the Innovative Scientist note making page labeled “Inquiry: Research Plan” is where students will write the steps to the science experiment.
- Students can work independently, pairs or in whole group to create the steps to the experiment. You can choose this based on your students prior knowledge about designing experiments. It is encouraged that even if students are working in pairs or independently that the steps be agreed upon whole group and charted for this introductory lesson.

- Check the plan for the following things:
 - Students are testing only cornstarch; therefore, every other material should be controlled using the tools they requested. For example you would want students to measure the liquids and amount of paper they include in each batch of paper pulp.
 - Students have included the need to make one batch of pulp with cornstarch and one batch of cornstarch without cornstarch.
 - Students may want to include a repeat test. For example include making two batches of each batch of cornstarch to make recycled paper. This is important because often one trial is not enough to prove something is true.
- If this is this is the students' first experience with experimental design, it is likely they will leave out a step. It is okay. This is a good time to share with students the idea that mistakes are okay, it is how all scientists learn.
- Through teacher questioning, you can coach students to including missing information. For example: "I notice you have included cornstarch as a material but I don't see that you are using it in your plan. Is it important that we use cornstarch in this experiment? Why?"
- Sample procedural steps are listed below:
 - Gather materials listed above
 - Tear paper into small pieces
 - Fill blender half way full with paper
 - Add 800 milliliters of water
 - Add 5 milligrams of cornstarch
 - Blend until mixture is pulp (consistency of oatmeal)
 - Pour mixture into large pan or tub
 - Cover deckle with mixture
 - Gently press pulp with sponge allowing water to drain into bucket
 - Lay deckle on labeled newspaper (label as cornstarch or no cornstarch)
 - Allow paper to dry in the sun for several hours
 - Repeat previous steps but OMIT cornstarch
 - After paper dries carefully peel it from deckle
 - Test durability of each paper
- Once students are to this step you will need to come up with a definition of durability that the class agrees on. Using that definition, students can create two or three tests they will use on each type of paper.
- Examples of tests could include folding paper, writing on paper with paper/pen/pencil, applying pressure to paper, etc...

- It is important to note to students that the data students are collecting in this experiment is observational data. Therefore, it is different than other experiments where you may be comparing the weight or temperature of something in an experiment. It may be a good idea to brainstorm a lists of scientists that would collect observational data.
- The last step to the planning process is answering the three questions on their Analyze: Data Collection section of their Innovative Scientist note making page. Students can answer these in pair groups or independently then share out with the class. The three questions are as follows:
 - What data will you collect? (Answers should relate back to durability tests.)
 - How will this information help you answer your research question? (Answers should relate back to variable, cornstarch, and durability.)
 - How will you organize your data? (Answers may vary. Ex: Table or Chart comparing durability of each of the recycled papers.)
- It usually takes a full class period to complete the lesson up to this point. If you are closing out the class, it would be a good idea to invite students write and/or share any wondering questions they have written up to this point.
- It is also important before you close out the day to be sure you have charted all of the experimental design steps.

Inquire

Conducting Experimental Research

- If this is a second day of this lesson, you may want to begin by reviewing the research plan/ experimental design the class created the previous day. Include the question, hypothesis, variable, and wondering questions in this discussion.
- Today is the Innovative Scientist fun day for the kids. All of hard work and planning leads up to a class period of fun and learning. In this part of the day students will actually be conducting the experiment based on the plan they created on the previous day.
- It is your decision as the teacher how you manage the experiment. You may find if this is your first experiment you are more comfortable to make the pulp as a whole group project, while allowing students to deekle, and test the durability in small groups. While other teachers may feel comfortable giving each group a blender and allowing them to work through the experiment.
- The teacher is the coach for this experiment. Students are the leaders and the instructor serves as their guide. It is important that lesson does not become a demonstration where students are only watching the experiment. In Innovative Scientists students are always active learners.

Analysis

Reflecting on Data

- After the paper has had time to dry, give each student (or group of students depending on how you choose to manage this experiment) graph paper to create their chart/table and perform their durability tests.
- Once students have performed the tests it is time for them to analyze their observational data. In other words they are answering their research question, “Did cornstarch make more durable paper?”
- Students should be able to refer back to their data chart to defend their answer on why they believe (or why they do not believe) adding cornstarch created a more durable paper.
- Have students check their conclusions against their original hypothesis. It is recommended that you save this step until last. Often if students begin by looking at their hypothesis rather than the question their only conclusion will be “My hypothesis was correct/incorrect.”
- Guide students to focus on their learning and connecting back on the experiment rather than only determining if they were correct or incorrect on their hypothesis.
- Lastly, it is important to model for students that if their hypothesis is incorrect it does not mean they failed. Often students associate being wrong with a failure. If this type of thinking occurs in your class it may be a good idea to celebrate mistakes in classes as opportunities where students have learned. It also may be interesting to share some failures of scientists who are considered successful. It is important that students understand that it is only through our mistakes and misunderstandings that we have the opportunity to learn.

Enhance & Inquire

Re-visioning through Wonderings

- Now that students have conducted the experiment, performed the durability tests, and analyzed their findings they are ready to enhance through inquiry.
- There is always something you could change about an experiment to impact the results. Have the class or small group of students discuss the following questions:
 - If you did this experiment again, how would you change it? How do you predict this change would impact the outcome?
 - What do you wonder now that you have finished the experiment?
 - Is there another (similar) experiment you'd like to try now that you have found the outcome of this one?
 - Were there any unintended variables in this experiment? If so, how could we control them better next time?

Communicate

Sharing Findings

- If students have worked in small groups for the analysis portion of this experiment, it would be a good idea for them to share their results and conclusion.
- Students should also share their answer to the questions in the enhance portion of this lesson. (wonderings, ideas for experiment enhancements, ideas for future experiments)
- As students are sharing they may notice that different groups had results that were a bit different. Encourage students to discuss these differences by supporting their conclusion with results from their charts/tables.
- If results are different it may be a good idea to discuss why data collected could be different for each group. Possible reasons include: Different durability tests or the fact that each group was using a different piece of paper.
- It may be a good idea to also discuss the roll of observational data in this experiment and if it leaves any room for opinion or error.

Inquiry

Wondering

- Give students to write down and share any additional wondering questions they have about today's experiment.
 - Finally, ask the students the three L's. What is something that you... Learned OR would Like to do again OR Lit your fire about todays lesson?
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INNOVATIVE SCIENTIST

Experimental Research



Connection

How is paper an innovation of the past?

Think of all of the products that are made of paper today. What are the unintended consequences of our use of paper products?

INQUIRY: RESEARCH PLAN

Question

Research Question

Does adding cornstarch to recycled paper mixture create a more durable paper?

Hypothesis

I predict.... because

Wondering Questions

Questions (Before, During or After)

ANALYSIS: DATA COLLECTION

What data will you collect?

How will it help you answer your question?

How will you organize your data?
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