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Paper Chromatography Lab

S.T.E.M. ON A SHOE STRING

By Brad Fulton
Educator of the Year, 2005
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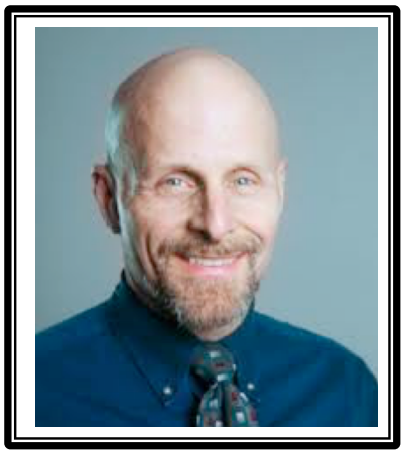
Educator of the Year



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- ♦ Consultant
- ♦ Educator
- ♦ Author
- ♦ Keynote presenter
- ♦ Teacher trainer
- ♦ Conference speaker

Known throughout the country for motivating and engaging teachers and students, Brad has co-authored over a dozen books that provide easy-to-teach yet mathematically rich activities for busy teachers while teaching full time for over 30 years. In addition, he has co-authored over 40 teacher training manuals full of activities and ideas that help teachers who believe mathematics must be both meaningful and powerful.

Seminar leader and trainer of mathematics teachers

- ♦ 2005 California League of Middle Schools Educator of the Year
- ♦ California Math Council and NCTM national featured presenter
- ♦ Lead trainer for summer teacher training institutes
- ♦ Trainer/consultant for district, county, regional, and national workshops

Author and co-author of mathematics curriculum

- ♦ Simply Great Math Activities series: six books covering all major strands
- ♦ Angle On Geometry Program: over 400 pages of research-based geometry instruction
- ♦ Math Discoveries series: bringing math alive for students in middle schools
- ♦ Teacher training seminar materials handbooks for elementary, middle, and secondary school

Available for workshops, keynote addresses, and conferences

All workshops provide participants with complete, ready-to-use activities that require minimal preparation and give clear and specific directions. Participants also receive journal prompts, homework suggestions, and ideas for extensions and assessment.

Brad's math activities are the best I've seen in 38 years of teaching!
Wayne Dequer, 7th grade math teacher, Arcadia, CA

"I can't begin to tell you how much you have inspired me!"
Sue Bonesteel, Math Dept. Chair, Phoenix, AZ

"Your entire audience was fully involved in math!! When they chatted, they chatted math. Real thinking!"
Brenda McGaffigan, principal, Santa Ana, CA

"Absolutely engaging. I can teach algebra to second graders!"
Lisa Fellers, teacher

References available upon request

Like my activities? How about giving me a favorable rating on the Teachers Pay Teachers website? Four stars would be much appreciated and would help me sleep better at night.

Like me even more? Then please don't make copies for your colleagues. I know it's tempting when they say, "Wow! Groovy activity! Can I have a copy?" But this is how I make my money, and why are they still saying "groovy" anyway?

If we make copies for our friends, can we honestly tell our students not to copy or take things that don't belong to them? (Ouch!)

Half priced site licensed copies are available on the TPT website. Please encourage them to take advantage of this affordable option. Okay?

Thanks and happy teaching,

Brad

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- ☐ b) Affordable staff development
- ☐ c) Ongoing staff development
- ■ d) *ALL OF THE ABOVE!*

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Great DVD presentations offer quality mathematics staff development at a fraction of the cost!

- **Effective because** they are classroom-tested and classroom-proven. These popular DVDs of Brad's trainings have been utilized by teachers throughout the country for years.
- **Affordable because** they are site-licensed. Buy only one copy for your whole school, print as many copies of the handouts as you need.
- **Ongoing because** when you hire new staff, simply hit "play" and the training begins. There's no need to bring back the consultant.

Paper Chromatography S.T.E.A.M. Lab
Science•Technology•Engineering•Art•Math

Overview:

Four activities in one! Students will be excited to learn about color in this visual and hands-on lab. Multiple options let you adapt the lesson for primary students through middle school.

They will learn how secondary colors are created by mixing primary colors and how those in turn blend to create new hues.

Art applications turn this S.T.E.M. lesson into a beautiful S.T.E.A.M. activity. Web links for further exploration allow more advanced students to study the science of chromatography and how it is used today.

Required Materials:

- ☒ Coffee filters
- ☒ Water-based and permanent markers
- ☒ Cups
- ☒ Water
- ☒ Isopropyl alcohol (rubbing alcohol)

Optional Materials:

- ☐ Chenille stems (pipe cleaners)
- ☐ Coffee stirrers

1. The Primary-Level Lesson

Procedure:

1. Give each student a coffee filter and some markers. Have them create random designs on the paper as shown.
2. Put about a centimeter of water into a cup. Then twist the coffee filter into a cone shape by gathering the outer edges together with the center of the filter as the vertex of the cone.
3. Insert the vertex of the cone into the cup until it touches the water. The water will "wick" up the paper filter and begin to spread the colors. This is a good time to discuss the concept of *capillary action*. Water is able to move upward upon a membrane against the force of gravity. This is also how a candle burns. Have you ever noticed that when you first light a candle the flame is small and then after a moment it grows bigger? At first, only the string is burning. Then the melted wax moves up the wick into the flame and vaporizes. From there the vaporized paraffin produces the bigger flame. Now the wax vapors are burning instead of the wick!

4. Students can observe the mixing of colors. Ask them what new colors were produced when blue and yellow ink mixed, (green); when yellow and red mixed, (orange); when red and blue mixed, (purple). Blue, yellow, and red are called *primary colors*. Green, orange, and purple are *secondary colors*. You can also have them observe combinations of secondary colors.

5. Do any students have filters that produced brown tones when none were used in the original design? Brown is typically made by mixing a primary color with the secondary color on the opposite side of the color wheel. For example, red + green = brown, blue + orange = brown, and yellow + purple = brown.

6. After the filters are completely saturated to the outer edges and the colors have blended, have the students take them out of the cups. Lay them out to dry on a cloth or paper towel. Be careful to set them on a surface that will not be stained.

7. Once they are dry, perhaps the following day, they can be pressed between books to flatten out the wrinkles and to be displayed. If you wish, they can be mounted on the wall. More artistic options include hanging them on a window so light illuminates them like stained glass. They can also be mounted on black construction paper for a stunning display. Other craft options are listed below.

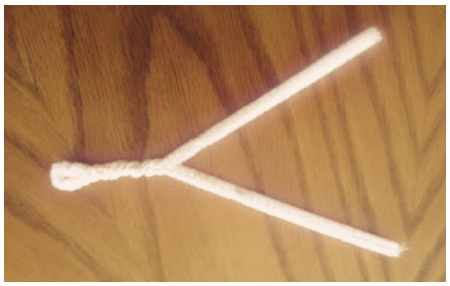
2. Making a flower

1. Students will need one chenille stem and two to three coffee filters that have been colored, wetted, and dried to make each flower.
2. Stack the filters on top of one another.
3. Push a chenille stem through the center of the circles. Roll the top of the wire stem into ball to keep it from pulling back through the hole. You can also put a dab of glue there to secure it.
4. Gather the dried filters back into a cone shape around the balled end of the chenille stem. Twist and crimp them as you do this.
5. Finally twist the base of the cone around the chenille stem. This can be secured with tape if you wish to help it hold better.

3. Making a butterfly

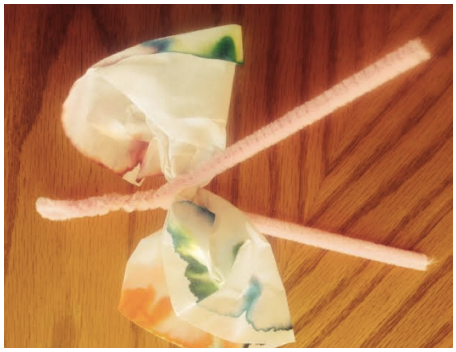
1. Students will need only one colored coffee filter for this project and one chenille stem.

2. Bend the chenille stem in half as shown.



3. Then twist a few turns to form the butterfly's tail.

4. Gather and pinch the coffee filter down the middle to form the two wings.

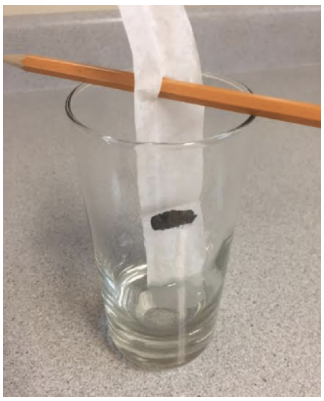


5. Place this in the "Y" of the chenille stem.

6. Give the wires a couple more twists above the wings to secure them. Spread the "antennae" and your butterfly is complete!

4. The Upper-grades version

1. Have the students cut a 2 cm wide strip from the center of their coffee filter as shown.
2. Use a black water-based marker to make a line across the filter about 3 cm from one the bottom.
3. Put 1 cm of water into a cup.
4. Suspend the strip in the cup so that the bottom of the filter reaches the bottom of the cup.
5. Push a pencil or coffee stirrer through the filter so that it is suspended with the bottom in the water.
6. As the capillary action occurs, the black ink will separate to reveal other colors that were used to make the ink.
7. Different types of ink are made from different colors. My students experimented with different brands of water-based markers, whiteboard markers, and overhead transparency markers. Some types and brands produce little or no results while others, like the overhead transparency markers, work much better.
8. You can also use permanent markers. These will require alcohol to separate the colors.
9. My students used this lab to understand the concept of *variables* and *controls*. They controlled the amount of water, the time of the experiment, the size of the cup, the dimensions of the strip, and other factors. They varied the type of pen, the type of liquid, and even the type of paper by using printer paper and paper towels. Some experimented with other colors of ink. What happens when you try to separate colored ink?



Notice the capillary action

Overhead transparency marker after
30 minutes ← → 3 hours

Ideas for further research

1. Paper chromatography is a branch of science. It is used to analyze inks and other pigments. Each type of ink or pigment leaves a unique "footprint" caused by the separation of the different molecules that comprise it. This separation in turn is caused by the differences in the *polarity* of the types of molecules.
2. The chromatograph is measured as a ratio. The distance each color travels is compared to the distance that the solvent traveled. For example, if a color travels 3.6 cm while the solvent traveled 4.8 cm, then the *retardation factor*, or R*f* is .75.
3. You can learn more about chromatography at
   - wikipedia.org/wiki/Paper_chromatography
4. More links for additional topics are provided on the following page.

Teaching S.T.E.A.M. curricula

More and more schools are integrating S.T.E.M. and S.T.E.A.M. activities as either stand-alone lessons or as a focus of the entire school's instruction. Let's look at how this Paper Chromatography activity ties into the components of S.T.E.A.M.

Science – As mentioned previously, students can study the effects of the variables and controls in this lab. You can focus your students on the sciences of color, capillary action, and of course chromatography. A link is provided above on chromatography. Here are some Wikipedia links for color and capillary action.

- wikipedia.org/wiki/Color
- wikipedia.org/wiki/Capillary_action

Technology – Older students can be directed to the more technical aspects of chromatography. Typically, this is done with much more sophisticated equipment than paper and a solvent as in this activity. The previous link directed students to *paper chromatography*. Here is a link to other methods such as gas chromatography.

- wikipedia.org/wiki/Chromatography

Engineering – There is very little engineering in this activity. Perhaps your students can design a better way to set up the experiment to get more accurate or measurable results. Can they find a way to improve the experiment for some of those inks that do not separate well with water and coffee filter paper?

Arts – When students are shown the aesthetics of science and math they want to engage more in those subjects. We tend to see art and literature as beautiful, but not math or science. In this activity, students study the blending of colors and the diffusing of water across the membrane and then use that to create butterflies and flowers. Students can also incorporate language arts into this lab by writing a report on their lab and explaining the effects of the variables on the results.

Math – Calculating the R*f* factor in paper chromatography is based on the concept of ratio. How far has the color moved compared to how far the fluid moved? In this activity, the movement of the colors is very minimal, so students may want to use a magnifying glass or a small microscope to study this.

If you liked this activity, you might also like some of the other lessons available in my TeachersPayTeachers store. Simply search for "**Teacher to Teacher Press**".

You can also find many free and inexpensive resources on my personal website, www.tttpress.com. **Be sure to subscribe to receive monthly newsletters, blogs, and FREE activities.**

Similar ***S.T.E.M. ON A SHOESTRING*** activities include:

- *Slime Time* – A gooey lab involving Non-Newtonian fluids. Get the PowerPoint too!
- *Ramp Races* – An engaging and exciting way to teach students the principles of physics: forces, motion, speed, friction, and more!
- *Invisible Ink Lab* – Make hidden messages appear using the principles of chemistry and simple kitchen ingredients
- *Milk Lab* – Watch polar and non-polar molecules interact in this rainbow-hued lab. PowerPoint presentation available too!

Feel free to contact me if you have questions or comments or would like to discuss a staff development training or keynote address at your site.

Happy teaching,

Brad