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SENCER as a Community of Transformation In STEM Reform

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Caps: A Never Ending Resource in Teaching and Learning in STEM/STEAM Education

Abour H. Cherif, Ph.D. Gerald Adams, Ph.D

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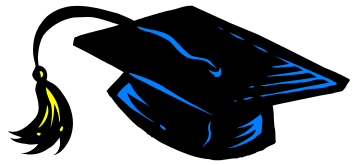
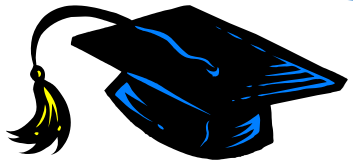
The Never Ending Resources In Teaching and Learning With STEM/STEAM Education



Lack of material resources to introduce and teach STEMS topics has been one of the things that school teachers have considered as barrier for them to effectively teaching STEM topics in k-12 levels. However, while resources are essential for effective teaching and learning, resources don't have to be expensive or special to be used in teaching.

Many familiar and all around materials can be used as good resources in introducing and teaching STEM topics. As you can see from the list and the diagram in the following slide, familiar materials such as milk, tea, water, cabbage, oil, bread, sand, caps, hair, etc. are good and effective resources for teaching science concepts. Indeed, any object you encounter, regardless of natural or human made, has science, math, design, engineering, arts, etc. elements and concepts impeded in its design, structure, and composition and as such it can be used to introduce, teach, and learn STEM topics.

The Never Ending Resources In Teaching and Learning With STEM/STEAM Education

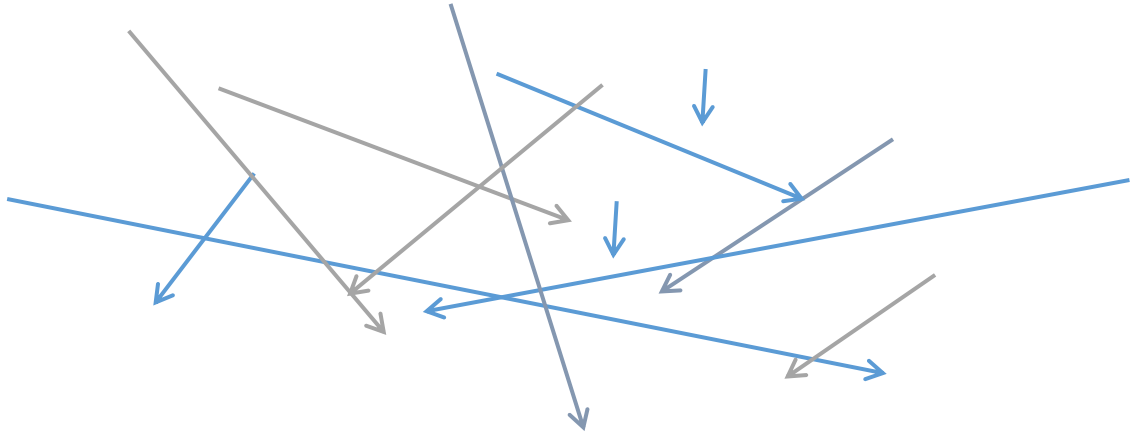


We Have Done

- Water
- Sand
- Milk
- Oil
- Caps
- Tea
- Fossils
- Coins
- Hair
- Shadow
- Hotdogs
- Popcorn
- Laser, Magnet, Electricity
- Cabbage & Onions

We Are Working On

- Air
- Salt
- Bread



The Search Continues

Caps, the Forgotten, Fascinating Objects in Teaching and Learning Science

Almost every week, most of us will open a jar or bottle and throw the cap away without thinking of the value it might have beyond keeping the contents sealed tightly inside.

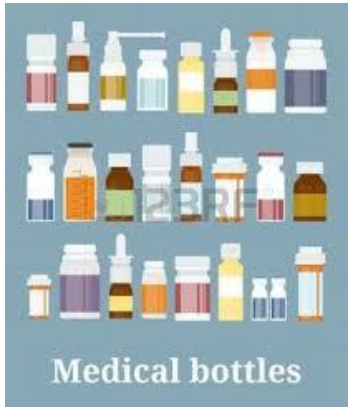
Bottle caps and jar lids are made of a variety of materials and come in different Sizes, Shapes, Designs and Levels of design complexity, Functions, Colors, Patterns

https://en.wikipedia.org/wiki/Bottle_cap

Caps, the Forgotten Objects in Teaching and Learning Science

Sizes, Shapes, Patterns, Colors, Functions, Composition, Designs and levels of design complexity

In addition, while the main function is the same for almost all types of caps, they use various mechanisms to achieve that function.



Using Caps Teaching and Learning As …

Objects

Objects/Tools

Tools

To Learn Concepts & principles

To demonstrate and illustrate learned concepts, Principles, Skills, design, thought, etc.

To Learn & practice skills of designing, making critical thinking reasoning

Engaging and Effective Teaching and Learning

Caps in Teaching and Learning

For teachers, ***caps*** can have a multitude of educational and pedagogical uses that help create learning pathways which work with a variety of student interests and needs and help remove potential barriers that deny many learners equal access to excellence and success in STEM and other fields.

Caps in Teaching and Learning

Caps are very useful for introducing students to many central STEM concepts, as well as effective tools for improving writing and language arts skills.

Caps can be used to develop observational and classification skills by sorting these objects into different:

- Colors
- Compositions (metal, plastic, etc.)
- Sizes
- Weights and densities
- Construction types
- Levels of design complexity

Caps in Teaching and Learning

With caps, teachers can illustrate mathematical concepts like number value, addition, subtraction, division, multiplication, ratios, fractions, percentages, and proportions and use statistics and graphs.

Through the study of caps' designs and levels of complexity, algorithmic as well as geometric concepts and skills can be introduced, learned, and applied.

Caps in Teaching and Learning

- Caps can also be used to:
  - introduce the concepts of color theory and primary and secondary colors.
  - study the relationships between shape and design, or structure and function.
  - study and differentiate between metals and non-metals and between magnetism and electricity.
  - study engineering and graphic design concepts.
- They can be applied creatively for arts, crafts, jewelry, buttons, or to create games, toys, and even music.
- The list of uses is nearly endless in both STEM and non-STEM fields.

Caps in Teaching and Learning

In designing a particular cap, STEM concepts are repeatedly involved, from physical and mathematical concepts to graphic design, selecting the right construction materials, choosing the correct shape, appealing to aesthetics (the best color, luster and form for visual appeal), to name a few.

All these elements have to fit and complement each other to achieve the main purpose and function of a given cap, and also communicate any hidden message the designer wishes to communicate to consumers and users of the product.

Caps

In addition, all these elements must be described and produced in written form correctly and in detail for all those who are involved in the processes, from the designers to the manufacturers, and from the decision makers to sales reps, to name a few.

When we study caps, our perceptions of them change from their being simple to complex objects, insignificant to very significant objects, and from being throw-away materials, to valuable pedagogical resources and recyclable materials.

Caps As Teaching and Learning Tools

Into how many categories, sub-categories, and subsequent sub-categories can caps be grouped?

- Teachers can, for example, ask students to divide caps into as many categories as they are able. Then the teacher can use each category as a starting point to introduce a given scientific, mathematical, and/or engineering concept.
- For example, in the color classification of caps, the class could investigate the differences between colored pigment and colored light, how we perceive color, how color is created or how colors are mixed. Students can also be asked to research the history of specific pigments and dyes, how colors have been used in our society, and many other fundamental topics.
- Researching how synthetic pigments have changed human lives and societies is a fascinating journey where students can learn a lot.

Caps As Teaching and Learning Tools

Into how many categories, sub-categories, and subsequent sub-categories can caps be grouped?

If the students classify caps by the material from which they are made, teachers can introduce the concept of metals (such as copper, iron, aluminum, etc.) and nonmetals (wood, plastic, cork, etc.), and how they differ from each other. They can explore which caps conduct electricity or can be magnetized, and which ones cannot. They can classify matter according to its composition, whether a pure substance (elements, compounds), or a mixture (heterogeneous or homogeneous), and use this as a springboard into the nature of matter, atoms, molecules, and chemical reactions.
This can lead to also teaching about the rare earth elements and opens new areas of teaching from technology and electronics to world relations and globalization. (Cherif and Adams, 2014).

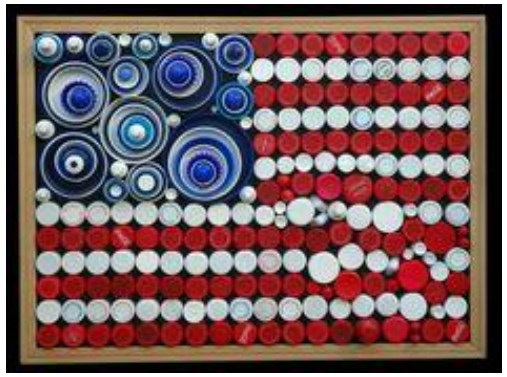
Caps Can Also Present Worthwhile Conceptual Challenges to Students and Teachers—Through Questions Such as These:

- How would you define or describe caps?
- How do you differentiate between caps, lids, and tops?
- Can you draw various kinds of caps in two and three dimensions?
- How can you design and build a cap that has only one function and a cap that has more than one function?
- How can you make transparent, translucent, and opaque caps?
- How is color added to a cap?
- What are the advantages of caps that screw on to the outside of a bottle opening compared to those that screw into the inner surface, or are forced into the bottle top, such as a cork?
- What are some of the limitations and challenges in using a given material (e.g., wood vs. plastic, cork vs. metal) for designing and creating caps?

Caps As Teaching and Learning Tools

When you think of using caps in your teaching, you also need to keep in mind that today students come to school with diverse interests, strengths, needs, and goals. Our job, as teachers, is to know our students, their strengths and weaknesses, and to reach them in different ways using familiar objects and proven teaching methods that work with a variety of students in gaining desirable skills, acquiring meaning, and transferring knowledge (e.g., Cherif, 2011; Cherif, Roze, Gialamas, 2016).

Caps As Teaching and Learning Tools



Using caps pedagogically in the learning process can help free the imagination, ignite creative thought, and motivate engagement in the learning process among many students!

Caps As Teaching and Learning Tools

Warm Up Activities:

Activity I: Let's Define Caps
Activity II: The Power of Prediction in Fostering Critical Thinking
Activity III: A Cap's Material Make-up.
Activity IV: Dual Function
Activity V: Caps in the Learning Environment
Activity VI: Let's Classify Our Intriguing Caps
Activity VII: Invention and the Creative Uses for Caps: Conversation with an Industrial Designer
Activity VIII: Let's Design Caps
Activity IX: The Power of Imagination - Visualizing and Drawing Images of Your Caps
Activity X: Our Colorful Caps
Activity XI: Caps, Magnets and Electricity
Activity XII: Caps, Weight and Density
Activity XIII: The Use of a Spray Device to Demonstrate Various Scientific Concepts
Activity XIV: Caps, Writing, and Language
Activity XIV: What is the Big Deal About Caps of Pharmacy Medicine Bottles?
Activity XV: Scientific Investigation and Research Studies
Activity XVI: Research Study: Recycling Medicine Bottles and Their Caps
Activity XIV: Do You Wonder What to Do with Your Bottle Pills Caps that Pharmacies Use to Package Prescriptions?
Activity XVII: Caps and The Power of Imagination
Activity XVIII: Patented You Caps!

Warm Up Activity

To stimulate students' minds and prepare them for working with caps, students are asked to engage in a warm-up activity designed to be conducted a few days before asking students to engage in actual hands-on activities with caps.

The main purpose of the Warm-up Activity is for the teachers to get to know their students and the levels of their personal experience and general knowledge and information. This will help teachers know where and how to start!

The teacher acts mostly as a facilitator for the discovery process by asking questions that help guide students through the process. Simpler questions are at the beginning, more advanced towards the end. Teachers should select a few questions based on the level of their students.

Warm Up Activity: Ask each student to respond:

List all the

- materials that a cap can be made of
- colors that you can think of
- shapes that a given object can be made into
- shapes that can be considered natural, as seen in nature
- colors that you don't think are natural, meaning not seen in a natural environment
- materials that you think don't occur naturally, meaning they are human-made materials

1. Define the words *definition*, *structure*, and *function*
2. Differentiate between elements, compounds, and mixtures
3. Differentiate between heterogeneous and homogenous substances
4. Identify at least 3 things that are made up of pure substances (elements or compounds)
5. Identify at least 3 things that you think are made up of mixtures of pure substances
6. Differentiate between solids, liquids, gases, and plasma, and give an example of each

Activity I: Let's Define Caps

To Define vs. Describe

One of the things that we noticed when we conducted caps-related activities with teachers and student-teachers was their difficulty in distinguishing between the concepts of definition and description.

No matter how much time these learners spent on refining their definitions of caps, they still tended to come up with statements that reflected more descriptions than definitions of a cap.

Activity I: Let's Define Caps

Here then are some guidelines for distinguishing these two concepts:

- **To define is to specify the essential nature, purpose, or basic qualities of something by placing it in a category and then distinguishing it from other members of that category. Thus, for example, we can define the term *cowl* as a monk's hood, by placing it into the category "hood" and giving it the differentiator "monk's." By placing a term into a category, we distinguish it from membership in other categories, and by differentiating the term from other members of that category we delimit it, or define it. Given a properly stated definition of something, we are able to distinguish it from anything else, including things that are similar but not fully like it. There are many kinds of hoods, but only the cowl is a hood worn by monks.**

- **To describe is to give essential characteristics and features of something. Thus, we can describe a cowl as a head covering that is part of another piece of clothing, such as a jumper or sweatshirt or robe, and we can further say that a cowl forms a shell-like enclosure over the top and sides of the head. We would then be giving a fairly complete <u>description</u> of a hood, but not distinguishing it from other hoods.**

- **In defining the term *cap,* we would, of course, want to distinguish it from head coverings and place it into the category of covers for jars and bottles, but also lenses (lens cap) and knees (kneecap) and other items being protected.**

Activity I: Let's Define Caps

- **Most of the dictionaries that students use in school or at home don't define caps. This makes this activity an intriguing educational challenge.**
- **Without an agreed upon definition for caps, students might have a difficult time communicating with each other effectively while using caps to explore various subjects.**
- **With this in mind, the following activity is designed to help students talk, listen, read, write, and reflect as they become directly involved in the search for a meaningful definition for caps that distinguish them from other similar objects such as lids and tops.**
- **Engaging students in an instructional process such as this helps promote critical thinking and improves the overall quality of learning among students.**

Activity I: Let's Define Caps

The procedure:

1. **Divide the students into groups of four.**
2. **Give each group a number of caps that differ in color, size, shape, design, complexity and the material(s) of which they are made.**
3. **Ask the members of each group to examine each cap, and then describe each one in writing according to: Structure, Function, both structure and function, or Other selected features.**
4. **Ask each group:**
    - **To choose or revise their descriptions of each cap so that all the members of a given group agree on one description.**
    - **To use their revised description of a cap to define a cap. Make sure that all the members of a given group agree on one definition.**
    - **To identify whether their final definition of a cap is functional or structural definition, both, or neither.**
    - **To identify whether their final definition of a cap and their revised description of a cap differ from or support each other.**
    - **To identify the challenges they encountered in coming up with a definition for caps?**

5. Write down their answers to these questions and end their report by writing one or two paragraphs on what they have learned from this activity.

Activity I: Let's Define Caps

Examples of Students' Definitions of Caps:

1. **A circular piece that serves as a sealer for bottles and containers to maintain its contents, preserving its flavor, freshness, dryness, etc.**

2. **A cap is an object that encompasses or covers an object (specific to the container) to prevent a substance from spilling out. Most commonly seen as circular, they can have many shapes, be many sizes, and are made out of many different materials that are sturdy enough to execute the definition.**

3. **It is something we use to cover or seal different kinds of containers. They are made of different materials (i.e. plastic, metal, wood, etc.). Their shape varies depending on the nature of the container. They usually are made to prevent an object or substance from getting out of or in to the container.**

4. **It can be metal or plastic, or cork, or wood. They come in various sizes, shapes, and colors. Their primary use is to cover containers, bottles, jars, etc. They help keep things from spilling, keeping them fresh and safe in the container by preventing things from going in or out of the container.**

Activity II: The Power of Prediction in Fostering Critical Thinking

To predict is to state, to make known in advance, or to conclude based on special knowledge, information, experience, or proposed answers to questions about what has been observed. In this sense, we are forcing students to use their previous knowledge and experience as well as critical thinking to imagine what will happen or what they would see and provide cognitively informative prediction. The following activity is designed with this goal in mind.

Prior to engaging students in this activity, the teacher needs to prepare zipper sealed plastic bags (10 x 11 in or bigger) or containers each with various types of caps (color, size, design, structure, make-up, etc.). Make sure that each bag has a different number of caps (between 50-150).

Activity II: The Power of Prediction in Fostering Critical Thinking

1. Divide the class into groups of 4 students.
2. Give each group zipper-sealed plastic bags (10 x 11 in or bigger) or containers.
3. Ask the members of each group, without opening the bag to examine and be familiar with the caps to estimate the total number of caps in the zipper-sealed bag using the following approach:
   - **It doesn't have more than …… caps.**
   - **It doesn't have less than …… caps.**
   - **Our estimated number of caps (average number between more than and less than) would be ……. .**

Activity II: The Power of Prediction in Fostering Critical Thinking

4. Ask the members of each group, without opening the bag to examine and be familiar with the caps and to predict:

- **How many metal caps are there?**
- **How many non-metal caps are there?**
- **How many plastic caps are there?**
- **How many wooden caps are there?**
- **How many cork caps are there?**
- **How many aluminum caps are there?**
- **How many copper caps are there?**
- **How many iron caps are there?**
- **How many small size caps are there?**
- **How many medium size caps are there?**
- **How many large size caps are there?**

Activity II: The Power of Prediction in Fostering Critical Thinking

5. Ask the members of each group to present their prediction of each item in # 4 in both *numbers and percentage* or *numbers and graph*.
6. Upon completion, ask the members of each group:
    - To *test their predictions* by opening their zipper-sealed plastic bag, and *counting each identified item* in step #4.
    - To present their actual findings of each item in #4 in both numbers and percentages or numbers and graph.
7. *Compare and contrast* between their predictions and their actual findings.

Write down your answers to these questions and end your report by writing one or two paragraphs on what you have learned from this activity.

Activity IV: Dual Function

One of the fascinating things about caps is the fact that, beside their main function, many of them have additional essential functions. Without these functions the intended caps cannot be fully effective. For example, the fabric refresher bottle cap or the air freshener container cap serves more than to maintain the content within the bottle or the container. It is also the device through which the content can be spread into the air or onto clothes in a desirable fashion. The following activity is designed to help students discover the dual function of caps and the relationship between design, structure, and function.

Procedures:

- Divide the class into groups of 4 students. Give each group a zipper sealed plastic bag or a container with various types of caps.
- Ask the members of each group to examine and become familiar with the function of the caps in their container, and then work together to answer the following questions:

Activity IV: Dual Function

Procedures:

1. Identify those caps which function as a two-way cap for a given container and/or bottle.
2. What is the percentage of caps that function as two-way?
3. Come up with an informative hypothesis why this type of cap is designed as a two-way cap.
4. Perform Internet research to discover why this type of cap is designed as two-way?
5. Does your hypothesis agree or disagree with your findings?
6. How would you modify your hypothesis so it could lead to the findings that you have obtained?

Write down your answers of these questions and end your report by writing one or two paragraphs on what you have learned from this activity.

Activity VI: Let's Classify Our Intriguing Caps

The Challenge:
Into how many categories, sub-categories, and 2nd-sub-categories can you classify your caps?

1. Category
    a. Sub-category
        i. 2nd-sub-category
            - ……
            - ……
        ii. 2nd-sub-category
            - ……
            - ……
        iii. 2nd-sub-category
    b. Sub-category
        i. 2nd-sub-category
        ii. 2nd-sub-category
            - ……
            - ……
2. Category
    a. Sub-category
        i. 2nd-sub-category
            - ……
            - ……
        ii. 2nd-sub-category
    b. Sub-category
        i. 2nd-sub-category
        ii. 2nd-sub-category
3. Category
    a. Sub-category

Activity VI: Let's Classify Our Intriguing Caps

Classifying is assigning objects to classes indicating similarities in structure, function, etc.

The ability to study and examine objects and systematically group them into informative categories and sub-categories based on shared characteristics requires an understanding of various important and worthwhile aspects of the intended objects. The result of the classifying process is concepts, ideas that compare and contrast things, events, or that describe causal relations among them (Barrow and Million, 1990; Joyce, Weil, and Calhoun, 2009).

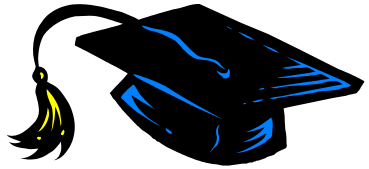
1. Category
    a. Sub-category
        i. 2nd-sub-category
            - ……
            - ……
        ii. 2nd-sub-category
            - ……
            - ……
        iii. 2nd-sub-category
    b. Sub-category
        i. 2nd-sub-category
        ii. 2nd-sub-category
            - ……
            - ……
2. Category
    a. Sub-category
        i. 2nd-sub-category
            - ……
            - ……
        ii. 2nd-sub-category
    b. Sub-category
        i. 2nd-sub-category
        ii. 2nd-sub-category
3. Category
    a. Sub-category

Activity VI: Let's Classify Our Intriguing Caps

Brainstorming is always a good way to arrive at effective ways to classify anything, including caps. Finding interesting secondary functions for caps is only one category students might consider.

1. Discuss with the members of your group how many different categories, sub-categories, and secondary sub-categories you can use to classify the caps in front of you?
2. List all the possible categories, sub-categories, and secondary sub-categories that you identified in question 1.
3. Using the caps in front of you, try to illustrate each category, sub-category, and secondary sub-category that you listed in question 2.

Caps Are Made of



- Metals
  - Pure substance
    - Elements
      - Atoms
      - Molecules
    - Compounds
  - Mixture of substances
    - Heterogeneous
      - Nonuniform Composition
    - Homogeneous
      - Uniform Composition
- Non-metals
  - Natural
  - Human-made

Inference and Conclusion

A few ways that can be used to classify caps for pedagogical reasons:

- **Resemblance: similar caps vs. non-similar caps**
- **Material make-up: metal vs. non-metal caps**
- **Color: colored vs. colorless caps**
- **Size: small, medium, or large caps**
- **Weight: light, medium, dense (heavy) caps**
- **Transparent, translucent, or opaque caps**
- **Design: simple vs. complex design**
- **Shape: cylinder, tapered, cone-shaped, complex, non-circular**
- **Toughness: scrachable vs. unscrachable by different materials**
- **Function: singular vs. dual function**
- **Sealing mechanism: screw in, screw on, push/pull**
- **Grooves: Inside grooves, outside grooves, etc.**
- **Complexity: Simple, moderate, complex**

Conversation with an Industrial Designer

We have asked the industrial design professor Rajib Adhikary the following question: "***When you design a given product, say a cap for a given bottle, what do you want to know before you start designing the cap?***"

I would require a proper BRIEF from the client asking me to do the design. The brief would clearly state the following:

- What is the bottle or container having this cap going to contain? Essentially, the cap plays a big role in the design and image of the product. (For example, is it going to be liquid, semi-liquid, solid, or gas; color or colorless, etc.)

Conversation with an Industrial Designer

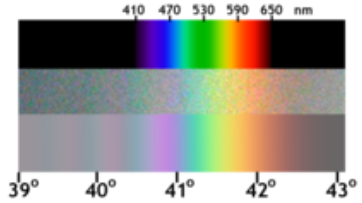
- Who is the end user of the product?
- What materials and processes are going to be involved? How much liberty do I have to choose from the many ways possible to manufacture the caps?
- Are we going to recycle the caps?

- Do you want any graphics on the caps? If so, then what kind of image do you want to portray? Do you have any corporate colors?
- Is there a cost constraint?
- How many pieces do you want?
- How much time does the designer have?
- Do you want this cap to be used in only one specific product or can be used in more than one product now or in the near future?

Caps and The Power of Design

Design

- Fosters Thinking

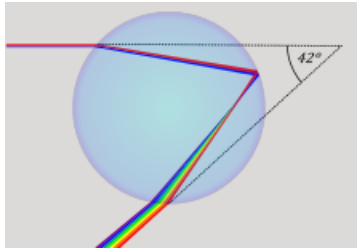


Thinking

- Fosters Imagination

Imagination

- Fosters Creativity



Creativity

- Fosters Innovation

Innovation-design thinking is to go beyond the physical appearances od an object

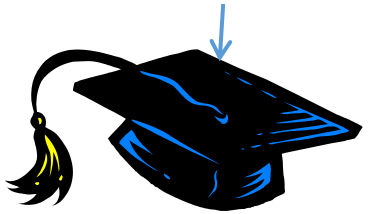
Photos sources: https://en.wikipedia.org/wiki/Rainbow
https://en.wikipedia.org/wiki/Rainbow#/media/File:Rainbow_At_Maraetai_Beach_New_Zealand.jpg

Potential Risks and Safety In Designing Objects

Simple Design

Complex Design

Reasons for Simplicity



Reasons for Complexity

Potential Risks

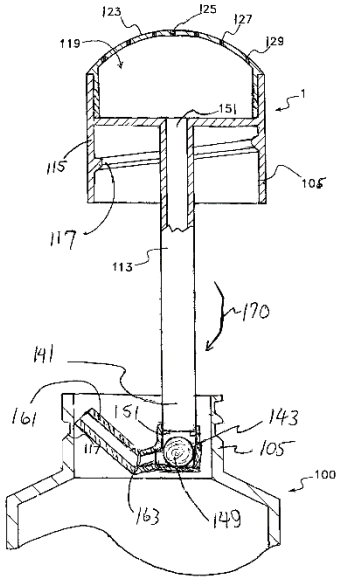
Potential Safety

Potential Risks

Potential Safety

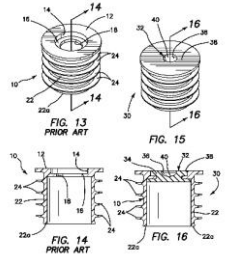
Essential Features and Characteristics of Better Design

Activity VIII: Let's Design Caps

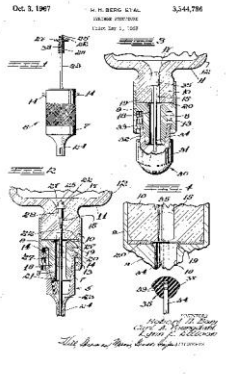


As long as there are human beings and indeed life on Earth, there is design and need for design. This means that the future of industrial design is great at all levels: profession and career, continuous needs, technological innovation, human endeavors, etc.

To design is to conceive and form an intended plan based on prior experience, knowledge, and available resources, and then to draw a sketch, and execute the plan for intended purposes.



With this in mind, for the learning activity, students need pencils, paper, clay or play-dough, and waxed-paper to complete the assignment. Based on the conversation with the professional industrial designer, let's re-examine the caps and then try to design our own caps.



Activity VIII: Let's Design Caps

1. From your own perspective, examine all the caps in front of you and then select:
   - The simplest cap. Draw, describe, and explain.
   - The most complex cap. Draw, describe, and explain.
   - The most intriguing cap. Draw, describe, and explain.
2. Did you make your selection based on functional, structural, material, or other types of criteria?
3. Compare your selection of most simple, complex, and intriguing caps with the rest of your group and then the whole class.
4. Compare your explanation of the most simple, complex, and intriguing caps with the rest of your group and then the whole class.
5. Using pencils and paper try to design your own most simple, complex, and intriguing caps with the rest of your group.
6. Using the clay or the play-dough and wax-paper try to transform the drawings of the cap designs you have just completed with pencil and paper into physical form.
7. If you or anyone in your group is skilled in the use of computer graphic software and digital technology, can you transform your drawings of the cap designs you have just completed with pencil and paper into two and three-dimensional digital form.
8. Write down your answers of these questions and end your report by writing one or two paragraphs on what you have learned from this activity.

Activity IX: The Power of Imagination - Visualizing and Drawing Images of Your Caps

1. Select five caps that differ in color, size, shape, and material.
2. Spend at least 2-3 minutes examining each cap individually using both hands, eyes, and mind. Then form an image in your mind for each cap based on the results of step 2.
3. Draw a picture of the most likely bottle or container that each cap you examined is used for.
4. Share and discuss you final drawing and conclusion with your classmates.
5. Compare your final drawing with the actual bottles and or containers that your teacher just provided you.
6. Write one or two paragraphs on what have you learned from this activity.

Color Theory and the Color Wheel

Throughout the years we have discovered that using caps to introduce topics such as light and color to our college students, whether they are art students, physics students, electronics students, or student-teachers, has been very useful in capturing students' interest, inspiring and motivating them to engage in the learning process, and helping them gain the skills to acquire, make meaning from, and transfer knowledge.

The colors of light and the colors of paints differ in their nature and in their primary and secondary colors. Primary colors are those which cannot be obtained by mixing other colors. Secondary colors are those which are produced by mixing two primary colors, while other colors are produced by mixing a variety of combinations and quantities, including (in painting) white and black.

Activity X: Our Colorful Caps - Color Theory and the Color Wheel

Primary colors

- Light → Red, Green, Blue
- Paints → Blue, Yellow, Red
- Inks → Cyan, Magenta, Yellow

Secondary colors

- Light → Cyan, Magenta, Yellow
- Paints → Green, Violet, Orange
- Inks → **Red, Green, Blue**

Inference and Conclusion

Primary and secondary Colors of Light, Inks, & Paints

RGB
Additive
Color

mixing light

RED GREEN BLUE

CMYK
Subtractive
Color

mixing ink

CYAN MAGENTA YELLOW

https://www.google.com/search?q=image+of+primary+colors+of+paint&tbm=isch&tbo=u&source=univ&sa=X&ved=0ahUKEwiLhaf_55fOAhUHyoMKHcbDApIQsAQIHQ#imgdii=TDE47lQATwpu1M%3A%3BTDE47lQATwpu1M%3A%3BXl9OB5O6gg4A7M%3A&imgrc=TDE47lQATwpu1M%3A

Color Theory and the Color Wheel

Today, caps can be found in all types of colors, both primary and secondary colors. Because of this, they can be used to illustrate various colors and/or to reinforce the understanding of color mixing and subtracting.

Artists use a variety of pigments to create exactly the colors they want. All the colors, with the exception of white, can be created by mixing the three primary colors: crimson, blue, and yellow. If an artist wants orange, she need only mix crimson and yellow. Mixing blue and crimson produces purple, and mixing yellow and blue creates green. These are called the secondary colors.

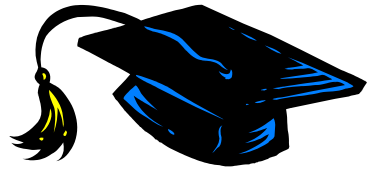
*www.**colorwheel**.com*

Activity X: Our Colorful Caps

1. **Identify the caps that represent the primary paint colors. The primary colors are those hues which cannot be obtained by mixing other colors, such as red, blue , or yellow.**
2. **What do you think will happen when you mix pairs of primary paint colors? *Mixing pairs of primary colors produces secondary colors.***
3. **Identify the caps that represent the secondary colors. Mixing pairs of primary colors such as blue with red makes purple, blue with yellow makes green, producing secondary colors, and yellow plus red makes orange.**
4. **Scientists and painters arranged primary and secondary colors on a color wheel. Use caps of different colors to show how primary and secondary colors are arranged on the color wheel.**
5. **What will happen when two complementary colors (primary color [red] with secondary color [green]) are mixed together? *Mixing two complementary colors will produce a tertiary gray or brown depending on exactly which paints are chosen and in what proportion*.**
6. **What will happen when you mix two opposite secondary colors with each other? *You will get brown or gray, or a muddy color of one of the secondary colors that you mixed.***
7. **What will happen when you mix primary and secondary colors that are next to each other on the color wheel? *You will get a color halfway between the two. (*Galton, 1995).**

You can repeat the above activity using the color wheel of <u>light</u> instead of the color wheel of pigment. (See Teacher Resources for data on the colors of light.)

Light Penetration Through Caps



Allowing light to pass through in a straight line

Allowing some light to pass through but scatter the light in all directions

Absorbing all light without reemission

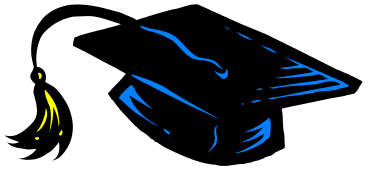
Transparent

Translucent

Opaque

Exploring Elements and the Way How Their Atoms Are Arranged

Activity XI: Caps, Magnets and Electricity



Attracted by a magnet

Are not attracted by a magnet

Conduct electricity

Do not conduct electricity

Conduct electricity

Do not conduct electricity

Inference and Conclusion

Activity XI: Caps, Magnets and Electricity

1. From your own perspective, define magnet and electricity. Write down your definitions.
2. Discuss your definitions with the members of your group.
3. As a group, choose (and write down) the best definition for magnet and for electricity.
4. Carefully study all the caps in front of you.
5. Discuss with your group which of the caps will be attracted by a magnet and which will not.
6. Divide the caps into two groups: (a) those you think will be attracted by a magnet, and (b) those you think will not. Explain your predictions.
7. Divide caps in group “a” into those you think will conduct electricity (group a.i), and those you think will not conduct electricity (group a.ii). Explain your predictions.
8. Divide caps in group “b” into those you think will attract magnets (group b.i), and those you think will not attract magnets (group b.ii). Explain your predictions.
9. Design experiments to examine your predictions in steps 7 and 8 to discover which ones are the most reasonable.
10. What have you learned from conducting this hands-on activity?

Activity XI: Caps, Magnets, and Electricity Questions

1. If a cap is attracted to the magnet, then this cap could be made up of one of these:

_____, _____, _____ .

a. List all the types of metals that you think are attracted to magnets:

_____, _____, _____ , _____ .

b. List all the types of metals that you think are not attracted to magnets:

_____, _____, _____, _____ .

2. If a cap conducts electricity, then this cap could be made up of one of the following:

_____, _____, _____ .

a. List all the types of metals that you think conduct electricity:

_____, _____, _____, _____ .

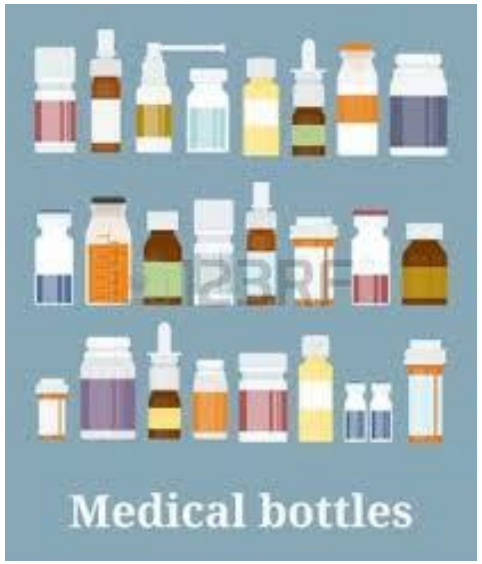
b. List all the types of metals that you think do not conduct electricity:

_____, _____, _____, _____ .

3. What do you infer about the relationship between magnetism and electricity?

Activity XIV: What's the Big Deal About Caps of Pharmacy Medicine Bottles?

Examples of Medicine Bottle Caps



© Can Stock Photo - csp19327572

Activity XIV: About Caps of Pharmacy Medicine Bottles

1. Divide the students into groups of 4. Give each group 2-3 different sizes of caps of pharmacy medicine bottles. (Preferably from a Walgreens pharmacy)
2. Give each group 2-3 caps of medicine bottles from other pharmacies.

3. Ask students to study each of the caps from design, structure, and function perspectives.
4. Then ask each group to compare and contrast the different types of caps on the various medicine bottles.

Activity XV: Scientific Investigation and Research Studies

It is natural for students to ask questions even before they enter elementary schools. But what is not natural for them without being taught is to practice asking the right questions, collect and evaluate the needed data, come up with the right solutions, and effectively communicate their solutions. Through the study of caps' design, levels of complexities, structure and function—such concepts and skills could be learned and applied. Through the process, students could easily learn and practice to:

- **Ask questions, define problems, and distinguish between questions and problems**
- **Develop and use models**
- **Plan and carry out investigations**
- **Collect, analyze, and interpret data**
- **Use mathematics to search for answers and create models**
- **Construct explanations and design solutions**
- **Use evidence to engage in informative argument, debate, etc.**
- **Obtain, evaluate, and communicate information**

Activity XVI: Research Study: Recycling Medicine Bottles and Their Caps

In this study, students conduct research to answer the following question: "How often do pharmacies or pharmaceutical companies collect and recycle their medicine bottles and/or caps?" Students do both Internet and field research to answer the question.

1. **Ask students to individually visit one or two pharmacies near their home and talk with the manager of the store and/or the pharmacist. Through the conversation try to:**
   - **Find out whether or not the pharmacy has a policy for collecting and recycling medicine bottles and/or their caps.**
   - **If yes, inquire about how often patients bring back their empty medicine bottles and whether they bring them with or without the caps.**
   - **If not, inquire about the reason for not having policy and procedures for doing so.**
2. **Upon completing their field research studies, ask the students, individually, to conduct Internet and/or library research to find out if there is any pharmacy or pharmaceutical company that collects their empty medicine bottles and/or their caps.**
3. **Write a research paper describing your research studies including procedures, findings, analysis, inferences, conclusion, recommendations, and references.**
4. **Write a letter to the manager or the pharmacist that you visited and share with them your findings. Include in your letter an informative rationale for why recycling is a good strategy for both good business practice and for environmental sustainability.**

Activity XIII: The Use of a Spray Device to Demonstrate Various Scientific Concepts

What Scientific Concepts Can You Teach and Demonstrate Using Spray Device Caps?

Activity XIII: The Use of a Spray Device to Demonstrate Various Scientific Concepts

The Spray Device on various bottles can be used, for example to:

- demonstrate the effect of air pressure on water,
- the relationship between volume and size, and
- the relationship between the depth and width of water in a container.

Make sure that each spray device is 100 percent clean. In preparation, divide the class into groups of 3 students, and give each group one spray device and 4 different bottles.

One bottle will have a small opening, one will have a wide opening, one bottle will be short and one will be tall.

Give students a measuring tape, some newsprint, and regular newspapers.

The Use of a Spray Device to Demonstrate Various Scientific Concepts

1. Each group will tape the 11 × 14 piece of paper to the wall, no higher than average shoulder height.
2. Every group must put newspaper on the floor to protect the floor from water.
3. The groups will fill the four bottles with water and add a different color of food coloring to each bottle.
4. Ask all the students: If you place the spray device on a bottle and spray the white paper from a distance of 2 feet, 4 feet, 6 feet, and then 8 feet, which bottle will enable you to spray the farthest? Make sure students don't try this before they give their predictions.
5. Collect the predictions, write them on the board, and discuss them one by one.
6. When the discussion ends, allow the students to conduct their experiments and to record their observations on the data observation collection sheet.
7. Discuss with students whether and why their predictions differed from the results.
8. Ask the students to try to find explanations for what actually happened.
9. Introduce the concept of air pressure, the relationship between size and volume, and the relationship between depth and width, etc.

Possible Secondary Cap Uses

The following are only a few examples:

- Use as objects to illustrate and re-enforce mastering of cognitive skills such as adding, subtracting, multiplying, dividing, percentages, ratios, graphics, etc.
- Use to study design, and the relationship between shape, structure, and function
- Study shape and design, structure and function
- Make jewelry
- Use as buttons
- Make toys or games
- Create musical instruments with the caps
- Art project (building structure), collage, crafts, mold device
- Make miniature furniture
- Make wheels
- Make chips for games, pins for hair
- Decorate picture frames or flowerpots
- Use as containers

The Challenges in Recycling Caps

Caps in general and plastic caps in particular represent a significant dilemma and challenge to those who care about the environment and big advocate for recycling. While what is very attractive and useful pedagogically about caps is that they come in different shapes, sizes, colors, design, construction materials, etc., these same type of diversities and characteristics are what make caps a very challenging objects to recycling companies and facilities.

The Challenges in Recycling Caps

As Mikkelson (2015) explained:

"Plastic bottle caps have no inherent monetary value. Unlike aluminum cans (and the metal tabs attached to them), they aren't worth anything as raw material because such caps are the wrong form of plastic to be recycled. There is therefore virtually no market for used plastic bottle tops." (¶. 6).

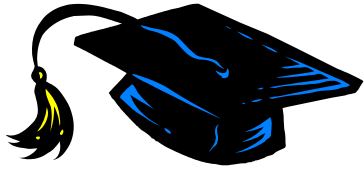
Thus, the question becomes, why, beyond their main designated designed function, plastic caps which have significant pedagogical and educational uses, no one has been able to really come up with monetary value for re-suing bottle pills caps?

The Challenges in Recycling Caps

In an interview with Sierra Magazine's Josie Garthwaite (2008), Garthwaite stated that:

*"Plastic bottle **caps** are made from a type of plastic called **polypropylene**. You would recognize it in those three chasing arrows as the number five and letter PP underneath that. Plastic **bottles**, on the other hand, are usually made from a different kind of plastic called **polyethylene terepthalate**, or number one and PET. And polypropylene, that number-five plastic bottle caps, those can be made into things like garden rakes, and brooms, and ice scrapers, usually sturdy things." (cited in Pesca, 2008, ¶. 7).*

Plastic is a family of synthetic polymers that are made from petroleum, coal or organically derived products!



Thermoplastics

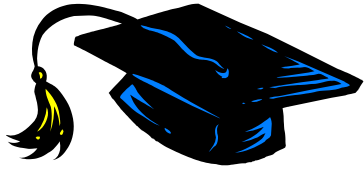
Plastics that can be melted by heating so that they can be remolded into new products and shapes

Thermosets

Plastics that when cured cannot be remolded

Which of these two types of plastic do you think is more readily recyclable than the other one?

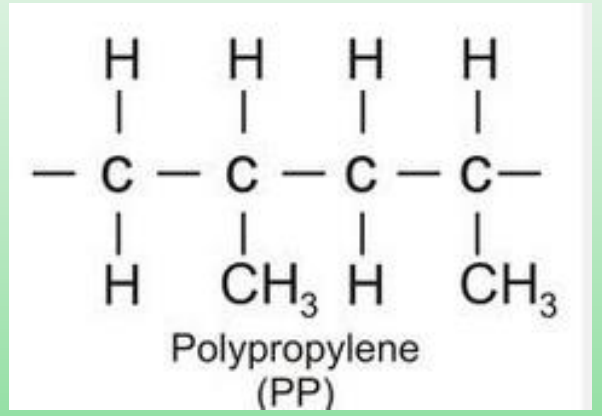
Plastic is a family of synthetic polymers that are made from petroleum, coal or organically derived products!



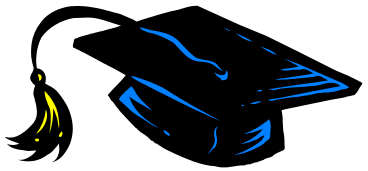
- **Thermoplastics**
  - Polypropylene (PP)
  - Polyethylene (PE)
  - Polycarbonates (PC)
  - acrylonitrile-butadiene-styrene (ABS),
  - Polyvinyl chloride (PVC)
  - Polystyrene (PS)
  - Nylon
- **Thermosets**
  - Ex., polyurethane foam, epoxies, phenolics, and rubber

Polypropylene Vs. Polyethylene

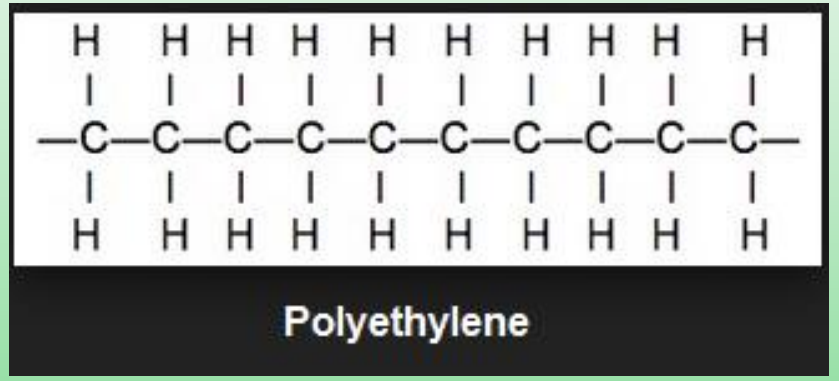
Polypropylene (PP)



Plastic bottle caps



Polyethylene (PE)



Plastic bottles

Caps' Material Make-up

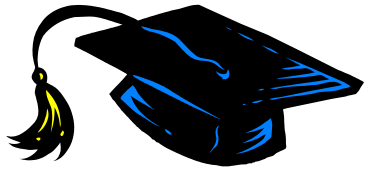
Hint: *plastic, wood, cork, glass, iron/steel, aluminum, rubber, copper, cobalt and nickel, brass, tin, silver, bronze, and gold.*

Materials	Examples	Availability of the Sample (many, some, few, rare)	Color	Additional Information
Plastic				
Metal Containing Iron				
Aluminum				
Cork				
Glass				
Ceramic				
Copper				
Wood				
Paper				
Other				

Number and Type of Components in Caps

Number of Components (material)	Number of Caps	Components Type of Material(s)	Additional Observations
One Material	3	plastic	Cap has inner opening
Two Materials	2	Metal (tin?) and cork	Cap is screw-on type
Three Materials			
Four Materials			
Five Material			
Five + Materials			

Patents in USA



Utility Patent

A new, useful invention that is not obvious to others in the field of invention

A process, a machine, a manufacture, a composition of matter, and/or an improvement an existing idea

Design Patent

A new and original design that ornaments a manufactured device

A product design that is ornamental and/or aesthetic, but it can't be functional

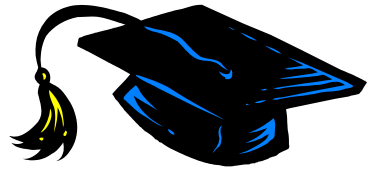
Plant Patent

Novel, nonobvious, asexually reproducible plant

Asexual method to cultivating different types of plants, to create mutants or hybrids and/ or newly found seedlings

Where Does Your Novel Innovated Cap Fit in Patent's Categories?

Patents in USA



Utility Patent

A process, a machine, a manufacture, a composition of matter, and/or an improvement an existing idea

Hardest to get and to prepare, technological, mechanical, operational, workable, etc.

Design Patent

A product design that is ornamental and/or aesthetic, but it can't be functional

Unique to the United States, covers the outsides hap and ornamental of an object

Plant Patent

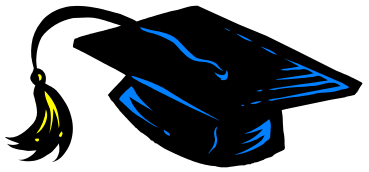
Asexual method to cultivating different types of plants, to create mutants or hybrids and/ or newly found seedlings

A very specialized field, most rare of all kinds of patents, the easiest & not that hard to get

Where Does Your Novel Innovated Cap Fit in Patent's Categories?

Where Does Your Novel Innovated Cap Fit in Patent's Categories?

Patents in USA



Utility Patent

A new, useful invention that is not obvious to others in the field of invention

Design Patent

A new and original design that ornaments a manufactured device

Plant Patent

Novel, nonobvious, asexually reproducible plant

Caps Come Under the Category of …… Because ……

How Well Do You Know the Patent's Categories?

In which category or categories would you file an application patent to get individual patents for the listed inventions, and why?

listed inventions	Utility Patent	Design Patent	Plant Patent
Airplane, shape & operation			
A rare shade of color paint			
Computer shape & function			
Customized cap			
Pin, shape and function			
A method for hybridizing roses			

Caps & Art

Caps, the Fascinating Objects in Teaching and Learning Science

Caps and Civic Engagement

Teachers in the Frontline for the Educational Well Being of Their Students

Examples from Classrooms

Caps As Teaching and Learning Tools

"If you experience pain and discomfort in removing the cap... double the dosage."

"Tommy, please come and open this child proof bottle for me..."

"I SPRAINED IT TRYING TO OPEN MY MEDICINE."

https://www.google.com/search?q=medicine+bottle+caps&tbm=isch&tbo=u&source=univ&sa=X&ved=0ahUKEwiR4JWG4ZHOAhUq5oMKHcz-DT8QsAQIPw&biw=1350&bih=600#tbm=isch&tbs=rimg%3ACVKJuvAGoNHIIjhqHwWF0Sm8B4I8kjH4cyEUIfSdFoMdLpoO0hxylj1bSJss4Q4UNVK2Orx5Ut4OjFviTrVHT6ITZioSCWofBYXRKbwHEfleFFtUkHNhKhIJgjySMfhzIRQR9Bs4Sx39BisqEgkh9J0Wgx0umhGjkmdnCjv29ioSCQ7SHHKWPVtIERkuOUQqBvT7KhIJmyzhDhQ1UrYRctP0HIOd8zcqEgk6vHlS3g6MWxHxyq51tk4OKCoSCeJOtUdPohNmEUPgRrM4S7IA&q=medicine%20bottle%20caps&imgrc=_

Caps As Teaching and Learning Tools

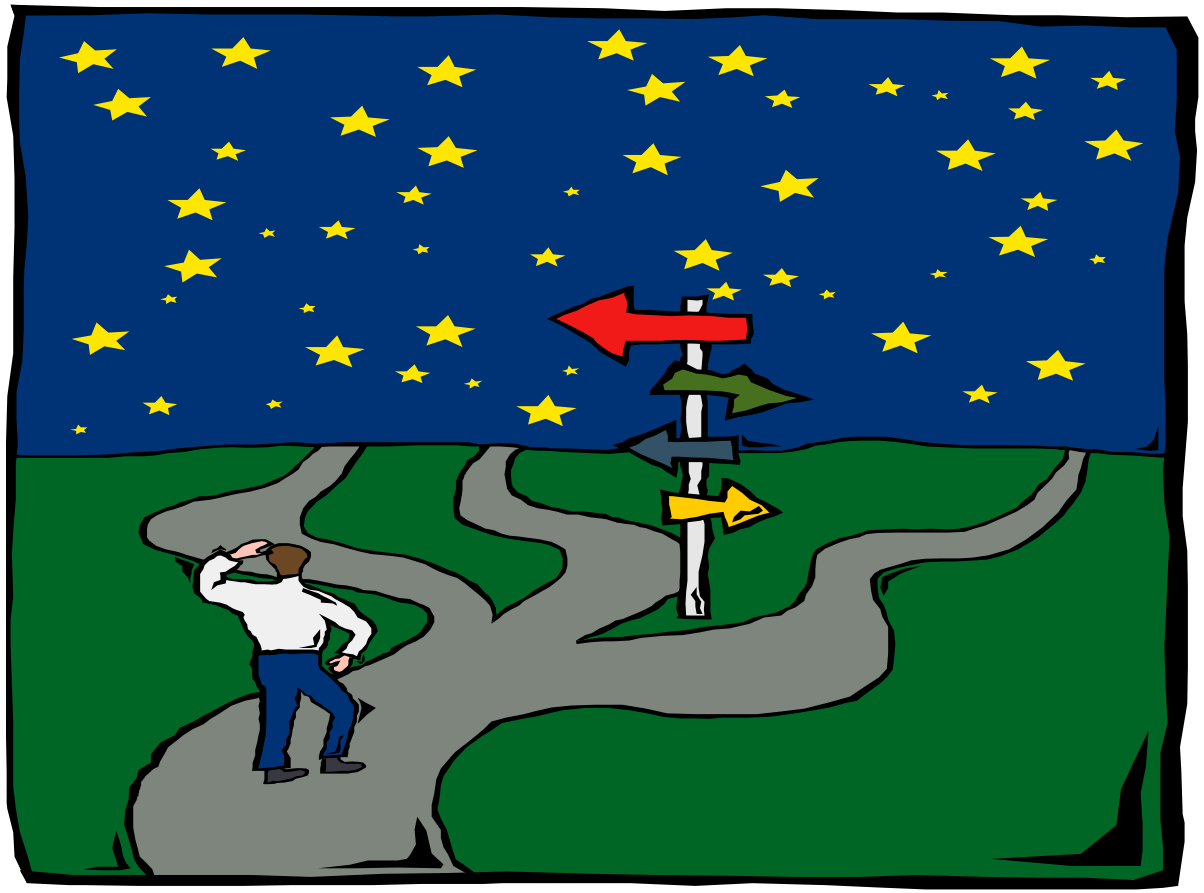
"Side effects may include bleeding gums from gnawing at the bottle cap."

"You may experience irritability and pain in the hands and wrist...and that's just from trying to get the cap off."

"HE DEALT SUCCESSFULLY WITH THE SAFETY CAP ON HIS MEDICINE BUT THE SAFETY SEAL GOT HIM!"

https://www.google.com/search?q=medicine+bottle+caps&tbm=isch&tbo=u&source=univ&sa=X&ved=0ahUKEwiR4JWG4ZHOAhUq5oMKHcz-DT8QsAQIPw&biw=1350&bih=600#tbm=isch&tbs=rimg%3ACVKJuvAGoNHIIjhqHwWF0Sm8B4I8kjH4cyEUIfSdFoMdLpoO0hxylj1bSJss4Q4UNVK2Orx5Ut4OjFviTrVHT6ITZioSCWofBYXRKbwHEfleFFtUkHNhKhIJgjySMfhzIRQR9Bs4Sx39BisqEgkh9J0Wgx0umhGjkmdnCjv29ioSCQ7SHHKWPVtIERkuOUQqBvT7KhIJmyzhDhQ1UrYRctP0HIOd8zcqEgk6vHlS3g6MWxHxyq51tk4OKCoSCeJOtUdPohNmEUPgRrM4S7IA&q=medicine%20bottle%20caps&imgrc=_

Q & A?



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Meet Our Presenters

Abour H. Cherif, Ph.D
Emeritus National
Associate Dean,
DeVry University
847-220-0895
abourcerif@att.net
acherif@aaua.org
www.abourcherif.com

Gerald Adams, Ph.D
Professor of Geology
Columbia College
Chicago
312-369-7540
gadams@colum.edu

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The Challenges in Recycling Empty Pill Bottle

Matthew 25 Ministries Empty Pill Bottle Recycling
Matthew25Ministries
Evansburg United Methodist Church

"In developing countries, medicines—when actually obtainable—are often dispensed into hands, pockets, leaves or any other available container. Matthew 25 Ministries accepts donations of basic medical supplies such as empty pill bottles to help improve health care quality in developing nations. Donations of clean, unlabeled pill bottles help the poorest of the poor in many ways: Medicine can be distributed in sterile containers. Pill bottles that are not appropriate for shipping are recycled for cash that goes towards Matthew 25:Ministries' programs."
http://www.evansburgumc.com/ministries/outreach/matthew-25-empty-pill-bottle-recycling/