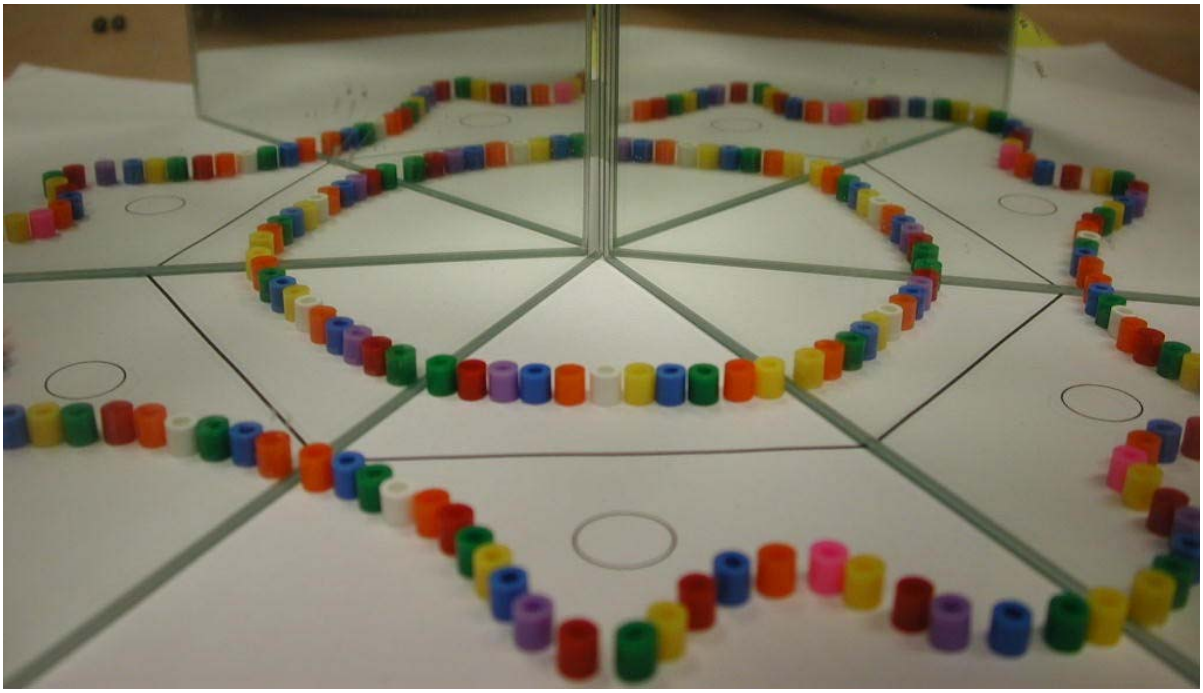
Mirror, mirror on the wall...

Eight Lessons on Mirrors



Teacher Guide

Kindergarten and Grades 1 & 2
Version 2.0 April 2009

Welmoet Damsma 2007

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Preface

This lesson series was developed by Welmoet Damsma for use in her thesis project for the *Masters of Mathematics and Science Education* program of the AMSTEL Institute of the University of Amsterdam. The module was tried out in two iterative cycles with Kindergarten and grade 1 & 2 students of elementary school De Nieuwe Kring in Diemen. The module was translated and edited for the European POLLEN project by Ed van den Berg who also contributed to the background section. Paul Hewitt graciously granted permission to use several illustrations from his *Conceptual Physics* in the background section.

POLLEN 2006 – 2009 is a European project for the promotion of inquiry learning in elementary science education. The project takes place in 12 cities in 12 countries including Amsterdam. POLLEN is English for seeds: the POLLEN project wants to saw seeds across education and society. The core ideas of POLLEN are:

- Active participation of children through *hands-on* and *minds-on* inquiry learning.
- Participation of society.

In each of the participating cities it is expected that POLLEN partners support inquiry learning in science through:

- In-service teacher education
- Materials and services for *hands-on/minds on* inquiry learning
- Advice and other support for science education

In Amsterdam we do this through in-service courses on inquiry (science) and design (technology) and guiding implementation in the classroom. We also assist schools in developing their own science and technology programs.

In the Amsterdam POLLEN project the following partners cooperate: the AMSTEL Institute of the University of Amsterdam, the Hogeschool of Amsterdam, and the VTB network Amsterdam.
Further information about the AMSTEL Institute can be found on:
http://www.science.uva.nl/amstelinstituut/home.cfm

Information on the POLLEN project is on:
http://www.pollen-europa.net

Table of Contents

Worksheets (separate pdf)

The Magic Mirror

Purpose:

- To encourage interest in science phenomena among children age 4 - 8
- To explore, observe, and name the properties of mirrors and mirror phenomena through investigation
- To practice communication skills by communicating observations and "discoveries" to the group

Level: Version A: Kindergarten, age 4-6
Version B: Grades 1&2, age 6-8, but extendable to higher ages (**this version**)

Number of lessons: 8, each lesson takes about 45 minutes but most lessons can be made to last anywhere from 35 – 75 minutes

The module consists of a Science kit with a Teacher Guide

Materials in the science kit per class:

1 big mirror for teacher demo
25 mirror tiles
25 double mirror tiles
Christmas balls
Glittering stars
Example magic mirror (students make their own)
Templates for magic mirrors
Example disco ball
Mini-disco balls
Flashlight
Glittering stuff
Colored beads
Spoons

Worksheets (with drawings only, no text):

Double mirror: line and dot
Double mirror: triangle
Double mirror: square
Double mirror: pentagon
Symmetry: complete tree
Symmetry: half a tree (1)
Symmetry: half a tree (2)
Symmetry: half a tree (3)
Symmetry: half a tree (4)

Background Information

This is a short introduction for the teacher. Actually, the mirror lessons do not require much background knowledge but we do recommend you read this section. **Please note that the information is NOT for the pupils**.

1. History of mirrors (http://en.wikipedia.org/wiki/Mirror)

Figure 1: Roman mirror made of bronze. Some parts are still mirroring a bit. First century AD.

People have seen their mirror image for a long time in dark pools of water, rivers and lakes. Mirroring was considered some kind of magic. Over 2000 years ago Egyptians, Greeks, and the Romans made mirrors of pieces of polished metal, usually silver and sometimes bronze. Glass was discovered by the Phoenicians around 5000 BC but only during the Roman times people in Sidon (Lebanon) made the first glass mirrors by putting some metal at the back of glass.

Glass blowing was discovered during Roman times but only in the 12th and 13th century AD a glass industry developed in Venice and Southern Germany/Bohemia. Mirrors were produced too, but they were very expensive. Therefore the mirrors in the palace of Versailles were very special and a sign of opulent wealth and power. From the 17th century mirrors were used more and more as decoration. Starting in the 19th century mirrors became much cheaper thanks to new technology and entered the houses of common people. Nowadays the metal at the back of mirrors usually is a thin layer of aluminum.

2. Two kinds of reflection

When you shine light from a laser pen or flashlight on the ceiling, everybody in the room can see the light spot on the ceiling. This means that the light rays of the flashlight which are coming from one direction, are reflected or "scattered" by the ceiling in all directions and enter the pupils of the eyes of all present. This is called *diffuse* reflection (Figure 2b, 3b). Diffuse reflection occurs with all objects around us except for shiny objects like mirrors.

When you shine the light from a laser pen or a narrow and parallel beam of light from a flashlight onto a mirror (please try the set up of figure 3[1]), then quite surprisingly one does not see a light spot on the mirror. The light beam is reflected in a particular direction and can only be seen in that direction. This is called *specular* reflection but with children we just call it *mirror* reflection (Figure 2a and 3a). Mirrors have a very smooth surface. In figure 3a we caught this reflection on a piece of paper. On the other hand, when we shine the light of a laser pen on paper, the light spot can be seen from all directions (figure 3b).

[1] Safety: never look directly into a laser beam or (mirror) reflections of it. Looking at *diffuse* reflections of laser beams on paper or on the wall is okay as then the laser rays and energy are scattered.

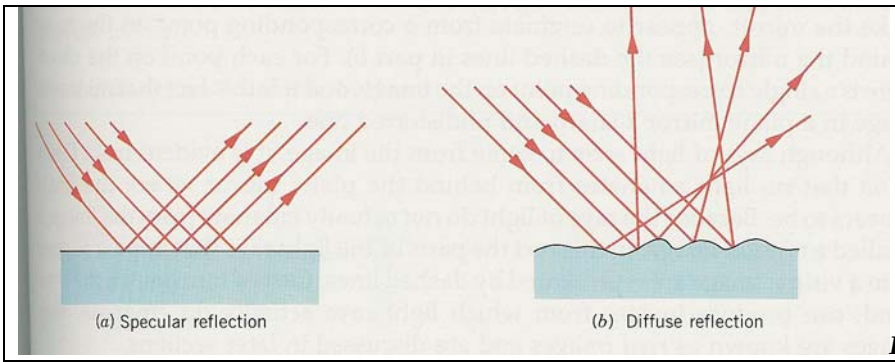


Figure 2

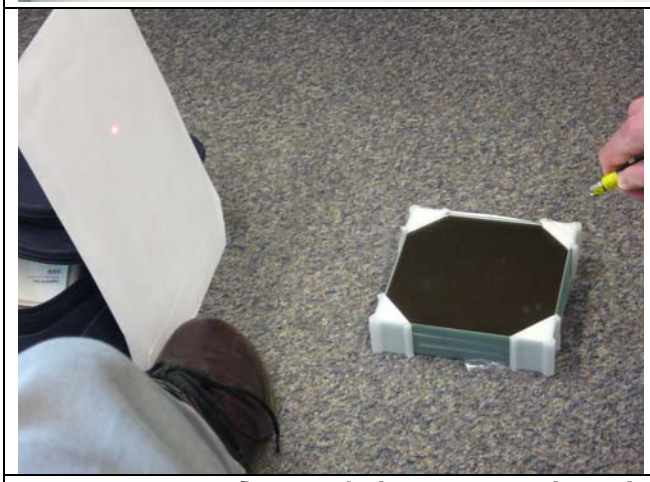


Figure 3a Mirror reflection: The laser pointer is directed at the mirror. However, looking from the side we do not see a lighted spot on the mirror. All the laser light is reflected in one direction only, towards the white paper screen. On the screen we see a light spot as the screen reflects the light diffusely to all directions including the direction of the camera

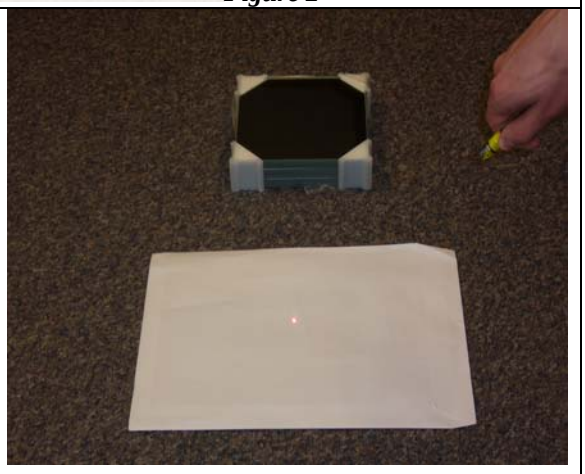


Figure 3b Diffuse reflection: De laser pointer is directed towards the white paper screen. From there the light is reflected in all directions including the direction of the camera. So the light spot is visible from all sides.

Figure 4: Example of mirror reflection from the disco ball and diffuse reflection .from the paper.

The light of the flashlight in figure 4 hits the disco ball and is then (mirror) reflected towards the paper. The paper reflects the light diffusely. The light spots on the paper can be seen from all directions. How are light rays reflected by a mirror?

Mirrors reflect light according to physics rules. When you shine with a flashlight on a mirror, you will see a light spot of reflected light on the ceiling or on the wall. When you move the flashlight, the light spot will move. The dashed line perpendicular to the mirror is called the normal line, it is an imaginary line. With that line we can define an angle of incidence and an angle of reflection (figure 5). In mirror reflection these angles are equal. We can predict where the incident light ray will go after reflection. Diffuse reflection also follows this rule, but due to the roughness of the surface, the light rays are reflected in all directions (Figure 2b).

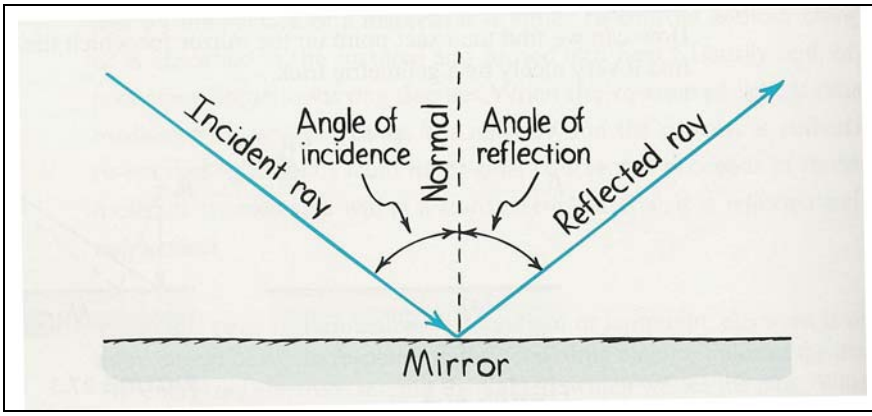
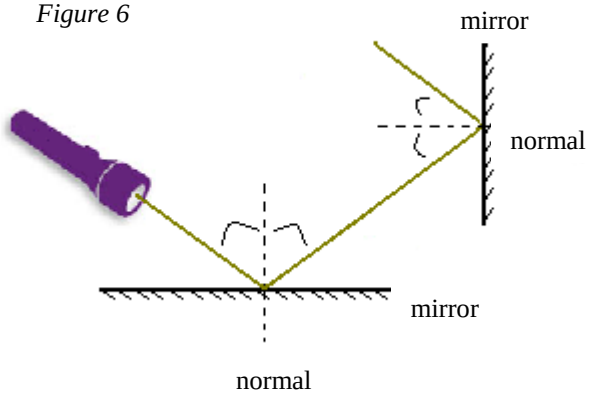


Figure 5
Angle of incidence equals angle of reflection

Figure 6



When you shine with a laser pointer or with a torch on a mirror, the light reflects and forms a spot on a screen (the wall, or a piece of paper). Using the mirror law, we can exactly predict where the light spot will be. What will happen when you hold a second mirror in the beam of reflected rays? In figure 7 you see a light beam reflected by two mirrors according to the law "angle of incidence = angle of reflection". You can use as many mirrors as you want, but it works best in a darkened room. Put a cylinder of paper around the torch so that the light beam does not diverge. DO NOT let children handle a laser pointer.

4. How do we see?

For seeing we need light. Light-rays have to enter our eyes. Light rays from the Sun or from lamps hit objects and are then scattered in all directions. In Figure 7 light rays from the Sun hit a book. The light is scattered in **all** directions, including the direction of the eyes of Lisa. Light rays from all parts of the book form an image on the retina of Lisa's eyes.

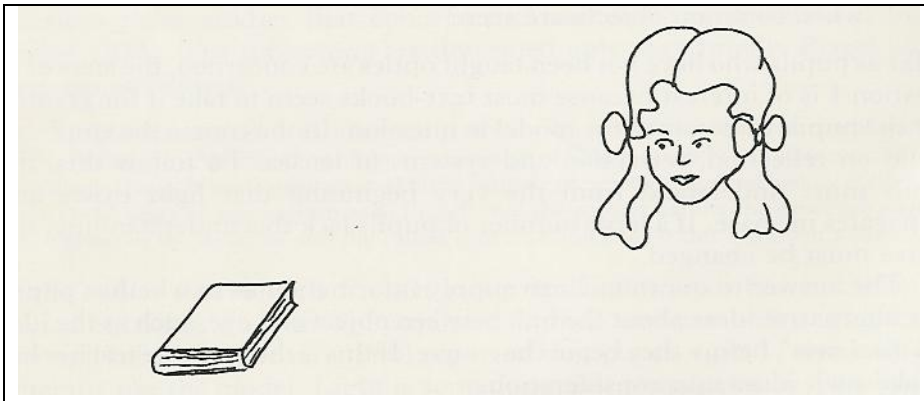


Figure 7: Light rays from the Sun are scattered in all directions by the book. Light rays hit all parts of the book. Some light rays from each part of the book are scattered in the direction of Lisa's eyes and form an image on the retina of her eyes.

5. Special mirrors

All kinds of shiny objects act like mirrors: Christmas balls, spoons, pans, windows, computer screens. A lake with clear water and a dark bottom mirrors very well when the surface is flat (no wind). Similarly transparent plastic mirrors reasonably well when put on top of dark paper (lesson 3). Transparent plastic on a light colored piece of paper does not mirror well. With a dark piece of paper as background the transparent plastic reflects some light while the light that goes through it gets absorbed by the dark colored paper. However, with the light colored paper much light is reflected by the paper and competes with the light reflected from the mirror. As the reflection on the paper is diffuse, it cannot generate a mirror image.

Some mirrors have a curved surface (figure 8). A Christmas ball distorts your mirror image. The ball is a convex mirror. A metal waste basket can also act as a convex mirror just like the outside of a spoon. There are also concave mirrors such as the inside of a spoon. Laughing mirrors consist of convex and concave parts which distort the image in funny ways.

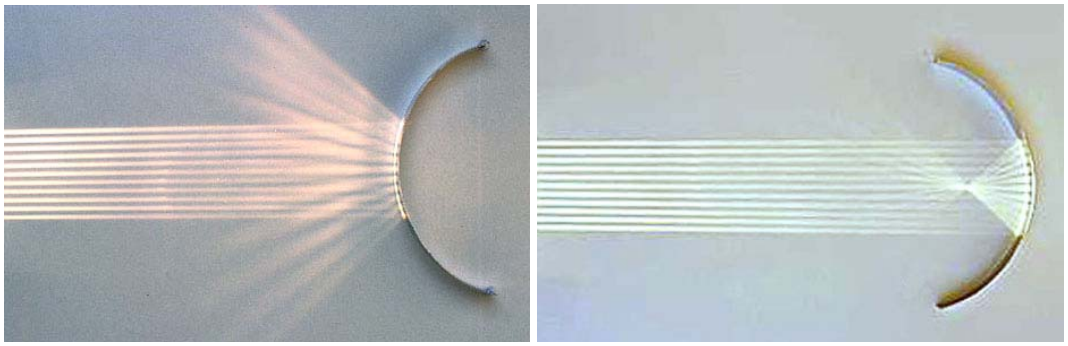


Figure 8: Reflection from a convex mirror (left) and from a concave mirror (right). For each light ray we can apply the rule that angle of incidence is the angle of reflection. These angles are measured from a line perpendicular to the surface of the mirror (the normal line). However at every point this perpendicular line has a different orientation.

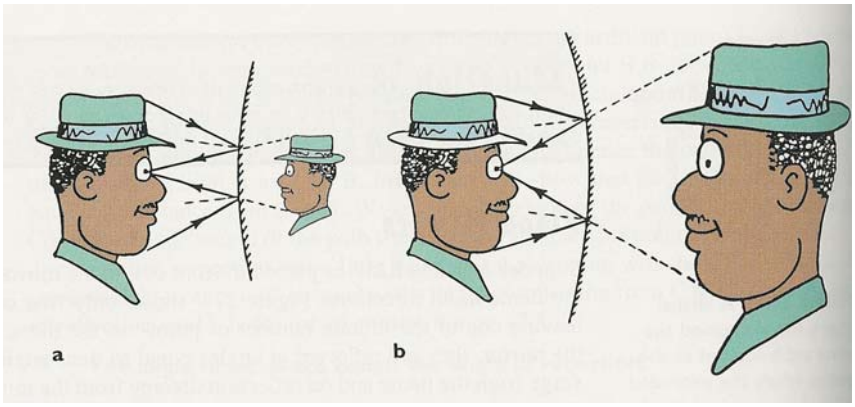


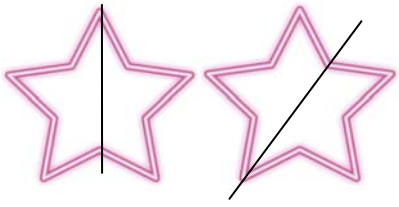
Figure 9
a. Reflection in a convex mirror (like the outside of a spoon). The image is smaller than the original and upright.
b. Reflection in a concave mirror (such as the inside of a spoon). The image is larger than the original. It is upright when the object is very near the mirror (within the focal length) and inverted when it is farther than the focal length. On the inside of a spoon the image usually is inverted, unless the spoon is very big and our face is very near.

6. Symmetry

There are many kinds of symmetry. In the lessons we will be looking at mirror symmetry. That means that we are looking whether two sides separated by a line are equal. The two parts should be each other's mirror image. One can check by placing a mirror on that line and the one side of the figure + its mirror image should look like the original picture without the mirror. The line is called an axis of symmetry. It separates the picture into two equal halves.

Figure 10: The head of the tiger is symmetric with respect to a vertical line in the middle of the nose. It is not symmetric with respect to a horizontal line through the mouth or anywhere else through the face.

Figure 11: The star has several axes of symmetry:



Mirrors: Potential Learning Outcomes

All activities:

Attitude: interest and curiosity with regard to mirrors (and that will succeed!), observing and describing objectively, critical attitude.

Lesson 1: Discover the mirror

Language: mirror, reflection, describing experience in words and gestures, listening.
Concepts: mirroring
Skills: describing and demonstrating observations and discoveries orally to other students in the circle.
Inquiry: Exploring, describing

Lesson 2: Discovering more mirrors

Language: reflection, mirroring, sparking, names of shiny/mirroring materials such as glass, metals, plastic.
Concepts: recognizing mirroring en not-mirroring objects in the environment
Skills: classifying of mirroring versus not mirroring objects/materials and writing observations in a table (Grades 1&2). Tracing light rays being reflected such as sun light from water or from a watch and creating light spots on the classroom ceiling including lightrays from multiple mirrors.
Inquiry: exploring

Lesson 3: The Magic Mirror

Language: absorption, reflection
Concepts: absorption, reflection, dark color paper absorbs much light en reflects little, light colored paper reflects much light.
Inquiry: Predicting and trying out which color paper forms the best background for a mirror using an OHP transparency, concluding and finding out that your preferred color is not necessarily the best one for a mirror (multiple criteria).

Lesson 4: Double mirror

Language: describing observations in words and gestures (that is quite complex in this activity but it works very well).
Mathematics: line, triangle, square, circle, spatial skills in making art products with the double mirror.
Concepts: multiple reflections between two mirrors can generate many images, difference between left and right in the reflections.
Skills: using mirrors to make art products, colors,
Inquiry: exploring, investigating relationship between angle and number of images, concluding, presenting.

Lesson 5: Reflection

Language: Light ray, reflection, reflected ray
Concepts: light rays, light beam (of torch), law of reflection (intuitively, getting a feeling for where you should look to find the reflected rays)
Mathematics: spatial insight, this becomes more complex with multiple reflections but kids are able, representing incident and reflected light rays in a diagram (not all kids can do this).
Skill: manipulating mirrors, tracing light beams, directing mirrors, improvising a reflecting disco ball.
Inquiry/Design: relationship of incident and reflected light rays, designing and executing an experiment, designing or just copying a disco ball.

Lesson 6: Symmetry

Language: Symmetric, asymmetric, horizontal, vertical, horizontal symmetry, vertical symmetry, axis of symmetry.
Concepts: symmetry, axis of symmetry, mirroring, left-right inversion (vertical axis), top-down inversion (horizontal axis)
Skill: manipulating the mirror
Mathematics: spatial insight, predicting/anticipating of results of mirroring (will the reflection result in a symmetrical figure or not?).
Inquiry: predicting and testing of symmetries

Lesson 7 (Kindergarten): Walking the line

Language: mirroring, left and right
Concepts: mirroring, left and right
Mathematics: Spatial skills, consistently being able to switch left and right such as turning left when the mirror indicates right.
Skills: coordination of vision in mirror and stepping in the right direction

Les 7 (grades 1&2): Symmetry in letters

Language Symmetric, asymmetric, horizontal, vertical, horizontal symmetry, vertical symmetry, axis of symmetry; symmetry in letters, mirroring of letters and words, assembling words with vertical or horizontal symmetry.
Concepts: symmetry, axis of symmetry, mirroring, left-right inversion (vertical axis), top-down inversion (horizontal axis)
Skill: manipulating the mirror
Mathematics: spatial insight, predicting/anticipating of results of mirroring (will the reflection result in the same letter or not?)
Inquiry/design: Predicting and testing of symmetries

Leson 8: Periscope

Language: periscope
Concepts: periscope, reflecting with two mirrors, understanding the behavior of light rays in a periscope.
Skills: converting a two dimensional predrawn structure into a 3-dimensional object, cutting, folding, pasting, attaching mirrors
Mathematics: spatial insight in the working of a periscope
Inquiry/Design: trouble shooting when construction is difficult or mirrors are not in the proper position

Lesson 1: Discover the Mirror

Everybody must have looked into a mirror, but have you played with it? In this lesson we will first look what we can do with a mirror.

Needed/Preparation:

- Big mirror
- Mirror for every child
- Optional worksheet 2 (to be copied)

Lesson description

Plenary

1. Spread the mirror tiles across a table. When the students enter, they will be interested right away.
2. The class starts with all the kids sitting in a big circle, as is custom in the lower grades in the Netherlands.
3. Take the big mirror. What is this? What can you see? Later the kids will get their own mirror. Alternatively (and better): start with a story about a mirror.

Individually

4. All students get their own mirror tile and are allowed to walk around for a few minutes to discover things.

Plenary

5. Students tell what they discovered. We suggest that you let other kids "copy" the discovery by trying it with their own mirror. For example, if one child reports that she can use the mirror to look behind her, let others try to position their mirrors such that they can look behind them also. The copying itself is an exercise in communicating through language and gestures!

Individually

6. It is possible to do another round of walking around and discovering. The children often get more ideas the second time around. They also like to walk around.

Extensions

You could ask the children to fill worksheet 2 to describe/sketch their discoveries.

Lesson 2: Discovering more mirrors

Apart from "real mirrors", many objects exhibit mirror effects, for example Christmas balls, spoons, pots and pans, CDs.

Needed/preparation:

- One box per group children
- Per box mirror objects such as christmas balls (are included in the kit), small stars, boxes, pieces of aluminum foil, metal teapot, metal scissors, CD boxes, top of a pan *
- Per box non-mirroring objects such as pieces of paper, cork, pencils, rubber bands, plastic beaker,etc.
- Possibly worksheet #3, one per child.

* Not all boxes need to have the same content.

Lesson description

Plenary:

1. What did we do last time?
2. There are other things that are like mirrors. Do you see some in the classroom? What do you see?
    - The children can look around to see.
    - Often the window mirrors a little bit. A computer screen does; metal objects do such as door knobs, a stapler, scissors; glass from cupboards.
3. The task: Each group gets a box and has to sort objects which mirror well, a little, or not at all.
    - It is possible to use worksheet #3, but it can be done without worksheet as well.

Individually/small group:

4. Executing the task.

Plenary:

5. Discuss the results.
    - You will not be able to discuss each and every object and will have to select from the children's observations.
    - You can make a list on the board.

- What was different about some mirrors? -> Christmas ball is convex, spoon is convex (outside) and concave (inside) and image upside down. In the Christmas ball you will see your nose very big and also the rest of the class.

- What did the mirroring objects have in common? -> smooth, shiny (aluminum foil mirrors well as long as it is not crumpled) and all metal objects mirror a bit when they have been polished. Glass and plastic sometimes as well.

Possible extensions:

- Let children bring something from home that mirrors.
- Let children fill worksheet #3 afterwards.

Lesson 3: The Magic Mirror

In the story of Snow-white there is a magic mirror. But is n't a plain mirror magic as well? How can it be that you see yourself so perfectly? Is n't it even stranger that you can see yourself too in a piece of transparent plastic with a piece of paper under it?

Needed/preparation:

- Big mirror
- Colored paper, particularly also dark blue and black
- One half of an A4 size of transparency per child
- Pieces of carton or other materials to make the mirror more sturdy
- Decoration for the mirror, for example glittering stuff, cotton, coloring pencils
- Short version of the tale of Snow-white to read to the children
- Example of magic mirror
- Scissors, glue, pencils
- Something round as a template for kids to cut a round shape out of the transparency

Lesson

Plenary:

1. Read the story of Snow-white (this could be a short version if the children already know the story).
2. In the story there is a magic mirror. What do you see when you look in that mirror? Do you think that is really possible?
3. We are going to make our own magic mirror. First we have to find out how we can do that.
4. Show a transparency. Can you see yourself in it?
5. Show now a transparency with a piece of paper behind it. Can you see yourself now? The mirror is made of a piece of plastic (show transparency) on top of paper. Show also how to cut the mirror in a nice shape using the template.
    - Children make a front and a back of the mirror and have to make it sturdy by using some carton or other material.
    - The transparency has to be cut into a nice round shape. Just let children find an object that can serve as a template for cutting.

- Watch out, only the edge of the transparency should be glued. If you put the glue all over, it will not mirror.

6. The example mirror is red. What would happen if you use another color? Does it make a difference? Let's first investigate because we want the best mirror!

- This is an investigation task for students which could be done individually or through a discussion with the children which includes trying out different colors. The darker the background, the better the mirror. So black and dark blue are the best colors. Hopefully the children discover this for themselves. Of course children may still want to choose other colors than black/dark blue for esthetic reasons.

Individually:

6. Each child gets a piece of transparency and each group of children gets several colors of paper. They first select a color for themselves.
7. Then they cut the paper in shape using the template.
8. They cut the transparency round using a suitable object as template.
9. They tape the carton or another reinforces between front and back of the mirror.
10. They put the transparency on the colored paper, glue only the edges.
11. Decorate.

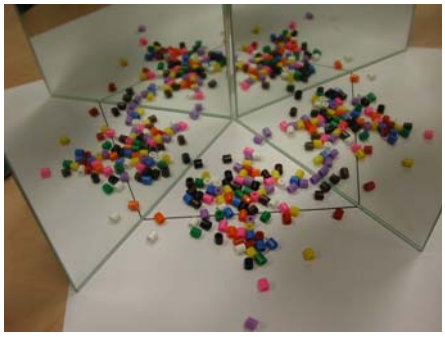
Extensions

- You can still discuss the results. Why did they choose a particular color?

Figure : All children except one on this table chose dark blue as their color for the magic mirror. One chose black, which is indeed the best color. They know, but often they still choose dark blue, as a compromise between what is beautiful and what is the best mirror (especially the girls, and this was an all-girl table). In grades 1&2 the percentage of black is higher.

Background for teacher: Why does a dark background work best? When light hits the transparency, some is reflected back (mirror reflection) and some passes through the transparency. There it can be reflected by the colored paper or be absorbed by it. If it is reflected by the paper, it will be **diffuse** reflection and not mirror reflection and the diffusely reflected light from the paper competes with the mirror reflection of the transparency itself. With darker paper, much more of the light that passes the transparency is absorbed so that the mirror effect of the transparency is less disturbed by the diffuse reflection from the colored paper. We see the same effect with glass windows during the day. When the inside of a room is darkish, the windows reflect the outside light like a mirror. However, when it is evening and the room is lighted, an outside observer receives much more light coming from inside through the window than from reflection of outside light. So looking from the outside into a lighted room, we do not see the mirror effect at night and can clearly see the inside of the room.

Lesson 4: The double mirror



You can experiment with two mirrors connected to each other as a kind of booklet. You will see multiple images and can make nice patterns that way.

Needed/preparation:

- Two mirrors taped together for every child
- Worksheets # 4 and 5 for each child
- Boxes with colored beads, one box per group of children
- Sheets 1 – 4 from the kit to be put on the board

Lesson description

Plenary (chairs arranged in circle):

1. All kids get a double mirror and walk around for a few minutes to "discover".
2. Plenary in circle: What did you discover? Students tell their discoveries while other students imitate to try to see it also with their own mirrors.

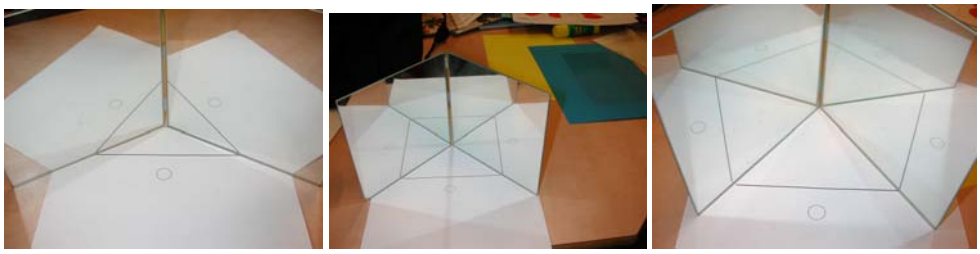
Teacher questions could be:

- What do you see when you put something between the mirrors?
- What can you do with these mirrors which you cannot do with a single mirror?
- How many times is it multiplied?
- What happens when you make the angle between the mirrors greater or smaller?
- So when do you do see something many times in the mirror? (mirrors close together, small angle).
- The students will come with many more discoveries, when imitating the position of the mirror, the teacher can see and verify.

Individually:

3. The students receive worksheet #4 with a line and a dot.
4. Teaching sheets 1 t/m 4 are put on the board.
5. Briefly show how children should position the mirror on the worksheet. The worksheet has a line and a dot. Using the mirrors the

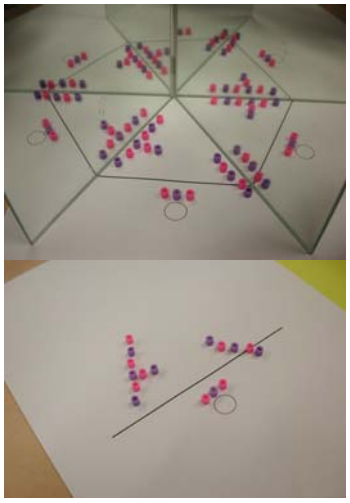
children can produce the patterns which can be seen on the teaching sheets on the board. (see photos).

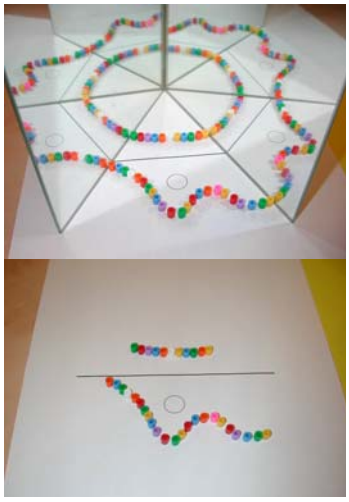


6. Each group is given a box with colored beads. With those beads they can make patterns between the mirrors. See photo. Try!
7. The students get worksheet #5. They are asked to make a drawing that will become extra pretty using the mirror. They should position the mirror properly.

Plenary (children sit in circle):

8. Discuss the results:
    - How did it go, examples?
    - What will look most pretty with the beads and with the drawing? Why?
- How did the students position the mirrors? Did they think about how to do this?





With just a few beads one can already make something very pretty.

Explanation about two mirrors

Take first one mirror or one mirror of the double mirror. Wink to yourself. Which eye did you wink, left or right? Which eye of the mirror image winked, left or right? Indeed, everything that is on the left, becomes right in the mirror. Now hold the double mirrors such that you see several images. Then wink. Some images will wink with the left eye and some with the right eye. So what happens? Some mirror images are really a mirror image of you. Other images are mirror images of other mirror images. How do you distinguish? Because the images of images wink with the same eye as you yourself.

Drawing of Anne, 6 years. Without the mirror it is not interesting, but with the mirror it is very pretty.

Eefje and Mara from De Nieuwe Kring, Diemen, Netherlands

Lesson 5: Reflection

Light reflects from a mirror. That is also how a disco ball works.

Needed/preparation:

- Mirror tiles
- Flashlight
- Christmas ball with mirrors (mini-disco ball)
- Classroom darkened (curtains closed)

Materials for improvisation

- Example of improvised ball from the science kit
- Styrofoam ball for every child (get from party store, office shop, or home supplies, or ...)
- Shiny silvery paper (from chocolate) or aluminum foil, anything that reflects well.
- Scissors, glue

Description of Lesson

Plenary:

1. In the darkened room a mirror lies on the table or on the floor. Ask: what will happen when I shine with a flashlight on the mirror?
    - Usually somebody will say that the light reflects and that there will be a light spot on the ceiling.

2. Do this or let one of the kids do it. The prediction is right, we will see a light spot on the ceiling. How come?
    - The light reflects.
    - What happens when you move the flashlight? The spot moves too.
    - If you shine the flashlight from directly above the mirror, where will the light spot be? (Let them predict first and then try).
    - If you shine the flashlight almost flat on the mirror, where is the spot then? First predict, then try.

3. Make a drawing on the blackboard with mirror, flashlight, and light ray (see background information).

4. What happens if you keep the second mirror in the light beam that bounces of the first mirror?

- Predict first, then let somebody help to demonstrate this.
- Keep de second mirror reasonably close to the first mirror.
- How well it works depends on the brightness of the flashlight and how dark the classroom is.
- Direct the second mirror to a place on the wall where you can see the light spot very well. Just try out where it will be very visible.

5. Take the mirror ball and shine on it with a flashlight (figure). You will get a pattern with many light spots. Turn the ball and you get the disco ball effect.

- How does this pattern form? All small mirrors!
- Each tiny mirror will reflect the light of the flashlight in a different direction. Think of a flashlight and the mirror tile. When you change the position of the mirror tile, the direction of the reflected beam changes. You could make a drawing on the board.
- Explain the improvisation of a disco mirror ball using a styrofoam ball and shiny paper from chocolates or aluminum foil. Show an example and shine on it with a torch. The classroom should be darkened to see the effect well. On the other hand, on a sunny day the Sun can be used.

Individually:

6. Students improvise a mirror ball.
7. Try out of the mirror ball. The students can try out with a flashlight in a dark part of the room. If the sun is bright, they can also try out in the sun.

Extensions:

- In a dark part of the room you can reflect a light ray with a combination of several mirrors. You can make it into a game by choosing a target that should be hit. With only the flashlight, this is easy. With one mirror it is still easy. But with two mirrors or three, students have to cooperate and think. It is possible with 4 or 5 mirrors if the flashlight is bright enough (fresh batteries) and the room dark enough.

Lesson 6: Symmetry

Introduction of the idea of symmetry

Needed/preparation:

- Mirror for each child
- worksheets 6 - 14 per child (copy)
- Posters 5 - 9 for on the board (posters with figures)

Lesson description

Plenary circle:

1. Poster 5 is put on the board (poster 5 is a picture of a tree). Keep the mirror in the middle (vertically) so that the left half is mirrored.
    - What do you see? -> You see a complete tree in the mirror.
    - What happens when you mirror the right side of the tree?

    So the left side is the same as the right side. That is called symmetric. But…when you put the mirror horizontally in the middle of the tree, you will not get a complete tree. The upper side of the tree is not the same as the bottom part. Show this to the children. You can also not put the mirror diagonally across the tree. There is only one line where you can put the mirror to get symmetry. So that is the mirror line.

2. Can we think of more objects which are symmetric? In worksheet 6 we see objects which are symmetric. Can you find where you should hold the mirror n order to see the picture properly? Draw the mirror line which we can also call axis of symmetry. In some figures it is possible to find several mirror lines or axis of symmetry.

Individually"

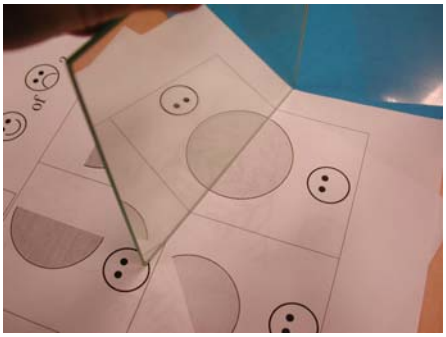
3. All children receive worksheet 6 and get to work.
    - When children say they are finished, ask them to look for things in the classroom which are symmetric..

Plenary:

4. Discuss the discoveries.

- Where should you keep the mirror?
- Which figures had more than one mirror line?
- Are faces perfectly symmetric? No, but almost! With people it is also that way. Everybody is almost symmetric. You can experiment with the face of your neighbor.

5. Then posters 6 – 9 are posted onto the board. These are half figures which can be made whole using the mirror. Which picture will become a whole tree? Show!
6. Explanation of the smilies: If the half tree does not become a whole tree then you draw a sad smily. If it does become a whole and pretty tree, then draw a happy smiley.
7. Explanation of worksheets 7 – 10: with all the figures you can show with a smiley whether it becomes the same figure which is drawn in the upper left.



Individually

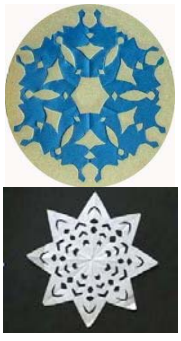
8. The children receive worksheets 7 – 10 and answer them.

Plenary:

9. Discuss the results:
   - Snowflake: the mirror can be positioned in many different ways. Watch out with figure 3, that one does not work!
   - Circle: is the same from all sides, always a happy smiley.

10. Explanation of worksheets 11 – 14: here you have to look whether the two figures are each other's mirror image. You can see that by putting the mirror in the middle in between the figures and comparing the mirror image with the other figure.
    - You can also do this right after the previous worksheets rather than have discussion first.

Extensions:

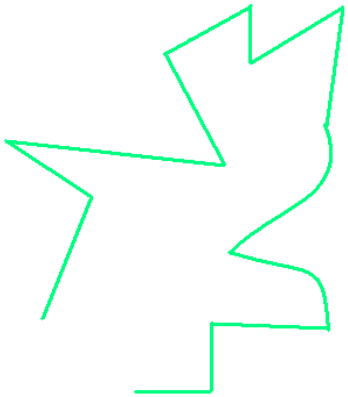


Snowflakes cut with scissors

- Butterflies and hearts can be made by folding the sheet in the middle and cutting. See the worksheets. When you fold it out again, it is a complete figure. If this works well, the children can make more figures by themselves.
- This is the same principle as the ink stain. Put some paint on a piece of paper, then fold and press and one can get interesting symmetric figures.
- You could cut more snow flakes and hang them on the wall. Snow flakes have beautiful symmetries!
- Worksheets 15 and 16 are for coloring. Can you color them in symmetric ways? (At www.schoolplaten.com you can find more examples, both simple and complicated under mandala's.

Lesson 7. Walking the lines (Kindergarten)

Using tape on the floor we make a path that children have to follow. They should just follow the line. Normally that is easy, however, how is it when you are only allowed to look at the tape through a mirror above your eyes?



Needed:

- Mirror tiles
- Tape or rope to indicate a path

1. Look for a place with some room. Use tape or rope to indicate a path with many sharp turns.

2. Better do this activities with little groups while the other children are doing something else, otherwise it gets too crowded, unless you make several set-ups.

3. The children stand in line at the start of the path and observe a trial.

4. Then they receive their mirror and the instruction to follow the line by only looking into the mirror which is horizontally face down above their eyes. Of course they are not allowed to cheat and look at the line directly. There are several ways of doing this:

- Keep the mirror above your eyes, you will see the world upside-down, but it is easy to see the lines of the path.
- Alternatively keep the mirror against your belly, face forward, bent over and look into the mirror (look at your belly).
- Or you could hold the mirror up in the air facing you and then walk backwards. This is a bit more difficult as the line might be a bit more difficult to get in view.
- Perhaps the children will come up with another way yet.

Lesson 7: Symmetry in letters (Grades 1 & 2)

Many letters are symmetric. Some horizontal and others vertical. Some are both and many are not symmetric at all.

Needed/preparation:

- Mirror for each child
- worksheets 17, 18-1, 18-2, 19 and 20 for every child (to be copied)

Lesson description

Plenary

1. Recalling from the previous lesson: What is symmetry?
2. Explanation what is horizontal and what is vertical.
    - This could be explained using crossword puzzles.
3. On the board draw an a and an A. Are they symmetric?
    - The a is horizontally symmetric, the A vertically.
4. Explanation of worksheets 18-1 and 18-2
    - Draw the diagram of worksheet 18 on the board and show how the children should fill in the diagram.

Individually

5. The students receive a mirror and the worksheets numbers 17, 18-1, and 18-2 and fill the diagrams.
    - You could divide the letters over the class. For example some groups of kids do all the small letters and other groups do all the capital letters. When they are done with their own letters, they could do the others yet.

Plenary

9. Discuss the results. Fill in the diagram on the board.
    - It would take too much time to discuss each letter in small and capital form. Best is to just write all the answers on the board and let the children check their own answers.
10. Now the children could use these letters to make words which are either horizontally or vertically symmetric.

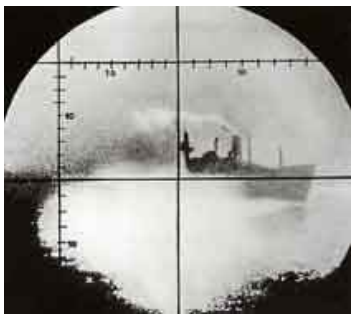
- There are more capitals than small letters which are symmetric. So it might be better to use caps or to simply mix caps and small letters.

11. There is an extra worksheet for letters with a vertical axis of symmetry.

Extensions:

- Explain what mirror writing is. Let the children try to write something in mirror writing and let it read to somebody else (make secret language which can only be read in a mirror.
- With carbon paper it is easy to write in mirror writing. If you put the carbon paper upside down, you automatically get a mirror image of the writing on the back of the paper you are writing on.

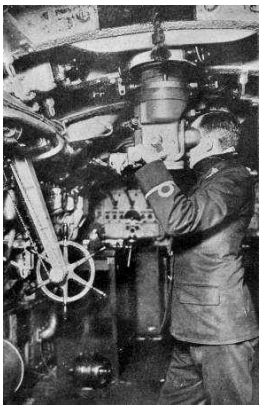
Lesson 8: The Periscope



Mirrors are not only fun, they are also useful. In a submarine they are used to spy on the enemy.

Needed/preparation:

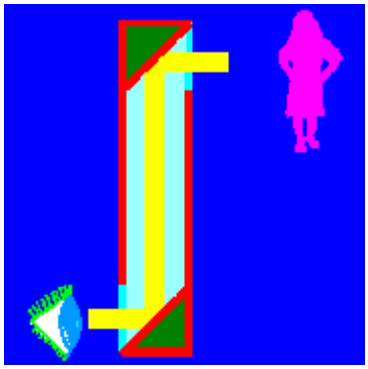
- Per child 2 mirrors of 4 x 7 cm (let them be cut at a building supply store or use mirror carton from office supplies).
- Per child copy the worksheets of the front and back of the periscope. Better yet transfer the pictures to more sturdy carton.
- Dubble sided tape
- Mirror
- Scissors and glue



Lesson description

Plenary:

1. Let one child hide behind a cupboard. Then stand with the mirror such that this child can see the other children. So the mirror can be used to look around the corner!
2. Ask whether they ever saw a submarine. Did they also see the thing with which people in the submarine can look above the water? That is called a periscope.
3. A periscope works with mirrors. Draw a picture of the submarine with the periscope and the two mirrors.
4. We will now make one of carton. With that you can spy on everyone!



Individually

5. We have two blue prints. Cut the front and the back of the mirror along the **bolt printed lines**.
6. Tape the two pieces together using the special edge for glue. Do this first.
7. The thin lines are for folding. Fold everything.
8. Glue the tube together and let it dry.

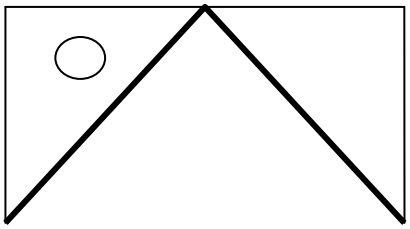
9. Prepare the ends where the mirrors will be put.
10. Tape the mirrors at the ends of the tube with double sided tape.
11. Your periscope is ready!

What can you see?

Other Lessons: What else is possible?

Some other ideas which surfaced during workshops on mirrors:

1. Double mirrors: use blocks (little cubes) and exercise counting.
2. With symmetries: make stars, parallelograms, other shapes.
3. With symmetries: do not put the example poster on the wall yet, let them first work with figures themselves and only later pay attention to the triangle and the square.
4. Put children across from each other and let one function as the mirror image of the other and so make "mirror movements". When one raises the right hand, the other has to raise the left hand, etc.
5. Make a kaleidoscope with three mirrors in a triangle.
6. Combine various double mirrors.
7. Disappearing tricks: Put a double mirror under an angle of 90 degrees, build a cupboard around it which is open on one side. This is now the stage of a theater. Looking straight in the mirrors one imagines looking at a stage while actually the "room" is a triangle and two corners of the stage are behind the mirrors. One can now put puppets on the stage and let them disappear.



Audience

Mirror "Cupboard" seen from above. The thick slanted lined are the mirrors. The circle indicates the head of a hidden puppet seen from above. The audience sees a rectangular empty room.

8. Use mirror carton, spoons, pans to make mirrors for laughing.
9. Design a mirror to catch thieves in a store.