# Composing Colours from Matter or Light (Ages 5 - 7 and 8 - 11)

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**Summary:** This six-sequence module aims primarily at teaching the children that colours are the result of an overlapping of other colours and that they can be broken down into separate components, whether coloured matter or coloured light. The six-session progression helps show the differences between the properties, which lie in colour, light and matter. Study focuses on the primary colours used for markers (combination of matter) and television (combination of lights).

**Target Concepts**: Optics (light: ages 5-7 and 8-11), matter (sample mixtures: ages 8-11).

# Sequence 1: Decomposing the Colours of Matter

## Summary:

By offering the students the opportunity to test a variety of marker pens, this first sequence will allow them to learn that colours can come from a single colouring agent or a blend of different colouring agents.

## Objective:

Show, through chromatography, that a colour can result from the combination of several colours.

## Duration:

1 hour, to leave the students the time to test all of the colours in a packet of markers.

## Materials:

For each group of 2 students:

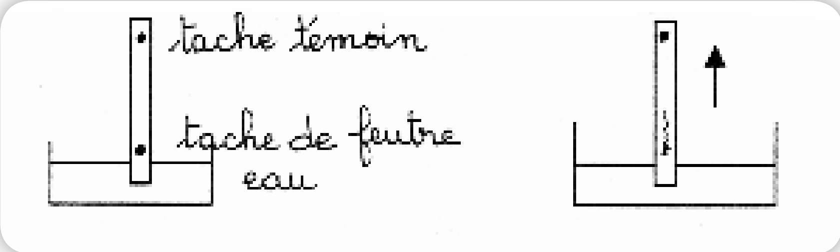
- Markers (water-based markers, i.e. Conté brand)
- Strips of filter paper (coffee filters)
- 1 jug
- water

## Target Concepts:

- Primary colours.
- Colour blends.

## Procedure:

In groups of two, use chromatography on each marker colour.




*Control stain*

*Water-based marker stain*

Capillarity makes the water "climb" up the filter paper, bringing the various pigments with it.

The pigments separate and deposit at different levels on the strip of filter paper.

# Group Analysis:

Classify the various chromatographs by number of colouring agents (pigments) that appear for each marker.

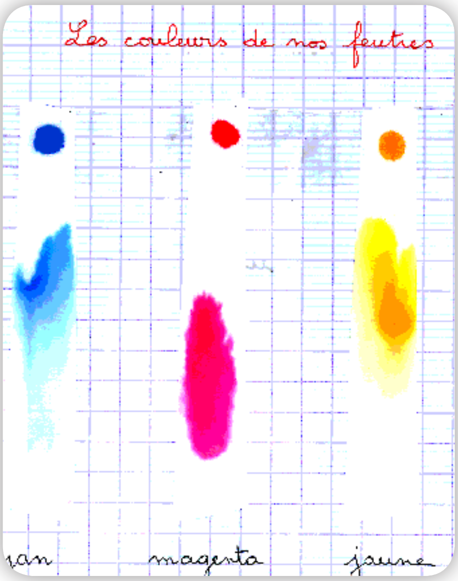
The result is:

- one colouring agent for yellow, light blue and pink: these are "pure" colours. They are referred to as the primary colours (yellow – teal – magenta) of matter (Figure 1).

- two or more colouring agents: the darker the colour, the more colouring agents it contains. (Figure 2).

## Examples of Student Work:

- Figure 1

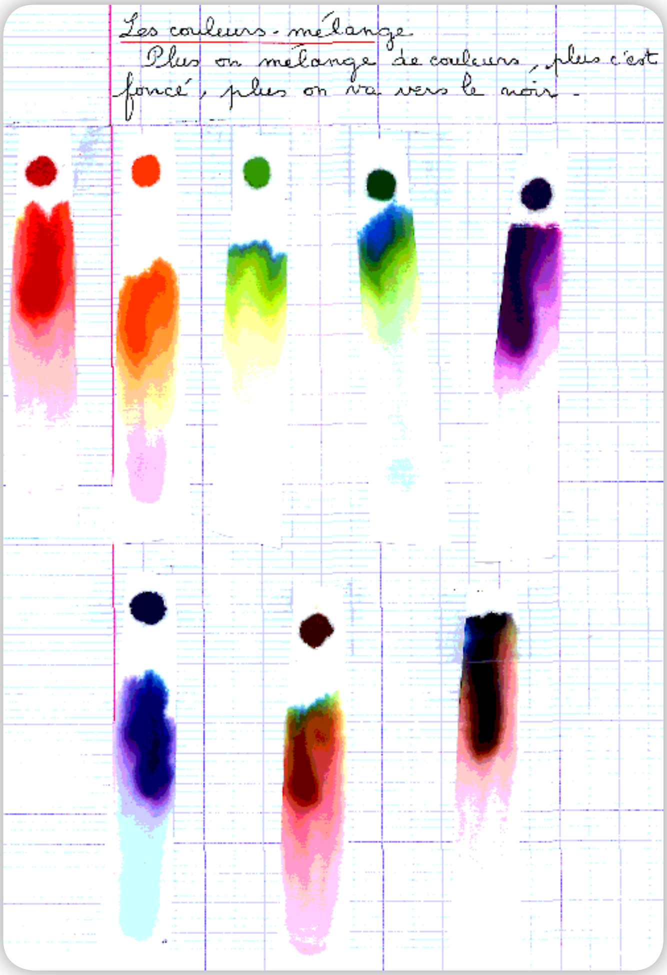



*Our Marker Colours*

*Teal – Magenta – Yellow*

*One single tint: pure colours*

- figure 2




*Colours – Blends*

*The greater the number of colours blended, the darker they are, and the closer they are to black.*

## Teacher's Note:

This session did not spark any questions about colour, but helped show that certain coloured inks are formed from the three primary inks.

The questions do not come on the scene until the comparison with what is derived from coloured light.

This session, considered in and of itself, is valuable only for the technical colour analysis factor.

There were no difficulties in carrying it out, from the material standpoint, or analysing the findings. Its fun discovery component ("like magic") is very stimulating.

The entry point it provides turns out to be an excellent way to broach the theme of colour.

# Sequence 2: Producing Colours - Matter

**Using the primary colours identified in the previous session, the students try to make other colours and forecast their results.**

## Objective:

Use the properties, observations and breakdown results from the previous session to "re-compose" colours.

## Duration:

1 hour:

10 minutes for chance trial

35 minutes for trial with predictions

15 minutes to summarise (alongside chromatography results)

## Materials for each student:

- Markers (water-based markers, i.e. Conté brand)
- Paper

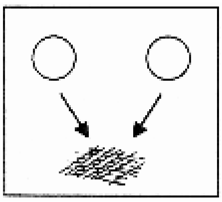
## Target Concepts:

- Primary colours.
- Blends of colours.

## Procedure:

- **Chance Trial.**

Mix "pure" colours two by two, then all three together



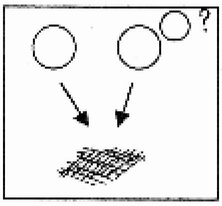
Control stains

Blend

Colour achieved

- **Trial with prediction**

Choose a colour, plan which markers to use to produce it, apply idea, confirm or infirm.



Colour planned

Markers chosen

Blend

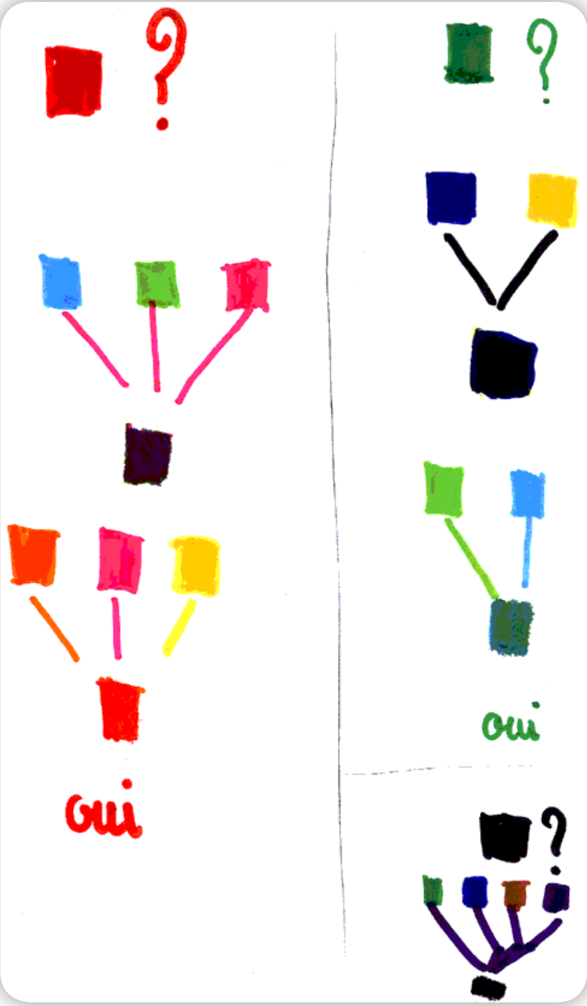
Colour achieved

## Analysis:

Draw parallel with chromatographs made in previous session, note link between breakdown and recomposition.

Note: the more the colours are blended, the darker they are and the closer they are to black.

## Examples of Student Work:




## Teacher's Note:

The objective of this session is to put the lessons learned in the previous session to work differently, to make forecasts and check them by actually blending the colours.

However, in the first part of the session, during the "chance" trials, no forecasts are explicitly requested. It is interesting to observe that certain students will already be planning their protocol according to the previous breakdowns.

The evidence they provide enable more systematic forecasts in the second part of the session.

One material issue may hinder the analysis process:

- After a few days, some of the colours from the blends made on paper will fade away (especially the red).
- It is preferable to confirm the forecasts just after they are made, rather than waiting for the next session.

# Sequence 3: Colours

**The students identify situations that show the "hidden" colours of white light and suggest experiments.**

## Objective:

Highlight the separation of colours in white light using a dispersive system.

Work on plotting out processes.

## Duration:

In two parts:

- 30 minutes in class to identify situations (possible individual research in Library/Document centre or at home).
- 1 hour 15 minutes for experimentation and plotting processes.

## Materials:

For entire class:

- 1 CD
- oil
- soap
- water

## Note:

Dividing the class into two parts gives the teacher the time necessary to find the materials requested by the children.

## Suggested experiments:

- Shine light on a CD with shiny, smooth surface (figure 1)
- Shine light on a stain made of water and oil
- Make soap bubbles in the light
- Light up a prism (figure 2).

For each experiment, the children must determine whether light is essential for seeing iridescence (like rainbows)

Another experiment can be performed:

- Make a rainbow ("Le petit chercheur" Bordas Jeunesse "La couleur" p. 8 and 9)

## Procedure:

The students can be put to work in alternating workshops on each experiment, in order to avoid material "overload" (it is better to have one good prism than several ineffectual ones). Each team prepares an experiment, performs it and plots it out to present it to the others. This process helps the children gain self-sufficiency.

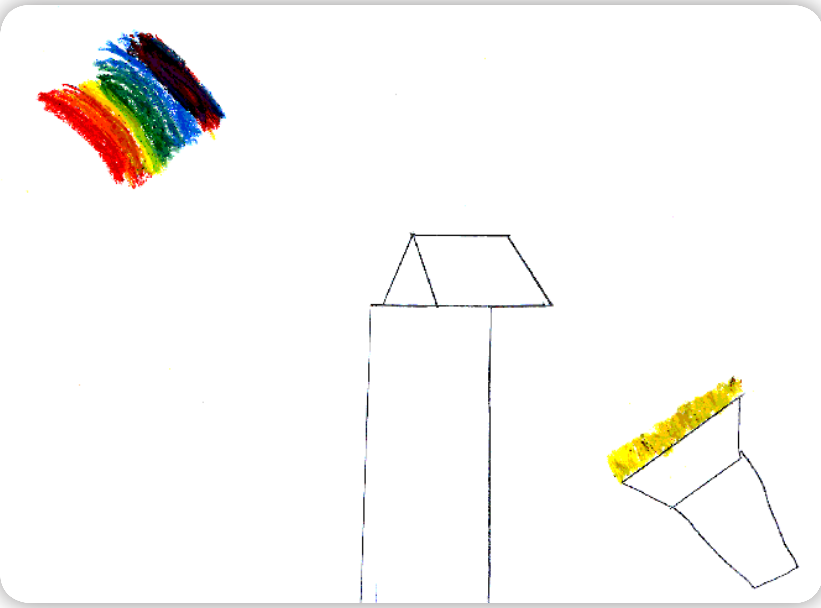
## Analysis:

- In all of the experiments, iridescence can be seen when light is shined on the objects. The only shared variable is light. The colours shown are the "hidden" colours in light.
- Attempts are made to determine the colours found (number and tints). The subjectivity of the identification process is emphasised, with each child possibly noting different hues (for instance: orange-yellow or orange-red or orange, etc.). For the 8- to 11-year-olds, six colours will be enough: purple/blue/green/yellow/orange/red.
- The gradual transition from one to the next is noted.

## Samples of Student Work:

- Figure 1

- Figure 2



## Teacher's Note:

- The children in another class suggested the experiments in a different order. They referred mainly to the presence of water (oil stain on dry ground, soap bubble and rainbow). One question as raised by certain children: "we can't tell whether the colours we see come from the light or the water". Here are some suggestions to make that distinction:
  1) turn off the light to look at the soap bubbles
  2) set up an arrangement where water plays no part: a Plexiglas ruler, CD, etc.
  Then, the teacher brings out a prism.
- Some difficulties encountered:
  For some children, light and the sun are the same thing. If the sun is not in view (due to cloudy skies, for example), the question, "is there any light?" is asked.
  Vocabulary reviews (transparent, opaque, translucent) were required following the discussions on the role that the clouds play as a screen.
  To anchor that vocabulary, we set up experiments in graphic arts using reused materials.

# Sequence 4: Television Light

**The students study a television screen using a magnifying glass and identify the colours to recreate all the others.**

## Objective:

Show all of the "primary" colours in light.
Comment: they are referred to as primary because they are used industrially (on video) to reconstitute all the others. However, this is a choice, as other complementary colours could have been chosen. (The comment is valid also for matter. The primary colours, as commonly taught in drawing, are blue, red and yellow. Yet in printing, the primary colours are blue, red and green.

## Duration:

2 x 45 minutes (observing a television screen through a magnifying glass can tire out the eyes)

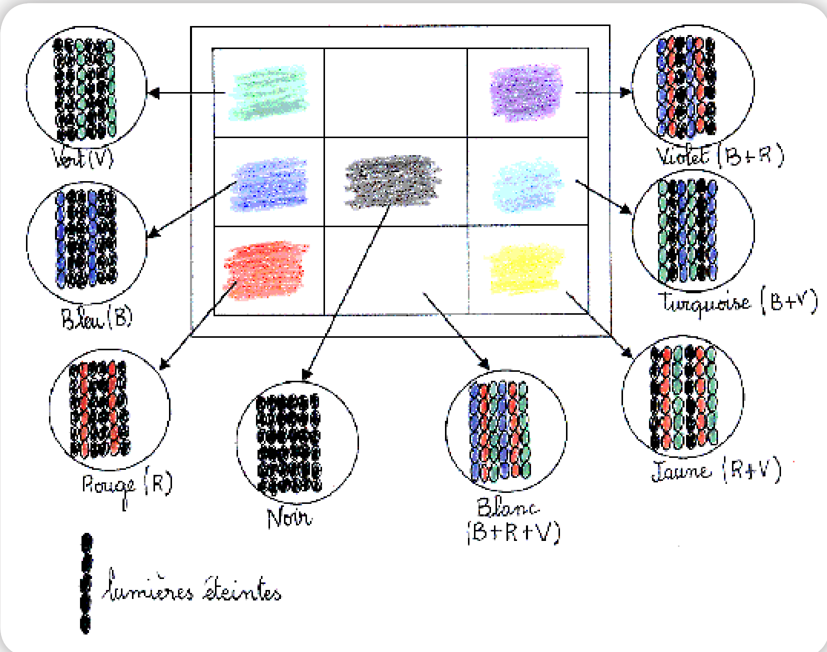
## Materials:

For the entire class:
- a television (frozen or moving image)
- magnifying glasses

## Procedure:

The students work in groups of two.

- Undirected observation (30 minutes)
  Have each team watch and depict what it sees for each colour. Start with the brightest colours and leave the black, white and, especially, the grey, for the end. (Figures 1 and 2).
  15 minutes analysing the results, highlighting the matrix and deactivated bands.
- "Guided" observation (45 minutes)
  This time, the students look colour by colour and are asked to fill out the following chart (for each colour, colour the matrix).




*Green (V) – Blue (B)– Red (R)– Black – White (BRV) – Yellow (R+V)–Turquoise(B+V) – Purple(B+R)*

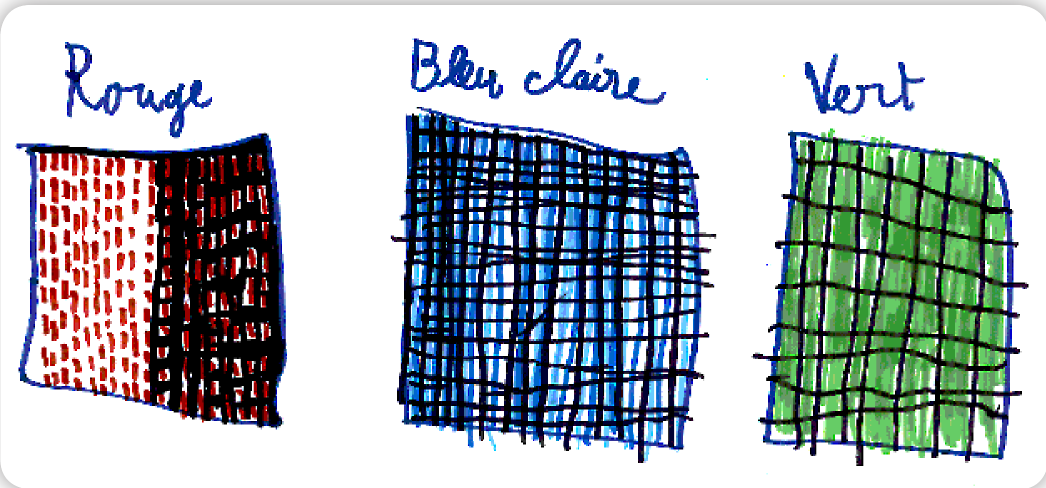
*Deactivated bands*

## Group Analysis:

- Only three colours are used to make all of the others: green, red and blue.
- For white, all of the lights are lit up.
- For black, all of the lights are turned out.
- Grey is difficult to analyse and seems to offer little value at this stage of elementary school (the intensity of the light varies and it is difficult to identify each colour's contribution).

## Samples of Student Work:

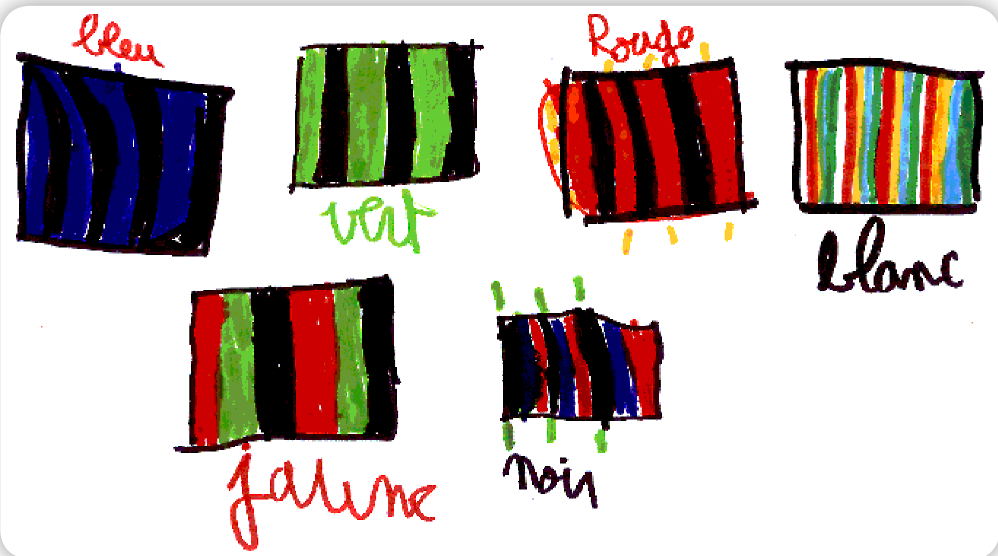
- **figure 1**




*Red – Light blue – Green*

The student sees the matrix-like form, as reflected in the heavy gridding. However, the colours are portrayed as plaids.

- **Figure 2**




Blue – Green – Red – White

Yellow -- Black

This student did not see the matrix form, as the lines are shown as only vertical. However, the colours are properly shown. The deactivated bands are not always seen.

### Teacher's Note:

Difficulties encountered in observation:

- Analysis is highly subjective: it is very difficult to remember what was seen from afar once a magnifying glass is brought in.
- On purpose:
  As two colours are very similar, the red looks pinker, making certain students draw blue, then pink; in other cases, colours blended in graphic arts led the students astray: blue and red yielded a brownish mixture, while blue and pink yielded a more purple mixture.
- On yellow: the two initial colours were not the ones expected (green and red)
  The green was not easily identified because it is very luminous and can give the visual impression of being yellow. It is unexpected and some children replaced green with yellow. Sometimes, it can be found in the drawings, in addition to the red and green.

# Sequence 5: Producing Colours – Light

**Based on the results of the previous sequence, the students use coloured lights to create other colours, specifying which ones they were able to produce.**

### Objective:

To use the results from the light breakdown experiment to "re-compose" other coloured lights.

### Duration:

Around 1 hour.

### Materials:

Per group of 3:
- 3 lamps from the Limoges CRDP (rheostat) (or ordinary lamps) +
- 3 "primary" lamps (blue, red, green)
- cardboard box, painted black or covered in black paper inside
- triangle-base pyramid to be used as a screen

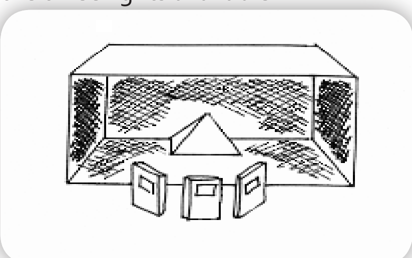
### Procedure:

There is enough material for only two groups. While the six students experimented, the rest of the class worked independently in other areas (reading and designing a work plan, for instance).

Each group was given a protocol listing the activities in order. Each team was to manage activities for 30 minutes, choosing to devote more or less time to a specific stage, if necessary.

**Unguided testing**

To regain familiarity with the properties of light composition covered in the previous session, by freely combining the three lights available.



**Producing a specific colour**

Choose a colour-light.
Plan which lamp(s) to use to produce it.
Carry out the experiment.
Confirm or infirm.
Record the procedures (in words or drawings).

**Make a rainbow**

Use the results from one of the experiments to recreate a rainbow. In other words, make purple, blue, green, yellow, orange and red lights, in order and uninterruptedly.

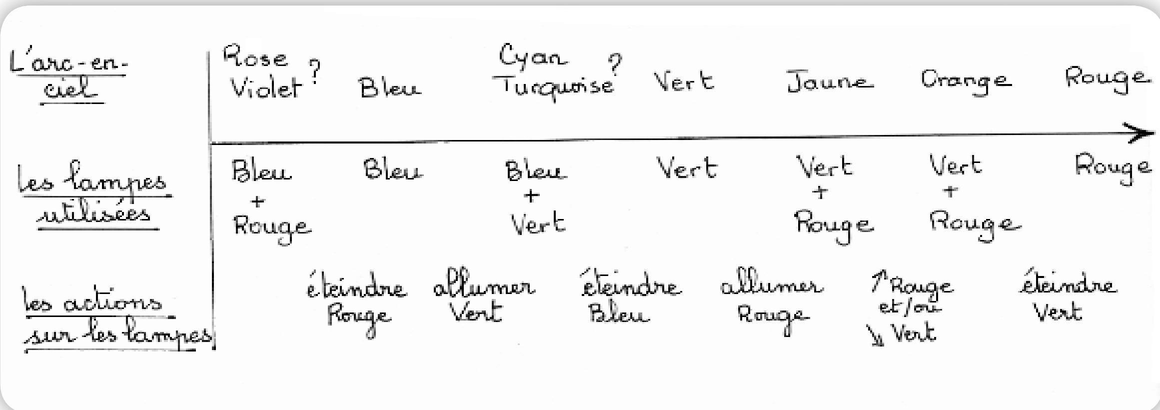
To do so, at the start of the experiment, turn all of the lamps on. Arrange them facing the pyramid-screen. Without moving them, move the rheostat to achieve the amount of light desired.

## Results:

- The first phase did not last long in most of the teams.
- Some children began directly with Stage 2, working from the television analysis chart. Most found:
  R B => purple
  B V => turquoise
  R V => yellow (always surprising)
  R V => orange (varying the intensity: either increase R, or decrease V)
  R V B => white
- All of the teams managed to create a rainbow. Only one did so by trial and error.

## Group summary:

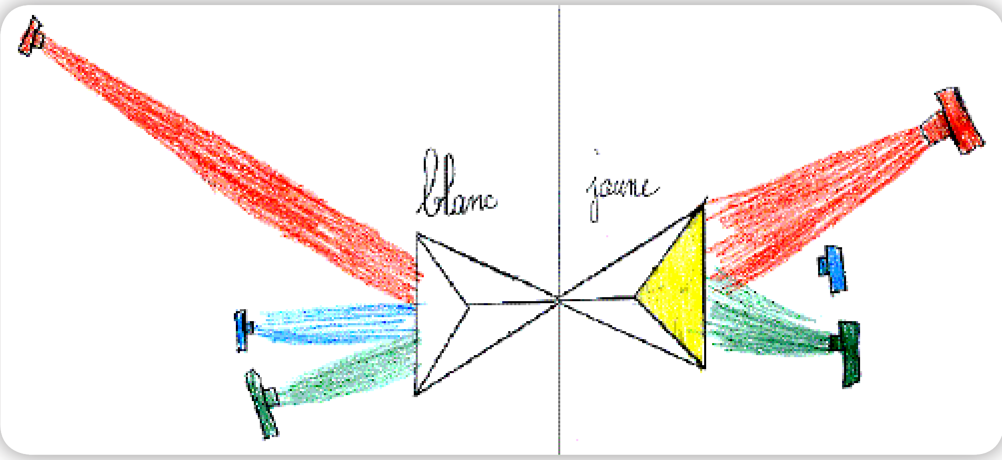
A summary of approximately 15 minutes was used to validate the results and present the process for making an axis-shaped rainbow.




| Rainbow | Pink Purple | Blue | Teal Turquoise | Green | Yellow | Orange | Red |
|---|---|---|---|---|---|---|---|
| Lamps used | Blue + Red | Blue | Blue + Green | Green | Green+ Red | Green + Red | Red |
| Action on lamps | Turn off red | | Turn on green | Turn off blue | Turn on red | More red and/or less green | Turn off green |

Green, red and blue are the "primary" colours in light. White light is created when these three primary colours are overlapped.

## Examples of Student Work:




## Teacher's Note:

The children did not manage to agree about what to call certain colours:

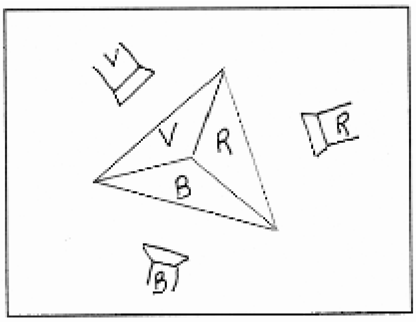
Purple or pink?

Regarding the blue-green blend, some children referred to blue-green, while others said turquoise. Others took on the name teal.

Rather than using the rheostat to vary the lights' intensity, some children chose to play on the distance between the lamps.

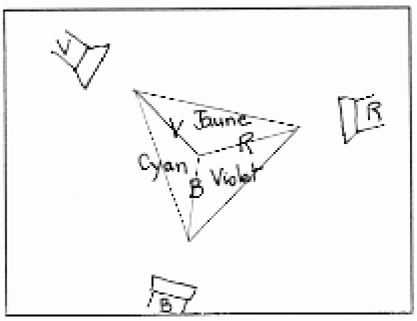
## Going farther:

It can be beneficial to rebuild the circle of colours in order to observe all the colours in the spectrum and the continuity between them. To do this, put the pyramid-screen box on the ground and take the "overhead view".




1) The lamps light up the sides of the pyramid.

=> the three primary colours can be seen




2) Turn the pyramid so that the lamps shine on the edges.

=> on the edges, the primary colours show.

=> on the sides, the matching blends show.

Together, the colours form the chromatic circle.

This additional activity, suggested and implemented by the teacher, lasted around 20 minutes. The children experienced it as an entertaining way of putting their knowledge to work and saw only the aesthetic value.

**Responses:** Audrey Bonte, teacher (8-11 year old students). Ecole du lac à Château la Vallière (37), abonte@9online.fr: Session 5, with average-quality lamps, did not work well. One of my students then suggested, recalling the multi-coloured tops that are spun around to blend the colours, producing two-tone tops, using television colours (red, green, navy blue). We were able to blend the colours and reproduce what we saw through the magnifying glass, on the television screen.

# Sequence 6: Summary

**This final session is an opportunity to establish the parallel between light and matter. The students are required to recall the results achieved and properly distinguish between mixtures of light and mixtures of matter.**

## Objective:

- present everything that was learned about colour.
- Combine the results into a chart.
- Briefly and accurately summarise the activities performed.

## Duration:

40 minutes

## Materials:

For each student:
- coloured pencils
- paper

## Process:

- Per group of four. For 20 minutes, they worked to produce a written statement fulfilling the teacher's instructions:
  - present all of the lessons learned about colour during the sessions.
  - choose an appropriate presentation format.
- The group summary offered the opportunity to compare and complete the statements.

## Teacher's Note:

- From their final year of pre-school, the children are accustomed to using two-entry charts. At several points in their primary schooling, they produce charts of this kind. It is therefore quite natural that their work recalled this format.
- Similarly, being accustomed to processing information, the children did not provide any superfluous details, but rather left some facts out: no intermediate blends, no conclusion.
- The benefits of writing a summary:
  headings added to columns: light colour, marker colour (to become the matter colour)
  tying the colour (coloured stain) to the name
  how to draw white (combination of all coloured lights)
  intermediate blends

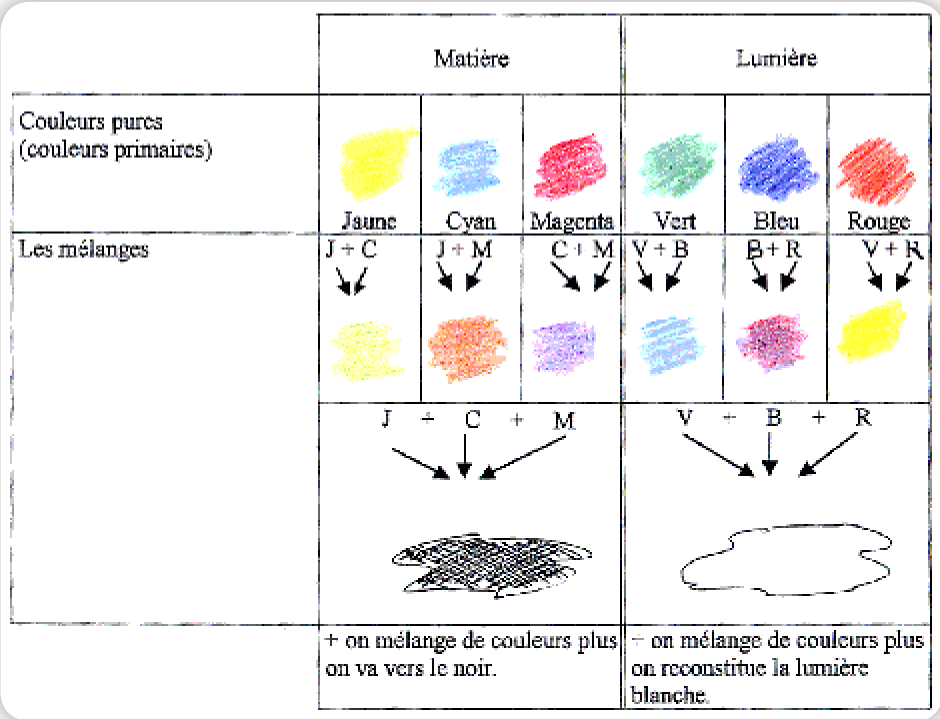
conclusion: since the columns were given headings, a sentence can be listed to summarise.

## Group Result

*Matter* *Light*

*Pure colours (primary colours)*

*Blends*



| | Matière | | | Lumière | | |
|---|---|---|---|---|---|---|
| Couleurs pures (couleurs primaires) | Jaune | Cyan | Magenta | Vert | Bleu | Rouge |
| Les mélanges | J + C | J + M | C + M | V + B | B + R | V + R |
| | J + C + M | | | V + B + R | | |
| | + on mélange de couleurs plus on va vers le noir. | | | + on mélange de couleurs plus on reconstitue la lumière blanche. | | |

*The more colours are blended the closer to black they are.*

*the fewer the colours blended, the closer to white light they become*