

THE RAINBOW IN THE CLASSROOM OF THE PRIMARY SCHOOL

by

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INTRODUCTION

The explanation of weather processes and of atmospheric phenomena usually requires some basic knowledge of physics. Therefore these subjects cannot be discussed in the classroom until the later years of secondary school. Nevertheless pupils already show an interest in the weather when they are much younger, as they know clouds, wind, rain and rainbows from every day life. In my opinion pupils should be stimulated to explore the everyday life aspects of atmospheric phenomena long before they are able to grasp the physical principles. Some possible activities in meteorology lessons for pupils aged 13-15 have been discussed elsewhere (Floor 1983). In this paper an example of lessons on an atmospheric phenomenon for even younger pupils will be described. The subject was the rainbow and it was treated at primary schools where pupils were in the age of 10-12. The purpose of the lessons was to increase the pupils' enthusiasm for rainbows and, more generally, for the beautiful phenomena that can be observed in the open air. The lessons were also meant as an exercise in making careful observations. The physical explanation, of course, was beyond the scope of these primary school lessons.

The design of the lessons on the rainbow can be summarized as follows. First each of the pupils made a drawing (or a painting) that showed, among other things, a rainbow. Together with the class I looked at the drawings. In doing that we noticed that the rainbows on the drawings were different from each other in several aspects. I continued by showing some slides (or photographs) of rainbows, paying special attention to the differences noted before. At the end of the lessons we drew some conclusions on the real appearance of the rainbow.

DRAWINGS

"Make a drawing or a painting showing a rainbow". This instruction should do to get a wonderful collection of rainbow drawings. More should not be said, except for asking for the location and time of the drawings, if they can be given. Pupils enjoy executing the task and very interesting paintings and drawings result. In addition the teacher can see from the pupils' work what they know about rainbows already. All pupils in my classes had seen a rainbow before and all could fulfil the

instruction. I collected the drawings and took them home to check them against a list of rainbow characteristics. The same list was used later on in the classroom discussions on rainbow features.

These are the characteristics listed:

1. The shape: a bow, so a part of a circle. This characteristic is known to all children and can be found on every drawing.
2. The wealth of colours: the most well known of all characteristics and also to be found on each drawing.
3. The number of colours; what colours: Now differences between the drawings can be noticed. The number of colours usually ranges from 3 to 8. This, of course, is a very difficult point. Perhaps you heard about the seven colours of the rainbow, but is this number real? Rainbows in advertisements often show six colours or less; on mediaeval paintings rainbows have only two or three colours. Some pupils have black lines between the colour-bands of the rainbow. Is black one of the colours?
4. The order of the colours: Here different drawings show also different results. Besides, it is not always easy to compare the order of four colours on one drawing with the sequence of eight colours on another one. In this case, however, it is possible for instance to notice that both rainbows have (or have not) a red outer rim.
5. Rain, dark skies or a dark raincloud can be seen on some drawings, but are missing on others.
6. The sun appears on quite a lot of drawings. Sometimes the sun is somewhat inside the rainbow, next it is outside it, often in a corner of the sheet of paper. On other drawings the sun is missing. Has the sun nothing to do with a rainbow? Has it been forgotten? Or is it just sitting outside the field of view of the artist?
7. How big is the rainbow? Some pupils draw a very small bow, that fits easily in the piece of paper they use. Others draw a large bow, that requires a wide field of view.
8. How far away is the rainbow? This also can be seen to vary from one drawing to another. On some occasions the bow starts at or beyond the horizon. In others it is much nearer than the horizon and stands, for instance, between the artist and a house or a tree on the drawing.

9. Miscellaneous: Sometimes the drawings show other things that can be discussed, like the treasure at the foot of the rainbow, holiday landscapes or short poems.

CLASSROOM DISCUSSION

The characteristics of the rainbow that were mentioned above were a guide for the classroom discussion. When looking at the drawings at home I noted the names of the pupils that had accentuated a special feature of the rainbow. Besides I used the notes on location and time of occurrence that some pupils had added to their work. Examples of these notes are: 'it rains and the sun is shining' or 'a summer evening'. The purpose of the discussions with the pupils was to make them discover some rules that are valid for rainbows. For example, there always appear to be some children who know that a rainbow is visible only with the sun in the back. Also some pupils have seen the rainbow colours, for instance in an aquarium in the same order as in the real rainbow. If one asks, some pupils tell that they have seen a rainbow in a garden sprinkler, a fountain or in waterfalls. They therefore can agree if you conclude that 'rain' is not necessary to create a rainbow, but that any source of water droplets will do. The classroom discussion also serves to make the pupils acquainted with the points in the list of characteristics, that will be used when looking at the slides.

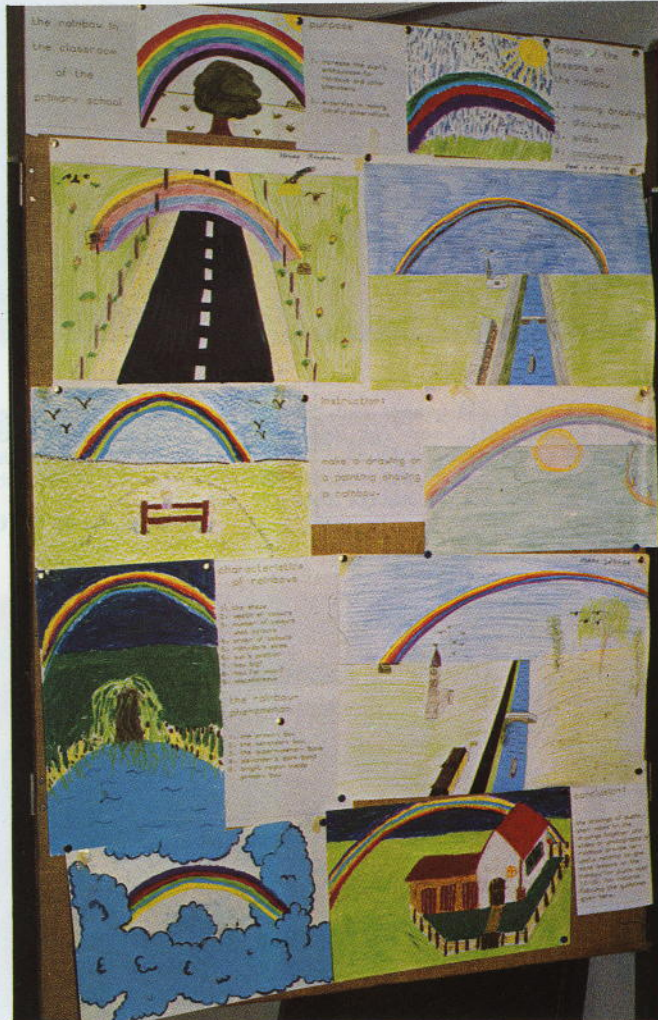
THE RAINBOW IN THE CLASSROOM

We would prefer, of course, to have a real rainbow in the classroom, to be able to compare it with our drawings and to decide which drawing corresponds best to a real rainbow. But, as this is impossible, we use photographs or slides of rainbows.

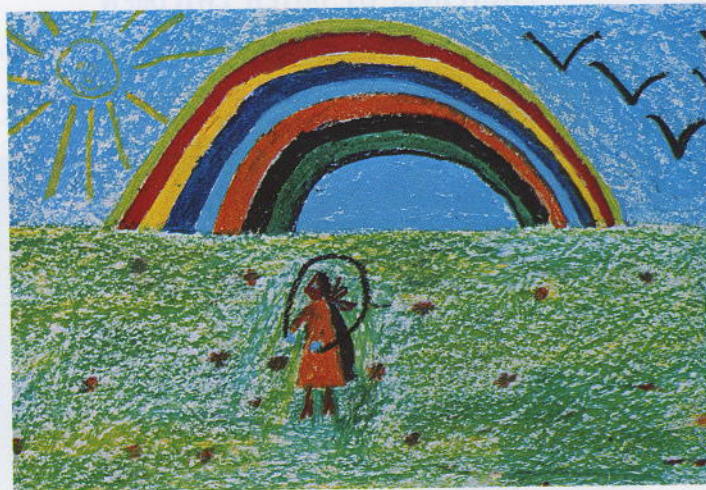
1. The shape of the rainbow on the slides can be seen immediately to be a part of a circle. (however, be careful, do not take measurements, as photographic perspective may cause distortions of the pure circle).
2. The wealth of colours can easily be seen on any colour-slide, except for some special cases (red rainbow, fogbow, lunar rainbow; see Boyer 1959, Greenler 1980, Humphreys 1964, Minnaert 1954).
3. How many colours? What colours? This is a difficult topic. It is seen immediately that different colours can be discerned much easier on the drawings than on slides. In the latter the colours gradually fade into each other (and they are never separated by black lines, as on some drawings). Sometimes it cannot be seen if there is some 'orange' between the 'red' and the 'yellow'. Besides, in some photographs the 'blue'

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PAINTINGS BY DUTCH CHILDREN



"Make a drawing or a painting showing a rainbow."
(photograph by J M Walker)



(Above) Note the number and the order of the colours. The sun is just outside the bow. The background is a clear sky, without rain or dark cumulonimbus clouds. The bow is at or behind the horizon. (Below) The sun is just outside the bow. Clouds or rain cannot be seen. The bow is nearer than the horizon.

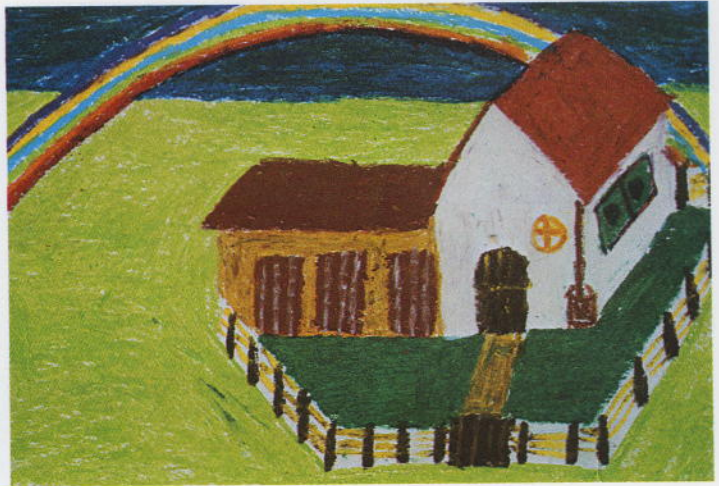
(photographs by C Floor)





(Above) Rainbow with changing distance to the observer. There is a pot of gold at the foot of the bow. (Below) Rainbow seen when washing car. (photographs by C Floor)

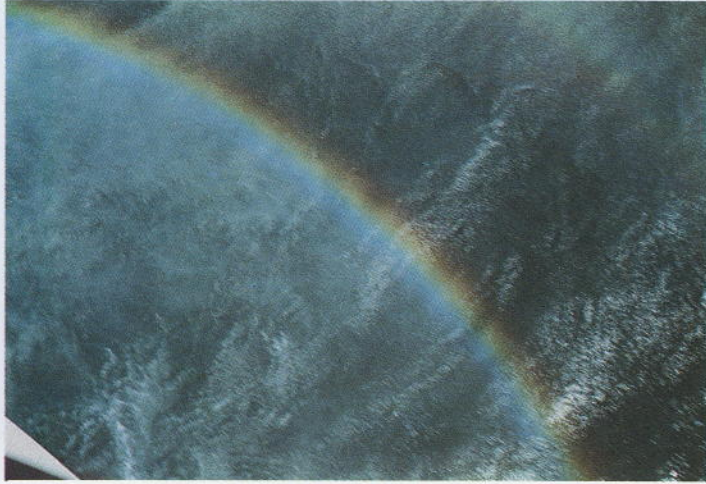




(Above) Note the order of the colours. The sun cannot be seen. The bow is behind the house but nearer than the horizon.
(Below) Sun and rain are shown. Note the order of the colours.
(photographs by C Floor)



... AND THE REAL THING ...



(Above) Rainbow in sea spray as seen from the deck of a ship.

(Below) Rainbow in the spray above a waterfall.

(photographs by J M Walker)



and the 'violet' can easily be seen, whilst on others they seem to be missing. At the inner side sometimes supernumerary bows can be seen, reiterations of colours, usually in pink or green turquoise tinge. The only conclusion we can draw from the slides on the number of colours in the bow is that there is no fixed number.

4. The order of the colours is the same as the order of the colours of the spectrum. (If we explain the spectrum as the colours of the rainbow, then a circular argument results). If there are supernumerary bows then it is difficult to define the order of colours, as some reiterations occur.
5. Rain cannot easily be seen on photographs of the rainbow, but dark skies or a cumulonimbus cloud usually can be seen very clearly. The contrast of the photograph is best when the rainbow has a background of dark sky.
6. The sun never appears on rainbow slides. The photographer always had the sun in the back. Sometimes this can be seen from the shadows on the photograph: they point to the centre of the rainbow-circle.
7. The size of the rainbow can only be seen on slides, taken with a superwide angle lens or a fish-eye lens. In other words: the field of view must be extra large. The size of the bow usually is expressed in degrees of arc. As the diameter of the bow is about 84° , its size equals at low sun nearly a quarter of the horizon. Therefore we cannot place more than four rainbows at the horizon. Keeping this in mind, quite a few of the rainbows on the drawings of the pupils must be judged too small.
8. At what distance is the rainbow? This question cannot be answered uniformly. The rainbow is seen in sunlit falling rain, if the observer stands in the right position. If the rain is near, then the rainbow can be concluded to be nearby, too. If the rain is at a great distance, then the same is true for the rainbow. In fact, the rainbow is not at a fixed place, but is everywhere in the direction where we see it, provided that there are sunlit raindrops. Sometimes some remarks can be made on the distance of the rainbows when studying the slides. This is the case if there is a building or another object on the photograph in front of which the rainbow can be seen. The part of the rainbow with the object as a background then can be seen to be less bright than other parts, where more droplets contribute to its brightness.

9. Miscellaneous. Some slides of the rainbow show that the rainbow phenomenon is more than just one colourful bright bow. Besides the primary bow the complete phenomenon consists of a secondary bow and a characteristic dark area (Alexander's dark band) in between the two (see references for detailed description).

The primary bow is a half-circle when the sun is at the horizon. When the sun's elevation increases, the rainbow sinks. At higher solar elevations (more than 42°) the (primary) bow even disappears below the horizon. At moderate latitudes high solar elevations occur mainly in summertime just around noon. From the notes the pupils give with their drawings maybe it can be concluded that there are no rainbows around that time of the day. For the rest the occurrence of the rainbow is not restricted to the summer season: it can be seen all year long.

CONCLUSION

The drawings of pupils, their notes on the drawings together with slides or photographs of rainbows provide very useful material to give some lessons on the rainbow for pupils aged 10-12, for instance following the guidelines given in this paper.

ACKNOWLEDGEMENT

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