Children & the Natural World

An Approach to Space

for Pre-Primary and Lower Primary School Ages

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in collaboration with

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with links to educational videos

About this book

This book presents series of fully developed activities and instructional material aiming at introducing and acquainting young children with basic concepts and phenomena of the solar system. These activities touch upon many of the children's interests and questions, and can assist the development of background knowledge.

The topics of the activities concern the shape of the earth, the sun and the moon, their position in the solar system, the movements of the earth, and the phenomenon of day and night. The activities are accompanied by educational videos (can be played by clicking on marked words in the text).

In addition to a detailed description, each of the activities includes a description of the experiences resulting from its implementation in the classroom. These present actual cases of teaching and learning, which allow the reader to anticipate the "reality of the classroom" and give ideas for handling possible difficulties that may arise during implementation.

The activities can be implemented as they are described in the book or they can serve as a basis for designing and carrying out projects.

The book is addressed to:

- Teachers of the early-years (preschool and lower primary education).
- Student Teachers.
- Parents, who are the first teachers of their children.

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Preface

The period between four and ten years of age is widely recognised as the time when children acquire a sense of natural phenomena and start to shape elements of scientific concepts. Some of the most important of these concepts and phenomena have to do with the world of outer space. While numerous studies have focused on exploring children's notions of the shape of the earth, its place in the universe, the day/night cycle and other related topics, there has been relatively little work on the organisation and outcomes of didactical activities.

This book presents supporting material plus three series of structured teaching activities designed to introduce some basic notions and to acquaint young children with phenomena relating primarily to our solar system. The approach followed reflects a view of learning in which the children engage dynamically in the learning process, exploring the phenomena and building up new knowledge. Learning is treated as a social activity, in which interaction between the children, their teachers, their parents and the material is fostered and promoted. The activities entice the children to learn, encourage them to apply their own knowledge and experience to new phenomena and knowledge, and cultivate creativity and the development of rational and scientific skills.

The book is unusual in that it is the product of years of practical work carried out by a researcher specialising in the Didactics of Science and a team of six experienced pre-primary teachers. The group designed the activities and implemented them systematically with a large number of children in different schools. The teachers in the work group documented the outcomes in detail, recorded the children's reactions, commented on their responses, and suggested ways of handling the problems that arose during the implementation of the activities. This feedback was used to modify the proposed activities to reflect the results of their actual classroom use. The richness of the experience gained from the implementation of the activities makes this book a tested and potentially serviceable tool for teachers, a useful aid that prepares them for the reality of the classroom.

For the teacher who makes use of it, this book provides helpful knowledge concerning the content, organisation and implementation of a series of teaching activities that can be used in schools and will improve the effectiveness of early-years teaching in this domain. In addition, its suggestions for family activities based on the specific or related topics provide an opportunity for the family involvement that is such an important element in a child's education.

Used with the accompanying videos, this book can be a very valuable tool for pre-primary and lower primary school teachers who want to introduce their pupils to topics relating to the planetary system our earth belongs to and encourage them to explore and approach their questions in a scientific manner, both in the classroom and beyond.

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Introduction

The natural environment in which we live is a very small part of the vast universe. Children are fascinated by space, and often in awe of it. They experience astronomical phenomena in their daily lives, and this drives them to interpret these events, thus shaping notions about what happens and why. These notions constitute their own "ideas" about astronomy.

Experience has shown that astronomy is one of the branches of science that particularly attracts the interest of young children, arouses their curiosity and awakens their imagination. Elementary astronomy, however, aims at something more than teaching young children some space-related concepts and phenomena, modifying their "astronomical ideas" to bring them into line with scientific reality, and developing their scientific skills: it aims to kindle in them, via pleasurable experiences, a liking for the subject and to foster positive attitudes towards it.

This is the starting-point from which this book endeavours to initiate young children into space-related concepts, events and phenomena as these actually occur and to acquaint them with their true causes. It attempts to instil this knowledge in them via activities and teaching material that constitute a pleasant way of engaging with the subject of astronomy.

This book also has another important aim, and that is to attract the interest of teachers and incite them to use and enjoy its activities with the children. In order to help teachers develop a more effective approach to the objectives of the activities, the book provides a corpus of essential basic knowledge about the concepts and phenomena they deal with, and answers the questions they will probably have.

The activities contained in this book are not restricted to the classroom, but can also be used in the home, providing opportunities for pleasant family occupation either independently or as a follow-up to the child's classroom activities.

The book contains three series of fully developed activities dealing with selected topics relating to our solar system that are considered suitable for and accessible to young children. These activities have to do with the shape of the earth, the sun and the moon, their place in our solar system, the motions of the earth and the phenomenon of the day/night cycle.

They have been tested by the six early years' teachers in the work group on a sample of 104 children in six different schools. Their classroom experiences, which are presented in the book, were of great assistance in developing and finalising the form of the activities and in choosing and compiling the teaching material.

The work group and the study framework

The work group was formed of six in service pre-primary teachers and one researcher/co-ordinator with a background in physics. The activities were developed through a process that included individual classroom work on the part of each teacher, as well as group work. Two of the most important constituents of the methodology followed were the colaborative development of the activities and action research (Kallery and Fragonicolaki 2007). In the classroom, the teachers used pre-prepared series of activities supplied by the researcher/co-ordinator, and recorded each stage of the lesson, taping the lectical interaction and keeping written notes of everything that occurred, supplementing these with personal commentary; the resulting tapes and logs were then systematically studied and analysed by the co-ordinator/researcher. The second element of the process was the regular semi-monthly meetings of the working group, in which the teachers described the practices they had adopted in the classroom and took part in general discussions and criticism of these practices and those described by the other members of the group. Facilitated by the co-ordinator/researcher, the group would decide on a common way to handle the teaching issues and problems they had experienced. This whole set of practices – opinion-pooling, mutual criticism by all the members of the group, re-consideration and new classroom activity – drove the revision of the activities and the accompanying video and led to the development of their final form.

The structure of the book

The book is arranged in four parts:

The first part, entitled "A few words about astronomy", presents some essential basic knowledge concerning the concepts and phenomena dealt with in the activities, as well as some basic information about our solar system that may help teachers handle the questions that are likely to arise during the course of the activities.

The second part, "Children's Ideas", discusses young children's notions regarding the concepts and phenomena associated with the themes of the activities, as these are described in international literature.

Part three, "Some Didactical Points", deals with some basic issues of methodology that are useful for the classroom implementation of the activities and can also be used more generally in teaching other science subjects.

The fourth part presents the activities themselves, and gives:
a) introductory information relating to their development and approach,
b) the structure of the set of activities,
c) the structure of the individual activities,
d) the actual activities, each fully developed and separately presented,
e) ways of assessing the outcomes of the activities, and
f) possible ways of expanding on the activities at home.
The final pages of the book are devoted to general commentary and observations.

Supplementary audio-visual material

This book comes with three short videas. **It is essential that these be played at the right times, as indicated in the outlines of the activities.**

PART 1

A FEW WORDS ABOUT ASTRONOMY

The answers to questions like those listed in Table 1, which have to do with our solar system, are basic general knowledge. For teachers who want to use the activities in this book this knowledge is essential, both for success in addressing the aims of the activities and for handling the questions that the children will probably ask.
Let us see what Astronomy has to say.

- What do we call "heavenly bodies" and what kinds of heavenly bodies are there?
- What is a planetary system?
- What heavenly bodies are or may be found in our planetary system?
- What kind of motions do these bodies perform?
- What shape is the earth?
- What motion of the earth results in the alternation of day and night, and what phenomenon does the revolution of the earth around the sun cause?
- Why does the rotation of the earth not make people dizzy?
- Why does the moon appear to change shape over the course of a month?

Table 1: The questions

Heavenly bodies are all the natural bodies that move around in space: the **stars**, the **planets** and their **satellites**, the **comets**, the **asteroids** and the **meteorites**. **Stars** are self-luminous bodies, that is, bodies like the sun that produce and give off light and heat. **Planets** – our earth is one – are bodies that are smaller than a star and do not produce visible light. **Planetary satellites** are bodies that are smaller than the planets. **Comets** are heavenly bodies with a cloak of ice and dust, which leave a trail of gas or dust behind them as they move and develop a luminous tail when they are heated by the light of the sun. **Asteroids** are huge pieces of rock or ice, usually irregularly shaped, like a potato; the larger ones may be spherical or elliptical. **Meteorites** are large pieces of rock or metal.

A planetary system is a set of heavenly bodies that contains a star, planets and possibly satellites around those planets. In a planetary system the planets revolve around the star. The planetary system to which our earth belongs is called the solar system, because the star in this system is the sun.

Our planetary system – the solar system – has a number of planets revolving around the sun; these include Venus, Mercury, Earth, Mars and Jupiter. Some of the luminous heavenly bodies that we see in the sky at night are planets in our solar system. Our solar system also includes the satellites of the planets (one of which is the moon, a satellite of the earth), meteorites and asteroids. From time to time our solar system is visited by comets.

All heavenly bodies move. The planets revolve around the sun, in elliptical orbits. The asteroids move all together in orbit around the sun. The orbits followed by meteorites are random, and they may fall to earth or another planet. Most of them burst into flame as they approach the earth and shatter before they fall to the ground. Comets follow elliptical orbits that go outside our solar system. These orbits are very long, and it may take many years for a comet to return to a particular point in its orbit. Comets can also move in an open orbit called a parabola, which means an open curve; these comets never return to the same point. Our sun moves around the centre of the galaxy to which our solar system belongs, followed by all the heavenly bodies that revolve around it.

The earth is not an exact sphere. It can be described as spherical with a bulge at the equator, as shown in Figure 1.

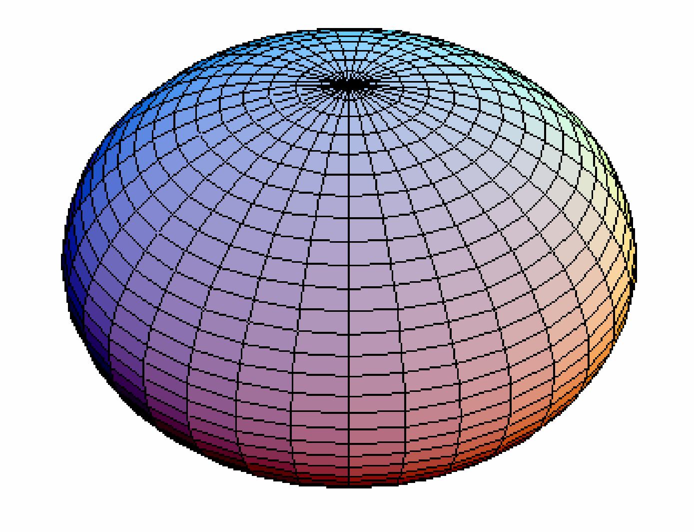


Figure 1. The shape of the earth. It is flattened at the poles and bulges at the equator.

Thus the earth's diameter at the equator is longer than the diameter that passes through the poles, as can be seen in Figure 2.

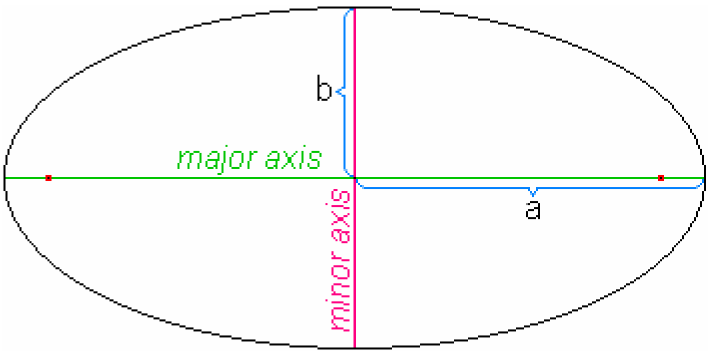


Figure 2. The diameter of the earth at the equator is longer than that which passes through the poles

The bulge at the earth's equator was caused by its spinning movement. The other planets have a similar shape, as do some other heavenly bodies.

Like the other planets, the earth turns around the sun and also around itself. We are all familiar with the notion of an axis around which the earth rotates. It is this rotation of the earth around its own axis that causes the phenomenon of the alternation of day and night: it is day on the side of the earth that is facing the sun, and night on the side that is turned away. It is the rotation of the earth around the sun that causes the succession of the seasons. The earth (and the other planets) follows the sun as it moves through space. That is why, if you look at its orbit not within our solar system but in the broader context of outer space, you will see that this orbit is essentially a spiral (see Figure 3.).

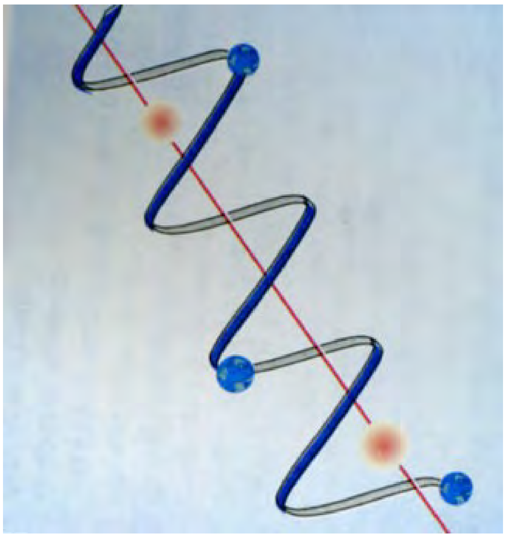


Figure 3. The earth's orbit in space

One rotation of the earth around its own axis takes 24 hours. That means that any place on the earth's surface will make a full revolution, that is, will return to the same point, every 24 hours. This is far too slow a spin to cause dizziness in the people on that spot. It is like a person taking 6 hours to turn himself, e.g., from facing north to facing west.

Many people believe that the reason why the moon appears in the sky with different shapes is because it is partially hidden by the earth or because the earth shades it. That, however, describes an eclipse of the moon. The moon is a sphere, like the earth, and like the earth only half of it is illuminated at any time (the half that is facing the sun). The moon revolves around the earth, making a complete circuit in the space of one lunar month (on average, this is 29.5 days). While it is revolving around the earth, we see different-sized portions of its illuminated side. Beginning with the new moon, when the side that is turned towards the earth is the side that is turned away from the sun, we gradually see more and more of the illuminated side, until that side is turned wholly towards the earth (full moon), and then, just as gradually, we see less and less of the illuminated side until it is once again wholly turned away from the earth (see Figure 4.). These different appearances of the illuminated part of the moon are its *phases* (see Figure 5).

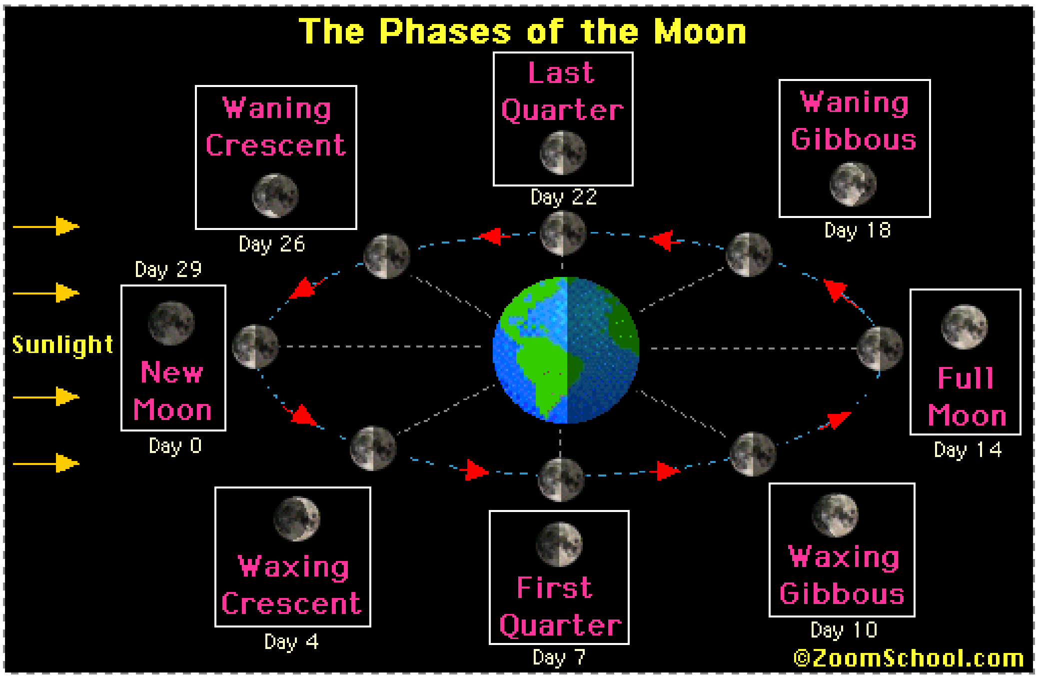
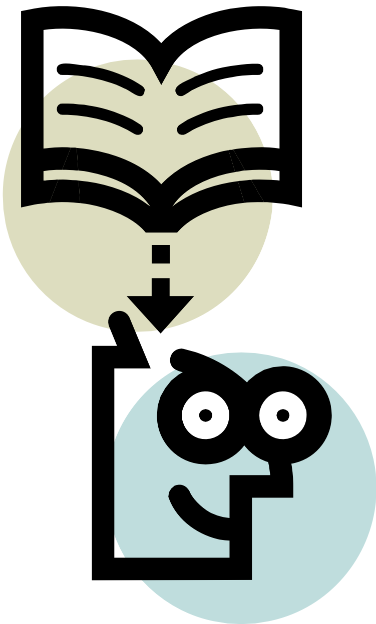


Figure 4. The changing phases of the moon from day 0 to day 29. The parts of the illuminated surface of the moon are shown as we see them from different parts of the earth.

Figure 5. The phases of the moon

PART 2

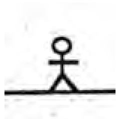


THE CHILDREN'S IDEAS

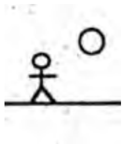
As young children try to acquire a sense of the natural phenomena they observe, they form their own notions about these phenomena and what causes them. Internationally, the ideas children from different parts of the world have about various astronomical phenomena and concepts have been intensively studied. In this book our focus will be on small children's notions about selected concepts and phenomena relating to our solar system, and particularly to the Earth-Sun system. Specifically, we will describe young children's perceptions of the shape of the earth, the motions of the earth, and the phenomenon of day and night.

♦ *Children's ideas about the shape of the earth*

Children have different types of notions about the shape of the Earth that do not coincide with scientific reality; this has been demonstrated in a number of studies (Baxter 1989, Nussbaum 1985, Sharp 1996, Vosniadou & Brewer 1990). Beginning with the most instinctive and moving towards those coming closer to scientific truth (as presented in Sharp 1999), these include:

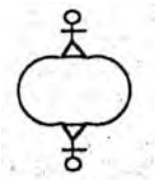


The flat earth: Children who hold this view think that the Earth is like a tray, which may be round, square or rectangular. People who move too far in any direction are in danger of falling off the edge. The flat-earth view seems to derive from children's direct experience of the world around tem.



The dual earth: Children often think that there are two earths, one flat and the other a sphere in the sky or, more generally, in space. People may live on one or the other or on both. In some cases the children think that the inhabited earth is spherical but it is sandwiched between a flat sky above and a flat ground beneath.

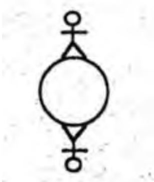
The hollow earth: Some children imagine the earth to be like a sphere with the upper hemisphere, the sky, covering the lower like a dome. In this view the ground, the lower hemisphere, is completely enclosed by the sky.



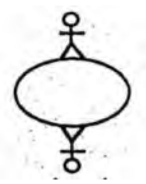
The squashed earth: In this case the children think that the earth is shaped like a "fat pancake" surrounded by the sky and space. People live all over its surface.

Other studies (Schoultz *et al.* 2001, Butterworth *et al.* 2002, Nobes *et al.* 2003), however, have shown that researchers who used a globe as a tangible reference point, thus introducing the scientific concept of the sphericity of the earth from the outset, found none of the above notions. Rather, they found that the children readily adopted the scientific model.

Two further notions that have been detected in children aged 10-11 are:



The spherical earth: According to some children the earth is shaped like a sphere, surrounded by sky and space. People live everywhere on its surface.



The almost spherical Earth: The earth is not a perfect sphere. Its diameter at the equator is longer than that between the two poles. This view coincides completely with the scientifically accepted notion.

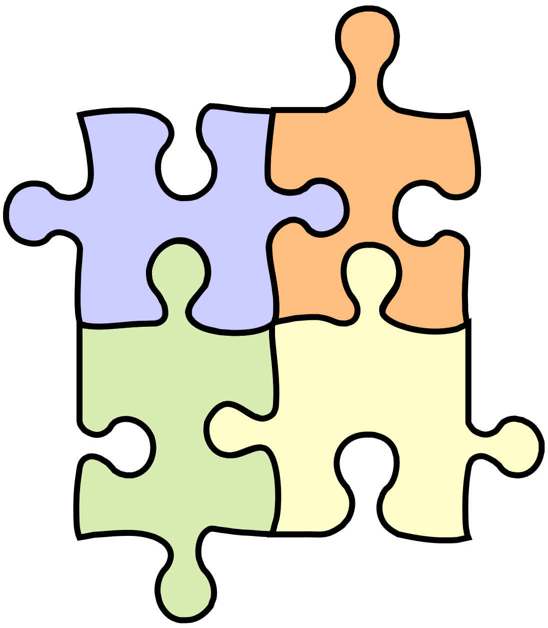
♦ *Children's ideas about the day / night cycle*

Research has elicited a number of views about the alternation of day and night, such as that:

- The phenomenon is due to the fact that the earth turns around the sun in one day.
- The phenomenon is due to the rising and falling motion of the sun.
- The sun turns around the earth once a day, lighting different parts successively as it goes.
- The earth revolves around its own axis in one day.

Research has also shown that very young children think of the sun as a living organism, and attribute anthropomorphic habits to it. For example, they may say, with regard to the coming of night, that the sun goes to sleep, or hides behind trees and hills. Or they may say that the sun drapes itself with clouds, or is hidden by the moon. Some of the explanations young children give for the alternation of day and night may be described as egocentric: examples include phrases like "the sun comes to wake us up", or "if there were no night we wouldn't be able to sleep", or "the sun comes so we can do our jobs and the night so we can go to bed".

PART 3



SOME DIDACTICAL POINTS

3.1. The importance of the children's own ideas

Research has shown that in general children's notions about the concepts and phenomena of the natural world do not, for the most part, correspond to scientific reality. Once, these ideas were simply rejected as childish. Later, the importance of these ideas in the context of learning was recognised, and the ideas held by children were systematically explored by numerous researchers (see e.g. Driver *et al.*, 2000). Children's ideas have influenced many educationists, who have developed teaching approaches referring to them and taking them into account.

Children bring their notions into the classroom with them, and one of the objectives of their science education is to develop their interpretive abilities so that these ideas can become useful concepts. If teachers are aware of what children think and how they interpret things associated with the topics of various activities, they can address these questions more easily and more effectively and handle them in a way that is conducive to that aim.

3.2. Scientific skills

By about age 3, a child's world already contains abstract concepts. Their exploration of the natural world passes through a stage where their ideas can be associated with and represented by pictures and words. For these young children, nature study is a matter of curiosity and exploration, but gradually it will come to include asking questions, measuring and comparing, investigating and experimenting in a more structured manner, drawing conclusions and generalising (de Boo 2000). These processes, which are described as science process skills or "skills of scientific method", are the intellectual and physical skills employed by scientists when they are studying or interpreting the natural world. For children, scientific skills are a means of shaping concepts during the learning process, and they cannot be cultivated independently of content. In general, the sciences that focus on the natural world are considered to comprise two types of knowledge: knowledge of the content of a particular field (concepts, phenomena), and the skills involved in studying it; and one cannot exist independently of the other (Zimmerman, 2000).

Scientific skills are cultivated in children through activities that explore or test their ideas. Successfully incorporating scientific skills into activities with topics drawn from nature makes learning their content more attractive and more effective, gives the children a deeper understanding of the science content, kindles their interest and makes them develop positive attitudes towards the subject of their study.

The scientific skills that are most useful in early childhood and the lower primary grades, the skills that have been labelled basic skills (Funk *et al.* 1985, Harlen 1996), are: observation, communication, comparison, classification, measurement, interpretation and prediction. The main scientific skills that are promoted by the activities in this book, and which are briefly outlined in the following paragraphs, are observation, comparison, communication, interpretation and drawing conclusions.

Observation

Observation enables us to learn about the world around us. The information we obtain by observation sparks our curiosity and makes us think, leads us to ask questions, to interpret our environment and to explore it further. The ability to observe is the most basic skill for any science dealing with the natural world and is essential for the development of other scientific skills (Funk *et al.* 1985). Careful recording of the details of various events and the order in which they take place is an important aspect of what is called active observation. Active observation will contain the following elements (Harlen 1996, Harlen and Jelly 1995):

- Combinative use of the different senses, e.g. sight, touch, hearing, taste, smell.
- Identification of relevant details.
- Determination of similarities and differences.
- Discerning the order in which the events occur.
- Use of sensory aids (e.g. magnifying glasses, microscopes, binoculars, telescopes, etc.) to study details.

Comparison

Comparison allows us to identify properties or characteristics that some things have and others do not. Knowledge of their similarities, differences and reciprocal relations enables us to arrive at a better understanding of things and events in the natural world. Comparison, as already noted, requires careful and systematic observation in order to record details in the objects or phenomena being compared.

Communication

The ability to communicate with others is a fundamental skill in anything we do. It lets others share in our ideas, helps us put our thoughts in order, and plays a major role in problem-solving. Oral speech, writing, drawing, visual evidence and the representation of things in various ways using symbols, drawings, mathematical equations, maps or diagrams are all methods of communication that are frequently used in studying the natural world. These methods use skills that develop the ability to understand scientific language better and express ideas more clearly. Children often select words to use without necessarily knowing their real meaning. Encouraging them to explain precisely what they mean by these words and to listen to what others are saying helps them understand the differences that can cause alternative conceptions. Discussion also helps in cases where children have ideas but find it hard to express them. Recapitulation, reference, and having children present their findings after an investigational or observational activity must serve a specific purpose and not become a meaningless routine. It is important that all the children take part in this process (Funk *et al.* 1985, Harlen 1996, Harlen and Jelly 1995).

The factors that foster the development of communication skills in the natural sciences include:

- Speech, listening or writing, for channelling ideas and clarifying meaning.
- Taking notes and recording observations during the investigation (in whatever manner is feasible for specific ages involved).
- Using different ways, depending on the age group, to convey and transfer information (e.g. diagrams, drawing, constructions, etc.)

- Choosing a suitable means of communication which can be understood by the others.
- Using alternative sources of information.

Interpretation and drawing conclusions

The ability to interpret and explain the things that happen around us allows us to appraise and understand our environment better. Interpretation includes synthesising the results of investigation and observation, and lets us discern the relations between them. This process enables us to arrive at certain conclusions (Funk *et al.* 1985, Harlen 1996, Harlen and Jelly 1995). In interpretation, explanations must:

1. Be made on the basis of evidence and be consistent with it.
2. Be based on ideas acquired from previous experience.

Indications that interpretive skills are being exercised include:

- The synthesis of different pieces of information in a way that makes their meaning clear.
- The determination of a relation between two variables.
- The identification of similarities or motifs in observations or the results of an investigation.
- The confirmation of motifs or relations by all the data.

3.3 Teacher's Questions

Asking questions is an important part of teaching practice. Teachers ask questions for different reasons, e.g. to advance the children's activities, to check their knowledge, to get them thinking, to encourage them to investigate and experiment. What is important is less the number of questions than their nature and content.
Teachers' questions are of different kinds. One distinction is between productive and non-productive questions. Productive questions are, for example, those the teacher asks, when an observation is being carried out very superficially, to draw the children's attention to something they would otherwise not have noticed, or those giving the children problems

to solve, or those leading to comparisons and actions (Elstgeest 1986). Another distinction is that between open and closed questions. A closed question indicates that there is one correct answer, which may discourage children from attempting to answer it. An open question, on the other hand, invites the children to express their views and ideas and promotes investigation (Harlen 1996). A third distinction is that between person-centred and subject-centred questions. Subject-centred questions cannot be answered unless someone knows the answer. These are the simple "how?", "why?" and "what?" questions, and children may hesitate to respond for fear of giving the wrong answer. Person-centred questions, by contrast, which take the form "why do you believe that…?" or "what do you think…?", allow the children to formulate and express their own opinions about the topic and are considered to be more appropriate, particularly for young children.

3.4 Handling children's questions

Children ask countless questions arising out of their experiences and observations (Chaille and Britain 1991). Their questions may be philosophical, they may be comments in question form, they may ask for simple information, or they may require complex scientific answers (Harlen 1996). The question is how the teacher should handle children's questions (Jelly 1986). Should they answer them directly? Will a direct answer help the children understand the topic? Does the complexity of the question allow the teacher to give an answer that is scientifically acceptable, which is particularly essential when dealing with young children (Zaporozhets, Zinchenko & Elkonin 1971)?
It is not at all uncommon for teachers to have trouble answering many of the questions children ask, either because the questions are too complicated for the teachers themselves, or because the answers are beyond the grasp of young children. How, then, should teachers handle children's questions, in order to make constructive use of the precious opportunities they afford (Kallery 2000)?
Handling children's questions is a skill that teachers can easily develop. It requires some thought about the possible motivation for the question and some knowledge of how to convert it into an opportunity to explore the topic further. A question can also provide an opening for the children to

gather more information, guided by the teacher. The word that should always be associated in teachers' minds with questions from young children is not "answer" but "handle". In general terms, in handling children's questions the teacher should remember that:

- Small children's questions are an expression of **interest** and should be taken seriously.
- The teacher may not be able to answer some of their "why" questions, and indeed there may be some that should not be answered.

Finally, encouraging children to ask questions and helping them find answers fosters an enquiring spirit (Jelly 1986). That is why teachers must understand the topics of the lessons they teach, so that with the help of suitable material and activities they can guide the children to the desired goals.

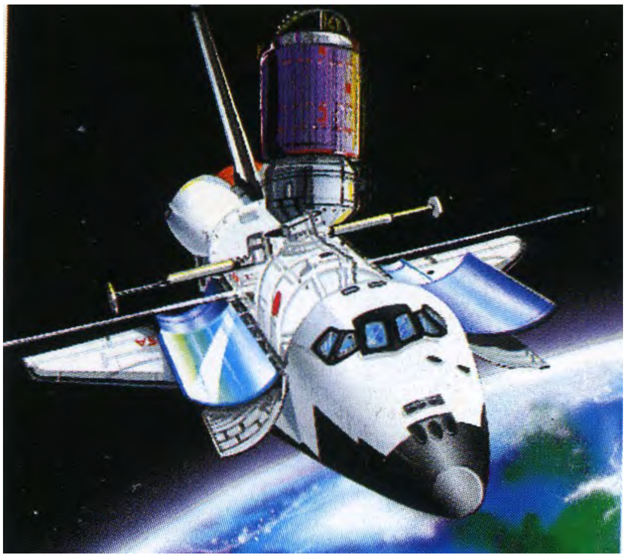
3.5 The 'project method' and children's questions

The kind and the level of the questions children ask also depends on the stimuli they are given. A teacher's introduction to a topic gives the children something to think about and ponder over, and may spark some questions. There is, however, another way of doing this, namely by displaying material that has been **appropriately** selected with a specific objective, so as to stimulate an expression of interest and elicit questions from the children. As Sheila Jelly (1986) noted in an article on helping children ask questions and answer them, "the first step is kindle the children's interest, and that means giving them direct contact with the material. It also means that we need to think carefully about the kind of material that will attract their curiosity". Based on the interest they show and the questions and ideas they express, the teacher can organise activities to explore the topic. This is the 'project method', and using this process the children can work out answers to some of their questions. **But a project-generating process cannot be considered scientific unless it employs the stages and skills of the scientific method.** The teacher can look for examples of this way of working, which will serve as a scientific foundation for the implementation of the activities, ensuring

maximum effectiveness in addressing the children's ideas and handling their questions.
The teacher can also use this method to extend the activities beyond the concepts and phenomena touched on by the children's questions and expressions of interest and thus to address additional concepts and phenomena that enter into the basic foundation essential for their further education. We must remember that young children may not express an interest in, or ask questions about, elementary matters before they have been introduced to them: it is thus up to the teacher to give them the appropriate stimuli. We must also remember that method cannot operate independently of content.

In concluding the methodological part of this book, it is worth emphasising once again that "teaching" science to young children means giving them a chance to take part in suitably designed explorations of concepts and phenomena. In modern curricula, indeed, one of the priorities of early childhood education is to develop in young children a spirit of investigation, which is considered essential for the development of scientific literacy.

PART 4



THE ACTIVITIES

4.1 Introduction

As is clear from the reported results of studies of children's ideas on various astronomical topics (see Part 2, above), young children entertain a variety of notions about concepts and phenomena relating to our solar system. These form the themes of the activities in this book. Given the differences in these views, and the different background knowledge that children of this age have, we have developed a set of activities intended to initiate young children into concepts, events and phenomena as these actually take place in space and to acquaint them with their real causes. As noted above, the activities focus on concepts and phenomena that are deemed suitable for and accessible to young children and that can be studied in pre-primary classrooms (Bredekamp and Copple 1997). These include the shape of the sun, earth and moon, their place in our solar system, the motions of the earth and the day/night cycle, and are part of the basic background knowledge that will prepare the children to understand more easily the more complex concepts relating to our solar system that they will be introduced to at later stages in their education.

The activities proposed in this book are arranged in three series. Particular importance is attached to the sequence of the activities, which is designed to support the construction of meaning. As noted in the introductory chapter, the accompanying educational videos contain three discrete episodes, which are to be played individually as part of specific activities, as outlined in each case.

The activities and the videos were designed in the light of three research findings:

A) Many children think that the earth and other heavenly bodies remain in space because something is holding them up there (e.g. Vosniadou & Brewer 1990). This led us to decide against using a globe in the first series of activities.

B) Many children are confused by the two simultaneous motions of the earth (around the sun and around its own axis).

C) Many children are confused by the notion that the sun moves (Valanides *et al* 2000).
These last two findings influenced the decision to introduce the two motions of the earth at different stages on the video and to keep the sun motionless (see also Kallery, 2011).

The approach adopted in the activities is that of the social construction of knowledge. The teacher plays an active role in guiding the children and introducing the new knowledge, and in creating a learning environment that helps kindle their interest (Duit & Treagust 2003, Fleer 1993, Pintrich *et al.*, 1993). The children have an opportunity to work in groups and to learn on the one hand from their continuous interaction with the teacher and on the other from their interaction with their classmates. The group and whole-class discussions are part of the learning experience in all the activities.

4.2 The structure of the series

Each of the three series of activities includes the following parts:

Aims: Outline of the learning objectives of each series of activities.

Activities: Detailed description of each part of each activity in the series (see below).

Assessment: Suggested ways of evaluating the learning outcomes. This applies to the second and third series only (the first series is introductory).

Related family activity: Suggestions for extending the activities to involve the family, so that the children can continue to explore the topic at home.

Note

It is important, if the aims are to be achieved, that the activities be carried out in the order they are given and that the video be shown only as indicated, for otherwise the children may become confused and gain false impressions.

4.3 The structure of the activities

Each of the activities in the book contains the following parts:

Investigation: Outline of the topic the activity is designed to explore.

Materials: List and description of materials needed for the specific activity.

Skills: List of scientific skills promoted by the investigation into the specific topic.

Sequence: Detailed description of the successive steps to be followed in implementing the activity, with the necessary instructions.

Sample guidance questions: Suggestions for questions that the teacher might use during the activity, if necessary, to guide the children or to focus their attention on some specific point.

Implementation – practices and actual classroom experience: Descriptions of the outcomes of the activities, the practices used, the children's response, anything that occurred during the activities, any problems that arose during the implementation of the activities and how they were handled. All this material comes from the analysis of the work group's tapes and notes, and is expected to be helpful to teachers using these activities, as a source of useful ideas and information.

Note

The duration of the activities is determined by the structure and the kind of activity, as well as the size of the group.

If the children take a lively interest in the activity, it can be extended beyond the usual 30-40 minutes. If the activity cannot be completed in one session, then it can be continued later the same day or even the next day, after a brief review.

4.4. The series of activities

4.4.1 Activities: Series A

The first series comprises three activities, the first to be carried out at school, the second at home and the third at school again.

➢ Aim of the activities in this series

The activities in this series are designed to acquaint the children, through action and discussion, with the form and shape of heavenly bodies in the immediate vicinity of the earth, and especially the sun and the moon.

Activity 1

Investigation

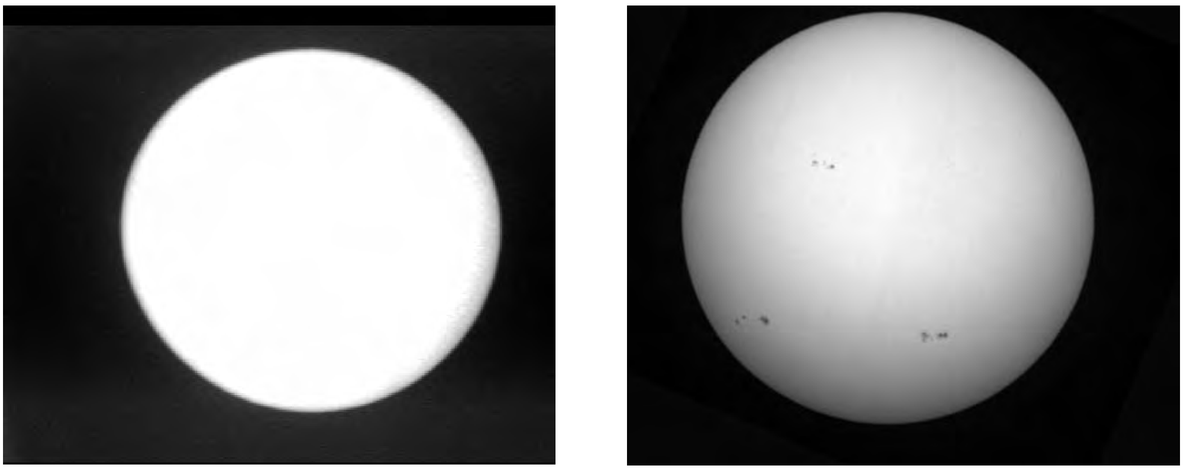
a) I observe the sky by day and take note of what I see
b) I observe the sun and describe it

Materials

Glasses with special filters for looking at the sun – the ones used to observe a solar eclipse. The sun is very bright, so to be able to look at it we must reduce its radiance. These special filter glasses absorb 99% of visible solar radiation, with the result that the ambient space looks dark and the sun appears roughly as shown in the photographs in Figure 1.1. The glasses must be handled with care so as not to damage the filters, must be kept in their original cases, and must be replaced if the filters become scratched.

Skills

Observation, comparison, communication.



(a) (b)

Figure 1.1 (a) and (b). Photographs of the sun in visible light

Sequence

- Choose a day when there are no clouds in the sky and a time when the sun is high enough to be observed easily.
- Gather the children into a circle and ask them: "What do you think we will see if we look at the sky today"? The purpose of this question is to get the children to mention the sun, as a starting-point for the discussion.
- Ask each child for his opinion, and have the whole group discuss any replies mentioning the sun (the children will probably name other things as well, e.g. birds, clouds, planes, etc.).
- Ask the children to describe how they think the sun is, and discuss its shape and colour with the group.
- Tell the children that you are all going to observe the sun. Show them the special glasses and explain how to handle them.
- Divide the children into small groups (2-3).
- Find a good observation point in the schoolyard. Have each group in turn look at the sun, under the teacher's supervision. Make sure the children **are wearing the special filter glasses**. Allow the children to look at the sun **for about 15 seconds at a time**. **If a child wants more time, he/she can be given another turn later on**.
- While the children are looking at the sun, ask them to observe and describe it. It will be helpful for the next stage of the activity if the teacher takes notes or records what the children say on tape.
- Take the children back to the classroom. Gather all the groups together. Have one child from each group present that group's observations. If necessary, the other members of the group can add their own comments.
- Write down what each group says, and afterwards have the children compare the results of each group's observations and identify any differences. If there is any disagreement, talk about it with the whole group to see where it comes from. It is very important to know whether any children see things differently, or interpret what they see differently, and so on.
- Ask the children to draw a picture of what they saw, and then to describe or explain their picture to the group.
- Compare the children's drawings, and also look at them in relation to the sun itself (the teacher should also have observed the sun with the filter glasses, so as to have an objective view). Dwell

particularly on their descriptions of the sun and its shape, laying especial weight on its spherical shape.

- If the discussion is broadened to include other bodies as well, e.g. the moon and the earth, then the term 'heavenly bodies' can be introduced and applied to all of them, the sun included.

Implementation – actual classroom practice and experience

The introductory discussion

In the introductory discussion the children called on existing knowledge and expressed interesting views. They mentioned the existence in the sky of two heavenly bodies in particular, the sun and the moon. In two kindergartens the children used the word 'space' instead of 'sky': *The sun and the moon are in space,* they said. Their teachers made use of the opportunity thus provided to introduce a group discussion of the new term 'space' and the children's opinions about it, asking the children to say what they think space is. *It is where the earth and the moon are,* several children replied. Others said: *It is the place where there are lots of planets, planets like the earth. Space has no air, you can't breathe there.* One child said that *space has planets, the stars and the moon.* In order to clarify his contribution, and to launch a new discussion with the group, the teacher asked him whether he meant that the stars and the moon are planets. *No,* he answered, *the moon is different, the planets are far, far away. We can't see them. The astronauts go there with spaceships. The moon we can see.* Another view expressed by the children was that space *is something like the sky.* The teachers discussed the children's opinions with the group, and added some new information, introducing a new term: *In space,* they said, *there are indeed planets and other bodies as well. We call them all 'heavenly bodies'.* In one kindergarten a little girl asked her teacher why they are called 'heavenly bodies' and whether they were anything like the geometrical bodies they had been working with recently in other activities. The teacher used the opportunity to bring in concepts that had formed the basis for other activities, and answered that yes, they were the same kind of thing, and that like geometrical bodies they too had volume and took up space.

After the group discussion the teachers asked the children if they would like to observe the sky, telling them *the great news*, as one teacher put it: they would be observing the sun through special glasses that would let them look at it without being dazzled, so that they could see what it really looks like. They all reacted to this announcement with gleeful enthusiasm. As one teacher wrote: *They displayed tremendous enthusiasm. They felt there was something magical about what we were going to do.*

The observation

Small groups of children observed the sun under the supervision and guidance of their teacher. Their reaction to the real aspect of the sun was one of surprise and shock, both at its size and at its form and colour. Several children were unwilling to believe that what they saw was really the sun, since it was so very different from the image they had in their minds. That sparked many questions (C: child):

C1. *Wow...what's that, then... is it really the sun... I can see something white and very small... Can I put them* [the glasses] *on again for a bit to see if it is really the sun..?*

C2. *It is white and like... no, yellow... what... but it's great, fantastic.*

C3. *I saw the sun but it was just a dot. Why is that? The sun is much bigger than the earth.*

C4. *The sun is pure white and very beautiful. Where did the yellow go, miss?*

Many children, seeing the circumference and the colour of the sun so clearly, began to talk about the moon, but when they took the glasses off they realised that what they had been looking at was the sun. Some of them also mentioned that the sun they saw had no rays.

C1. *It has to be the sun but it looks like the moon. It's a circle.*

C2. *I am seeing the sun with the magic glasses, it doesn't have rays and it looks like the moon.*

C3. *I saw the sun, which looked like the moon. It is round and white, the sun. My, my, it's great.*

Some children described the colour of the sun as being like light. *It is not white,* they said, *it is like light.* Another thing that made a

strong impression on them was the fact that what surrounded the sun - space – was not blue but very dark, almost black.
C1. *I can see the sun and around it is darkness.*
C2. *…the sky is black…*

To describe the shape of the sun most children used the words *round* and *circle.* Few children used the term *sphere.*
C. *It is a sphere, small and white….*

The teachers wrote down the children's reactions and also their questions, which served as a basis for interesting discussions in the next part of the activity.

(b)

(a)

Figures 1.2 (a) and (b). The children observe the sun wearing glasses with special filters (eclipse observation filters)

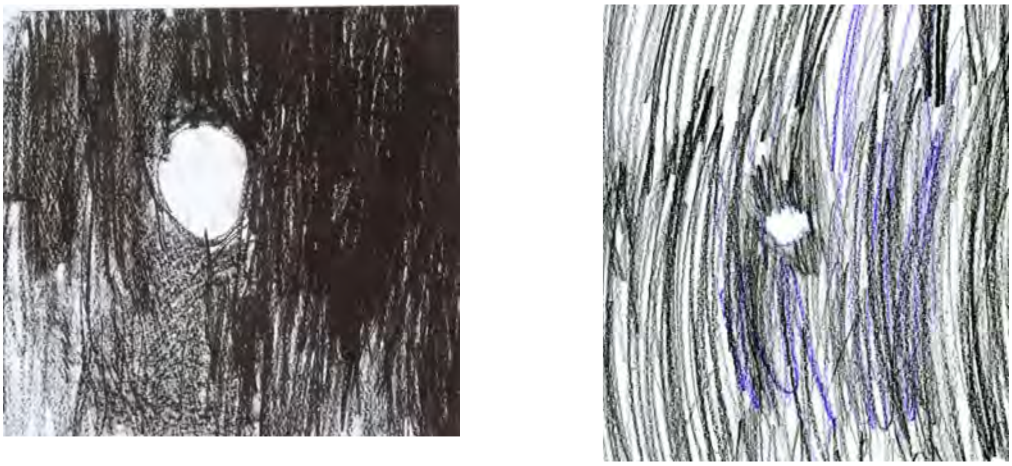
Back in the classroom

Once all the children had returned to the classroom they began to discuss what they had seen. The groups agreed that the sun was *round*. The children who used the term 'sphere' corrected their classmates: *You're saying it wrong,* they told them. *It's a sphere.* One teacher reported that the children described the sun as *like a ball*. In most kindergartens the teachers used this discussion to clarify the difference between the terms 'round/circle' and 'sphere'. Using the children's own expressions as a starting-point, the teachers discussed the difference between a circle (plane figure) and a sphere (three-dimensional geometric body), showing the children a circle, a sphere or a ball. In this way they introduced the concept of 'sphericity' and the word 'spherical' to describe the shape of the sun. This discussion served as a particularly constructive introduction to the following activity, focusing on the sphericity of the earth.

In general, the teachers reported that the post-observation discussion also helped the children understand *why the sun looks like the moon through the glasses*, why *its colour looks different through the glasses*, and *why it looks so small from the earth.* In general the discussions helped them link their observations and their prior knowledge and resolve the perplexities that arose from what they observed.

Drawing

After the discussion it was time to draw. The teachers asked the children to depict the sun as they saw it with the filters and to compare their drawings. Most children drew a round white sun against a background of grey or black. Some of them did not want to give up their usual way of depicting the sun, even though they admitted that it wasn't really like that, and drew it with a fringe of yellow rays or with eyes and a smiling mouth. When asked about their pictures they said: *I know that is not how it is but I drew it that way because I wanted to.* The other children agreed that the sun they saw did not have eyes or a smile. One little girl, in fact, as her mother told the teacher the following day, went up to the refrigerator when she got home and pointed to a fridge magnet with a picture of a smiling sun on it and said: *You know, Mummy, the* *sun isn't really like that. I saw it. I put on the glasses and I saw it. I'll draw you a new picture that shows it the way it really is.* One of the teachers had the children who drew the sun differently from the way they described what they had seen repeat the observation and draw it again on another day.



(a) **(b)**

Figures 1.3 (a) and (b). The children drew the sun and the area around it as it appeared when they were wearing the 'magic' glasses.

Another teacher gave each child a sheet of white A4 paper with a line dividing it in two and asked the class to draw the sun as they see it with their bare eyes in one part and as they saw it with the filter glasses in the other (Figure 1. 4). This task was intended to get the children to compare the two and identify the differences between them.

(a) **(b)**

Figure 1.4 (a) and (b). Pictures of the sun as it appears when observed without, and with, filter glasses.

Activity 2

This activity is one of those designed to be implemented by the child **with his/her family**.

Investigation

I observe the sky at night and take note of what I see.

Materials

Paper and pencil to record the observations and, if available, a pair of ordinary binoculars or a small telescope (this is not essential).

Skills

Observation, communication.

Note

Special filters are not used for night observations.

Sequence

- Choose a cloudless night. One or more family members observe the sky with the child. It would be helpful if an adult wrote down the child's comments while he/she is observing the sky.
- Ideally, the observation should be repeated on more than one night.
- The observation must be done when the moon is up. Carrying out the observation over more than one night allows the children to observe and record the differences in the moon's shape.
- Weather permitting, it would be useful to repeat the observation on the night of the full moon, when it appears perfectly spherical, or a night before or after the full moon, when the difference in shape is minimal. This is particularly helpful for the classroom discussion of the shape of this heavenly body, which will come later.
- If available, ordinary binoculars or a small telescope can be used for better observation.
- It would be very constructive to have the children draw what they see and bring their drawing(s) to school for the next part of the project.

Activity 3

Concluding the series

The children tell the class what they saw in their nighttime observations and discuss everything they observed in the sky.

Skills

Comparison, communication.

Sequence

Once all the children have completed their nighttime observations, the project continues at school.

- Ask the children to bring the results of their observations and their drawings(s) to school.
- Gather the children into a circle and ask them in turn to present the results of their observations, showing the class their drawings or whatever other recorded observations they have made.
- Ask the children to compare their findings and to point out the similarities and differences. This will allow them to see and discuss additional things that their classmates may have observed and recorded or things that the others may have recorded in a different way (their recorded observations, whether in drawings or some other form, may often reflect subjective interpretations).
- Discuss the findings of their daytime and nighttime observations of heavenly bodies with the whole group, focusing primarily on the sun and the moon and concentrating on **their spherical shape**.
- Ask the children to describe the shape of the two heavenly bodies again, and discuss it in terms of their observations.

Note

What do we do if the children ask why the moon does not always have the same shape in the sky, or why we see it with different shapes? The scientific answer to this question is probably too hard for young children to understand. It may be possible to divert this question – and thus avoid giving a direct answer – by turning it into a topic for investigation, using an illustration of the phases of the moon like the one given in Figure 5 of the "A few words about astronomy" section: e.g. "let's see how the moon changes shape". If the children persist, however, then the teacher could use the illustration of the phases of the moon to explain that: "You know that the side of the moon that is facing the sun is always bright. As the moon moves around the earth, changing position, we see a different piece of the moon's lighted surface each day, sometimes a smaller piece and sometimes a larger one".

Implementation – actual classroom practice and experience

Nighttime observation

The parents who showed interest not only helped their children carry out the activity but some of them also purchased optical instruments for the purposes of the project. *T,* wrote one teacher, *reported that they had looked at the night sky and that his mother bought a telescope so they could see better.* Some of the parents who joined their child in this activity were filled with enthusiasm. One mother, for example, thanked her child's teacher and added that: *You showed me a way to look at things that I had forgotten. We had a lovely time.*

The children who observed the night sky talked about their observations with the group and showed their drawings to the other children. They reported seeing *the stars which are very far away* and the moon in different phases. They described the shape of the moon, which some of them had seen full or nearly full and others at less than a quarter full:

C. *I saw the moon and it was round and white.*

C. *The moon was white and big in the sky. It was like a ball.*

C. *I saw it* [the moon], *it was shaped like this* [showing with his hands], *like a banana.*

Some children observed the sky on successive days, and described the moon initially as *like a big, round moon that gets a little smaller every day.* One child produced an interesting drawing (Figure 5) showing the moon in successive phases, from crescent to full. The child told the class about his observations: *When the sun sets, night comes. When we look at the sky at night we see the moon. At the beginning it is very small and looks like a slice of watermelon. When it is small we also see many stars. As the nights go by the moon gets bigger and fills up until it becomes round. Then that is the full moon. Afterwards the moon gets smaller for some nights and we only see stars in the sky. Some brighter and some not so bright.*

1st night

2nd night

3rd night

Figure 1.5. Three successive (not consecutive) observations of the moon. The child used a silver-coloured crayon for these drawings.

Some other children brought a kind of log of their observations, which they had dictated to their parents. Here are some extracts from one such log:
Tonight the moon was very bright, it was a half moon. There were stars beside it, small ones and big ones. The sky was dark blue. Clouds passed in front of it, and they looked like smoke.

The moon today is very small. But I can see a big bright star, and a small one like a beetle and a small one like a fly and many more.

In one of the kindergartens a little girl knew, and told the class, that when you look at the moon and you see it perfectly round that you are seeing the illuminated half while the other half is dark.

The children who had no support from home and thus had not observed the night sky took part in the discussion, offering experiences from prior personal observation. Their descriptions were similar to those of the other children: *I didn't look now but I have seen the sky at night, I've seen the stars and the moon that is not always the same*. They also joined in the discussion with their classmates who had observed the night sky, sharing their views and experiences and drawing the night sky at school.
In the course of the discussion some children mentioned the colour of the sky: *The sky changes colour as it gets later. After the afternoon comes the night,* one child said. An observation like that could be used by the teacher to introduce the next activity, which has to do with the day/night cycle.

The children asked their teachers many questions:
C. *I want to go up there. How do you get up there?*
C. *Why does night happen?*
Many children responded to that last question with answers typical for their age group:
C. *So the wild beasts can come out*
C. *So we can sleep better*
C. *Because God wants it that way*
Views like these can also be used to introduce the activity dealing with the alternation of day and night.

Relatively few children asked why the moon changes shape: *Why is the moon sometimes like this and sometimes different?* When this question was asked, the teachers let the children express their views but tried to steer the discussion in a different direction so as to avoid having to give the relatively difficult answer. In one kindergarten, the teacher reported, some children used the word *eclipse* in their answers. Another teacher recorded the following very interesting notion, expressed by one child in her class: *The moon has moving pieces. Every day it finds one and so it becomes whole.*

(a) **(b)**

Figure 1.6 (a) and (b). Depictions of the sky from nighttime observations: The moon at less than one quarter and full.

Reviewing the children's observations

After all the children had reported on their observation of the night sky, the teachers asked the class for a global description of what they had observed in the sky by day and by night. The children readily described what they had seen: *In the daytime the sun and at night the moon and the stars. Sometimes we see the moon in the daytime, too, only it doesn't show up very well.*

One teacher, who talked with the children individually, received some interesting answers, often using scientific terminology:

T. *Do you know what the sun is?*
C1. *A* h*eavenly body.*
T. *What did it look like when you saw it without the glasses?*
C1. *It was yellow, and very bright*
T. *When you wore the glasses?*
C1. *Then it was like a very small ball, white or a bit bluish.*
T. *What do you think, is the sun really that small?*
C1. *Actually, it is a very, very big ball of fire.*

Talking with another child:

T. *Do you remember what we saw in the sky in the daytime?*
C2. *The sun.*
T. *Do you know what the sun is?*
C2. *It's a thing that gives light.*
T. *Do we call it a thing…?*
C2. *The sun is a heavenly body. It warms us.*
T. *How did you see it with your bare eyes?*
C2. *Big and bright, like fire.*
T. *With the glasses?*
C2. *Like a little pebble, round and white. I was surprised. Actually it must be big and yellow, like this* (indicates with his hands).

After this, the teachers asked the children to compare the shape of the two heavenly bodies, the sun and the moon. In general the children had no trouble describing them and comparing their shape:
C. *Both of them are spheres*
C. *I told my mummy that even when we see the moon looking like a slice or half a circle, it really is a sphere too.*
This report from one teacher is typical: *They were unanimous in saying that the shapes were the same and that these bodies were spheres.*
In one of the kindergartens, a child, during this review stage, pointed out that the bodies we see in the sky at night are there during the day as well. Some children, however, expressed the opinion that we do not see these bodies in the daytime because they are asleep. The other children tried to refute these anthropomorphic interpretations with 'scientific explanations': *They are there*, they told their classmates, *but we can't see them because their light doesn't show in the daytime. It only shows at night.*

4.4.2. Activities: Series B

Series B also comprises 3 activities.

➢ Aim of the activities in this series

The activities in the second series are designed to acquaint the children with the shape and the motions of the earth, and also with the shape and the motion of the other heavenly bodies in our solar system.

Activity 1

Investigation

Our Earth is a sphere.

Materials

Photographs of the earth as it appears from space
Photographs of the moon at the full

Skills

Observation, comparison, communication.

Sequence

- This phase could begin with artwork on the topic: "the shape of the earth". Have the children draw pictures of the earth, showing the shape they think it has.
- Group the children's drawings according to the shape they have given the earth.
- Gather the children into a circle.

- Ask the children to say why they think the earth has this shape.
- Listen to and record their answers, and have the group discuss the different kinds of shapes.
- Show the children photographs of the earth like the one in Figure 2.1., and explain that these are photographs that astronauts have taken from space.

Figure 2.1. The Earth as it appears from space (part of the surface of the moon can also be seen)

Figure 2.2. The full moon

- Discuss the photograph of the earth with the children and compare its spherical shape with the shape of the full moon (photograph Figure 2.2) and the shape of the sun, which the children have already observed and discussed in earlier activities (photographs, Figure 1.1).
- Discuss with the children the fact that the earth we live on and that appears to us to be flat is the same earth that the astronauts see as a sphere when they are far away from it in space. This discussion will be a useful background for what the children will observe at the beginning of the first video that will be shown during the next activity.

> ***Note***
> *Photographs of the earth, the full moon and the sun like those used in this book can be found in books on the subject and on the Internet.*

Implementation – actual classroom practice and experience

Our Earth is a sphere: drawing and discussion

The first activity in this series began with the children drawing the shape of the earth. In five of the six kindergartens, some children drew the Earth as a sphere and others drew it flat, as illustrated in Figures 2.5 and 2.6 .

Figure 2.5. The spherical earth

Figure 2.6 The flat earth

Some of the children drew one flat and one spherical earth on the same sheet of paper, as in the example in Figure 2.7.

Figure 2.7. The dual earth. One is flat and the other is spherical.

Other children drew the earth hollow, as in the examples in Figures 2.8, 2.9 and 2.10. In Figures 2.9 and 2.10 the sun and the sky are depicted inside the earth, as the children explained.

Figure 2.8. The hollow earth in space surrounded by other heavenly bodies

Figure 2.9. The hollow earth. The sun is inside it.

Figure 2.10. The hollow earth. The sky and the sun are inside it.

The last kind of depiction combines two of the previous ideas: the dual earth and the hollow earth. Figure 2.11 is an example of this category.

Figure 2.11. The dual earth. One is flat and the other spherical. The people and the houses are inside the Earth.

The children showed and explained their drawings, and in the ensuing group discussion the teachers began by asking the children who drew the earth flat to explain why they had drawn it that way: *Some of you drew the earth flat – how do you know that that is how it really is?* Some typical answers were:
Because that's the way it is, just look out in the yard! and, *Here where I am walking it is level, and out in the yard it is level too.* One particularly interesting answer was given by a little girl of about five: *I can't see the whole earth,* she said*, but here where I am standing it is flat.*

Then the teachers asked the children who thought that the earth is spherical and drew it that way, how they knew this. Some answered that they had talked about it with an older person (e.g. a parent), some that they had read books about it at home with parents and friends, and some that they had seen it in books in the school library. Some children had also seen a globe or, as one little girl put it: *I saw a fake one* (meaning a globe) *and it was a ball.*

The children who drew the earth with two different shapes in the same picture (e.g. Figure 2.7) said that they think that there is *one flat and one spherical earth. We live on the flat one.* When the teacher asked the child who drew the picture reproduced as Figure 2.7 why the tree was outside the round earth, she was told that: *It is on another earth.*
The children who drew the earth hollow said that *the earth is round inside there are houses trees flowers and people.*

In the only school where 17 out of the 18 children drew the earth as a sphere, the teacher attributed this high proportion to the fact that *the children had had previous experience of the shape of the earth from an environmental education programme focusing on water, during which they observed the ratio of water to land on the planet*. In that kindergarten the whole group discussed the single different drawing, which showed the earth as flat. The child who drew the picture justified his work, saying that: *I drew it that way because that is how I see it when I walk outside*.

If we compare the set of non-scientific notions of the earth's shape expressed by these children with those recorded in the literature (see the "children's ideas"), **we see that most of these coincide.**

There was sometimes interaction between two or more children in the discussions that took place after the children had shown and explained their drawings:
C1. *It is round like a ball*
C2. *Don't be silly, does it look like the earth is round, that it is shaped like a ball?*
C3. *No, of course not, but it is*.

The teachers showed the children the photograph of the earth as it appears from space (photograph, Figure 2.1), and explained that this was how they would see it if they could look at it from far away, as the astronauts had done from space. They also showed them the photograph of the full moon. In the ensuing discussion the children compared the heavenly bodies:
C1. *Our earth is round*
C2. *The moon is round. And it has some things that look like holes.*

C3. *The sun is round, like the moon.* (You may recall that when the children were observing the sun they had commented that: *it is the sun that I am seeing, but it looks like the moon*).

The group discussion closed with a word from the teachers: *We are very small and the earth is very big. We stand on it, and therefore we cannot see all of it, as we would be able to if we were in space, very far away from it. We can see only a small part of it. That is why we think, why it seems to us, that it is flat.*

In some kindergartens, after the end of the group discussion some children took the photograph of the earth and continued to discuss it among themselves.

Activity 2

Investigation

Our earth turns around itself and around the sun. The other planets also turn around the sun with the earth.

Materials

The educational video,
Photographs of planets

Skills

Observation, comparison, communication.

Sequence

- The activity begins with a discussion-review of the sphericity of the heavenly bodies, and continues with a discussion of the motions of the earth.
- Introduce the new knowledge in the form of a question: "Do you know that our earth moves through space?" Listen to the children's views and discuss them.
- Continue the activity by screening the first video episode, after giving the following introduction: **"Now, let's follow a group of astronauts on their journey and see what you would see if you could travel with them in space".** In this episode, a trip into space gives the children a chance to observe the apparent change in the

shape of the earth from flat to spherical, as well as the motion of the earth around itself and around the sun. They will also see the other heavenly bodies in our solar system and observe their spherical shape and their motion around the sun.

- In this episode, it is important to draw the children's attention to the fact that:
  a) The shape of the earth "changes" both as the spaceship gets farther away from its surface and as it approaches it.
  b) The earth can be seen to be spherical when the spaceship is in space.
  c) The earth moves around itself and around the sun
  d) All the planets, including the earth, perform the same motion.
- The episode can be replayed if necessary, freezing the picture at any point where further discussion seems to be necessary.
- After the end of the film, ask the children to describe what they observed (a) about the shape of the earth and the other heavenly bodies, (b) about the motions of the earth, and (c) about the motion of the other heavenly bodies. Use appropriate questions to focus the discussion on the shape of the sun and earth and the motions of the earth. Observation and discussion of the fact that "the earth is round and **revolves around the sun, not the sun around the earth**" will be particularly helpful for the subsequent discussion of the phenomenon of the alternation of day and night, since many children, and particularly the younger ones, think that it is the sun that goes around the earth and lights up different parts of it in succession. Discuss this with the children again, since after seeing the film they may have lots of questions.

Notes

1) The teacher must bear in mind that the heavenly bodies do not move with the speeds shown in the video, since that is not the subject of the film. If the children wonder or ask questions about this, it would be a good idea for the teacher to explain that in the film these motions have been speeded up so that we can see them, and then discuss the real length of these cycles with the children (i.e. the revolution of the earth around the sun takes one year, and the rotation of the earth about its own axis 24 hours).

2) If the children have questions about the relative size of the heavenly bodies they see in the film, the teacher could use an illustration like the one given as Figure 2.3, which shows part of the surface of the sun and the planets nearest to it, to demonstrate their real relative sizes.

3) If the children express an interest in the other planets during the discussion, this could be built on using photographs. Examples of suitable photographs for introducing the children to the other planets are given in Figure 2.4 (you can also find photographs of the other planets in books on the subject and on the Internet). This could lead to a discussion of their shape, and comparisons with the shape of the earth and the other heavenly bodies in our solar system that they already know about and, finally, to a discussion of the motion of the planets. Let them watch the first video episode again, to observe this motion.

Sample guidance questions

- What did our astronauts see in space?
- How did the astronauts see our earth when their spaceship took them very very high up?
- What did the shape of the earth look like?
- How does the earth appear to us who are on it and how does it look to people in space?
- Which of the heavenly bodies do you think move around the sun?
- Which do you think turns around which, our earth around the sun or the sun around our earth?
- Which heavenly body do you think moves around our earth?

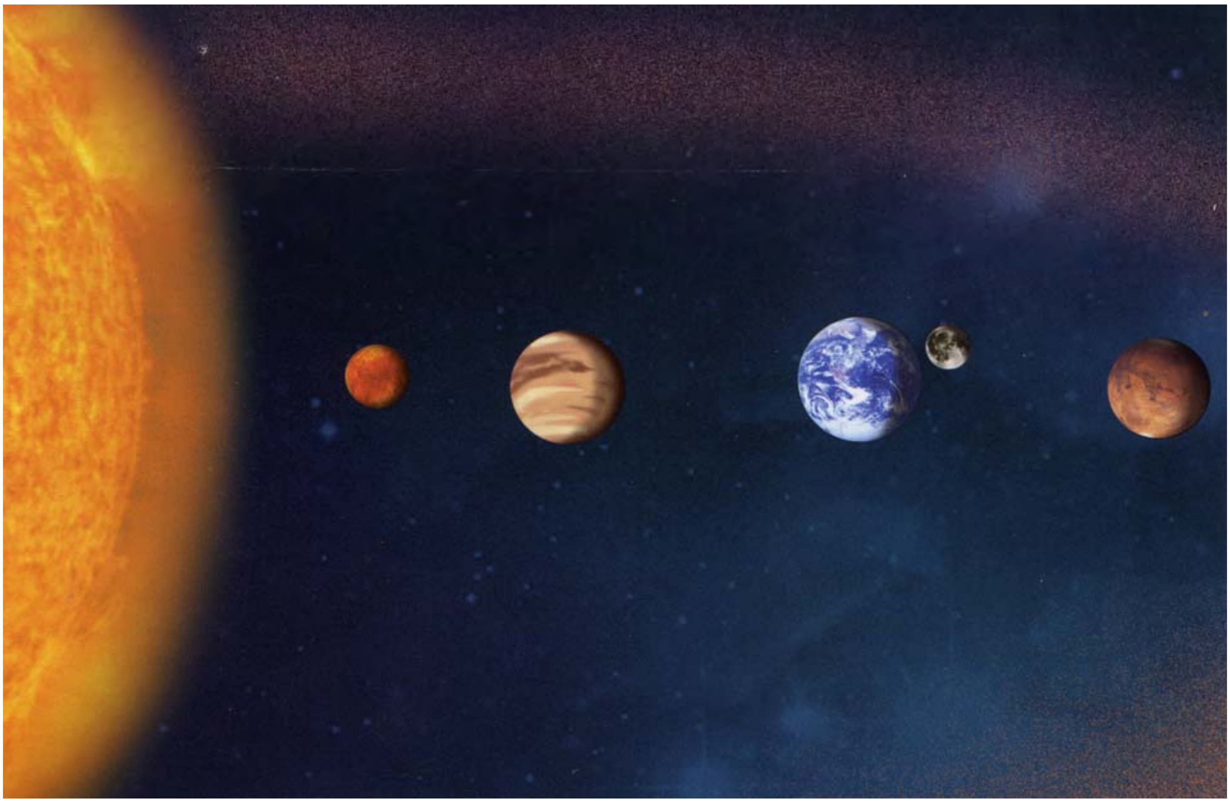


Figure 2.3 Relative sizes of the sun and the planets

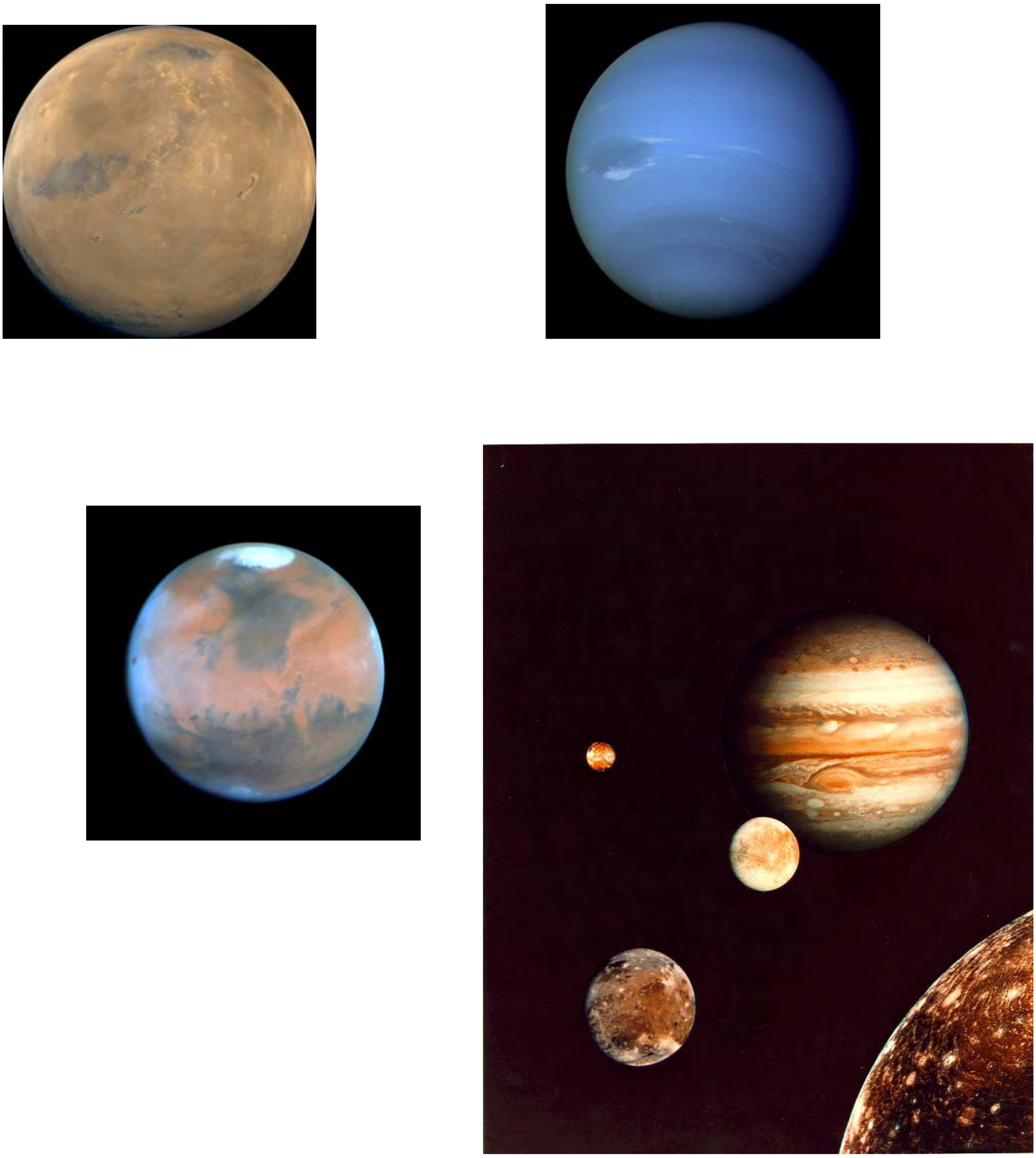


Figure 2.4. The planets Venus, Neptune, Mercury and Jupiter with its moons

Implementation – actual classroom practice and experience

The first video: the children's reactions and the discussion

After discussing the shape of the heavenly bodies and the children's ideas about their motions, the teachers told the children they were going to show them a short film: *Let's watch a group of astronauts preparing to travel into space. We will follow them on their journey and see what you would see if you could travel with them in space.*

The children loved the film. Their teachers could tell, however, right from the beginning, that they didn't have a very clear idea of what was going on. This was confirmed by their descriptions of the episode afterwards. So the teachers showed it again, and the second time round some of the teachers paused the film wherever they thought this necessary to allow the children to observe it more carefully, and also used this pause for commentary and discussion. The results of this second screening, and the children's comments during this replay, were striking. The children watched, talked about what they were seeing, and described the apparent changes in the shape of the earth:

C1. *Look, it's getting smaller and smaller*

C2. *It's going wa-a-a-ay up in the sky.*

C3. *Not in the sky, it's going into space, it's leaving the earth.*

C4. *Look, look, it's got round.*

C5. *There it is, there it is, it's round now.*

C6. *Yes, it was flat and then it became round.*

C7. *And now that it* [the spaceship] *is getting close it's becoming flat again.*

C8. *I can see it too.*

C9. *Me too.*

The children also pointed out how the earth moves:

C1. *Ah! That's how the earth turns!*

C2. *Yes, that's how it turns!*

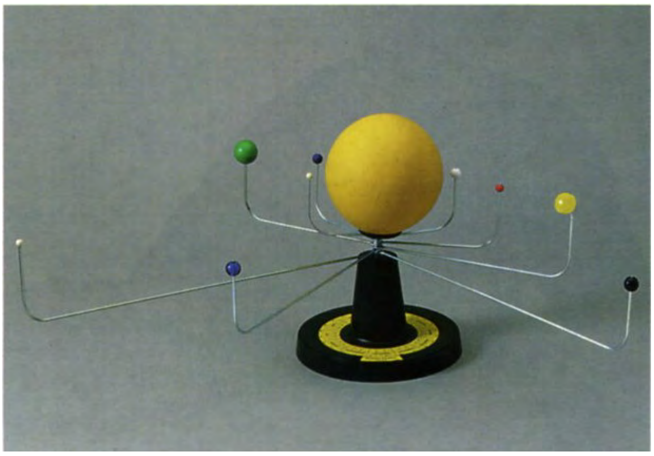
Several children paid attention to the motion of the moon, as well, saying things like *and the moon turns around our earth.* Some even used the expression: *is a satellite [of the earth].*

One child used a very interesting and noteworthy form of words in relation to the existence of other planets, saying that: *there are other planets-other earths*. This reflects the perception of specific similarities between the characteristics of the earth and those of the other planets in our solar system (including their motion), and putting them all in the same category of heavenly bodies.

One very important observation the children made is that there is nothing supporting the Earth or the other heavenly bodies.

C1. *It turns and it's not resting on anything.*
C2. *It's flying, it's resting on the air.*

This, you will remember, was one of our aims. As we mentioned when describing how the activities were designed, studies have shown that many children think that the Earth and other heavenly bodies stay in space because something is holding them up. This finding influenced our decision **not to use** models of the earth in which the earth is supported, e.g. a globe or illustrations like those in Figure 2.12, in the first series of activities. Also, models like the one in Figure 2.12 (b) **can create confusion** regarding the relative sizes of the earth, the sun and the moon (Sadler, 1987, as cited in Driver *et al.* 2000). We recommend, therefore, that **this type of model not be used** until the children have learned some basic realities about space. Such models can be used at more advanced stages of their study of our solar system, and once the children have understood the concept of a model or simulation.



(a)

(b)

Figure 2.12 (a) and (b). Models of our solar system and the sun-earth-moon system. If it is necessary to use such models, this is best left for a more advanced stage of their study of the solar system, once the children have acquired specific knowledge.

In some schools the children expressed their discovery that the earth is unsupported in the form of a question: *You mean, our earth is up in the air, it's not resting on anything*? For some children this question appeared to conceal a fear. One teacher, for example, noted that: *In one child, I could discern fear and insecurity in her eyes when she realised that our earth is in the air.* In such cases the teacher would be wise to talk about the subject with the whole group, to reassure the children and restore their sense of security. She could, for example, explain that the earth does not need to be supported, nor do any of the other heavenly bodies they saw in the video or observed in the sky (the sun and the moon). She can also explain that as the heavenly bodies turn around one another they hold each other up, and that in any case this is the way it has always been, and that our earth has been there, moving around the sun with all the other planets without resting on anything, for many many years.

After watching the film, the children had a great many questions for their teachers. They asked, for example, whether the earth is bigger than the sun. The teachers to whom this question was put explained that the sun looks smaller because it is very far away, and showed the children diagrams of the relative sizes of the planets and the sun, like the one in Figure 2.3. Other questions included:

- *How many planets are there and what are their names?*
- *What are falling stars?* [meaning meteorites]
- *What is there on the other planets?*
- *What is there on the sun?*

Teachers can answer these sorts of questions using knowledge and information from previous sections of the book.

Also, once the children had absorbed the fact that the earth turns around itself, they asked: *You mean, we're spinning around now? Why don't we get dizzy*?

To avoid giving a direct answer to this question, which the children might not be able to understand, teachers can convert it into a topic for investigation, suggesting for example that the class try to see what it is that makes us feel dizzier or not so dizzy when we whirl around. To acquire a better sense of the factors that can affect this sensation, the children can try it out for themselves, twirling around at different speeds. The whole group can then discuss their experiences.

After answering the children's questions, the teachers asked some of their own, to find out how many of the video's objectives had been achieved. The overwhelming majority of the children had a perfectly clear perception of the shape of the earth:

C1. *The earth appears round from space.*

C2. *The earth is round, like a ball. But it is flat here, where we are standing on it (stamping his feet on the floor).*

C3. *Now we know what the earth is really like. It is round, but to us it looks flat.*

In most cases, too, the children were clear about the fact that the earth moves around the sun.

Before the activity ended the children, who were thrilled by the first episode of the film (*fascinated,* as the teachers put it), demanded to be shown the astronauts' journey again. The discussion continued after this third screening. One teacher reported that: *They displayed enormous interest. If I had let them, they would have gone on talking about it for hours.* In some kindergartens, after it was over the children wanted to play. *So*, one teacher wrote*, we assigned roles. Thomas was the sun and*

Eugenia the earth and she twirled around while turning around Thomas-the-sun.
They did this to music. When the music stopped, so did the children. Several pairs of children asked to play, and did so.
The next day Andreas brought a DVD about the planets to school and asked me to play it. So the children watched, and they heard some more things about space and the other planets, adding to their knowledge. They showed great interest in the subject and continued to talk to one another about it.

Activity 3

Completing the series

The children are asked to graphically represent mainly the motion of the earth but also of any other heavenly bodies they wish. They may also combine drawing and collage.

Materials

Drawing materials.
Pictures of the earth, the moon, the sun and the planets that the children can cut out.

Skills

Communication.

Sequence

- Ask the children to draw the heavenly bodies they observed and to sketch their orbit (to show the motion they perform).
- Have the children show their work to the class, and explain their pictures. Use their drawings and explanations to discuss once again the identity of the bodies the children drew, their shape and their motion.

Implementation – actual classroom practice and experience

Drawing

A day or so later the teachers asked the children to draw the shape of the earth and its motion in relation to the sun. This was an individual, not a group, activity. Each child then showed the class his/her picture and explained what they meant to show and why they drew it that way.

Most of the children drew a round earth.

(A) **(B)**

Figure 2.13 (A and B): The spherical earth. The children commented that picture (A) closely resembled the reality. The children dictated to their teachers and asked them to write on their pictures what the shapes they had drawn on the surface of the earth represented (land, sea, etc.).

The children also drew the positions of the heavenly bodies and their orbits. In most cases the earth and the other planets were shown moving around the sun, as in Figures 2.14, 2.15 and 2.16.

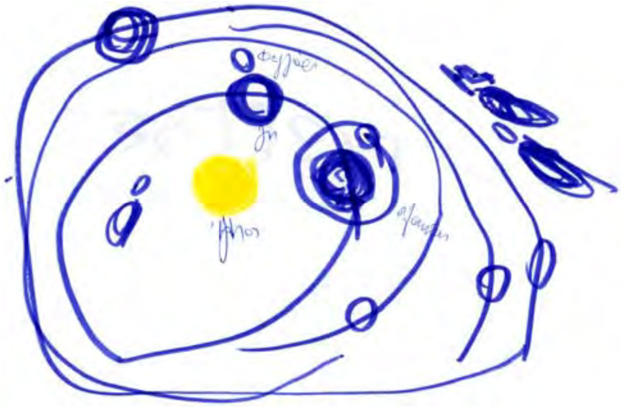


Figure 2.14. All the planets turn around the sun and the moon turns around the earth. The child pointed out each of the heavenly bodies to his teacher and she wrote their names on the picture.

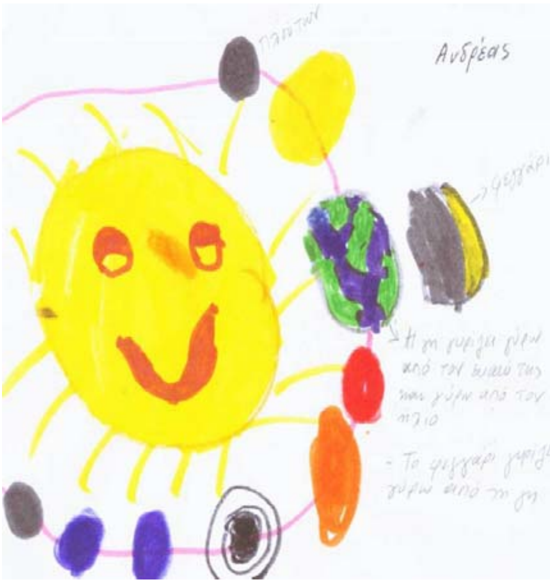


Figure 2.15. "I drew the sun in the middle and around it the earth and the other planets and the moon that turns around the earth".

The child who drew the picture reproduced as Figure 2.15 did not escape the criticism of the rest of the class, who pointed out that *the sun does not have eyes and a mouth*. He answered that, yes, he knew that, but simply liked to draw it that way.

Figure 2.16. "The earth turns around itself and around the sun. The moon turns around the earth".

Only a very few children drew the earth flat. One little girl's picture (Figure 2.17) is worth commenting on. She explained that, after drawing the sphere representing the earth, she tried to put other things on it, like houses and people, but there wasn't room, so she drew them on another part of the paper. This, she stated, did not mean to suggest the existence of a second, flat, earth.

Figure 2.17. The spherical earth and, beneath, a detail (magnified) of the life on it.

There were also a few cases (e.g. Figure 2.18) in which the child's drawing did not match his/her description of it. Given the child's explanation, which is recorded in the caption to the illustration, it is likely that the mauve line represents the earth's orbit around the sun wrongly drawn.

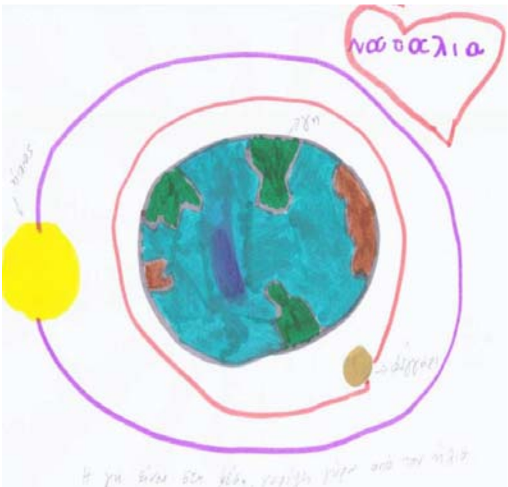


Figure 2.18. "The earth turns around the sun, the moon turns around the earth, the sun does not move". The drawing does not precisely correspond to the description.

General comments from the teachers

All the teachers recorded tremendous interest on the part of the children. *Although the activities were very long, they did not find them wearisome – on the contrary, they were extremely enthusiastic.* They also noted that some children who usually kept to themselves took an active part in these activities. *And it was quite remarkable*, said one teacher, *because H. is normally very introverted, but he spoke out spontaneously and joined in the activity, which is something he usually doesn't do. He went of his own accord to the map of the planetary system and pointed everything out correctly*. In some kindergartens *the younger ones (4-year-olds) were less forthcoming than the older children, but they paid attention and showed real interest.*

One of the outcomes of the successful completion of these activities was the emotional satisfaction experienced by the teachers, one of whom wrote that: *The satisfaction I saw in their* *eyes and the assuredness with which they answered my questions was a wonderfully satisfying experience for me.*

Assessment

The assessment part of this series concerns the learning outcomes of the first and second activities (the shape of the sun and the earth, the two motions of the earth - around itself and around the sun). Assessment should be done individually.
For the assessment you will need two colours of plasticine, yellow and blue.

- Give each child a stick of plasticine of each of the two colours and ask them to make "a sun and an earth".
- Ask them to say which of the two bodies is the sun and which is the earth.
- First ask each child **to say** which of the two heavenly bodies moves around the other and **then to point to it**. Then ask him/her **first to describe** and **then to show** how that body moves in relation to the other, illustrating his/her answer by moving the corresponding plasticine shape. This is a good way of finding out whether the children have understood what they are describing sufficiently well to be able to demonstrate it.
- Record their answers.

Note
Depending on the results of the assessment, the teacher may think it necessary to repeat some of the activities.

Results of the assessment

Each child was assessed individually, a full two weeks or more after the activities had been completed. The children used the yellow plasticine to represent the sun and the blue for the earth. Most of the children responded properly, making a spherical sun and a spherical earth. In just one of the kindergartens a few children (most of them four-year-olds) made a flat earth. In one kindergarten, too, some children made their (spherical) earth bigger than their (spherical) sun, e.g. the little girl in Figure 2.20. This may be partially due to the fact that in some scenes on the video the earth does look bigger than the sun, as the viewer approaches it. In that particular kindergarten the question of the relative sizes of the sun and the earth had never been raised, as it had in other kindergartens.

Most children described and demonstrated the motion of the earth around the sun perfectly correctly, rolling the blue plasticine ball around the yellow. One teacher noted that: *Even the ones who rarely spoke or took little part demonstrated the motion correctly and clearly stated that the earth performs two motions*. Most children also correctly demonstrated the earth's two motions, rolling the blue plasticine ball around the yellow while at the same time rotating it around its own axis (Figures 2.19 (a) and (b) and 2.20). They also used interesting expressions to describe this second motion: *The earth turns around itself like a ballerina*. It is interesting to note that in one kindergarten the children asked their teacher to give them some brown plasticine to make the moon, and tried to trace the movement of the moon around the earth at the same time as the motion of the earth around itself and around the sun. This shows a good perception of the motions of these three heavenly bodies.

(a)

(b)

Figure 2.19 (a) and (b). The children rolled the blue plasticine ball (earth) around the yellow (sun), while at the same time rotating it around itself.

Figure 2.20. This little girl made her earth spherical but bigger than the sun.

Related family activity

This activity can be continued and expanded on at home. The drawings the children made in school can serve as a basis for a discussion about the shapes and the motions of the heavenly bodies in our solar system, which in turn can spark a search for more information about our solar system.

4.4.3 Activities: Series C

There are 2 activities in this third series.

Aim of the activities in this series

The activities are designed to show the children which of the earth's motions is responsible for the phenomenon of the alternation of day and night and to let them investigate and become familiar with how this day/night cycle occurs at different places around the earth.

Activity 1

Investigation

The phenomenon of the alternation of day and night is due to the earth's rotation around itself (or around its axis).

Materials

Photographs showing one half of the earth illuminated.
The 2nd video episode provided.

Skills

Observation, comparison, communication, drawing conclusions.

Sequence

- Gather the children into a circle.

- Using appropriate questions get the children to describe the gradual change of the light intensity on the earth over the course of a twenty-four hour period.
- Ask the children to say what they think is the reason for this change.
- Discuss their views **extensively** with the whole group.
- Play the second video episode. In this episode the two motions of the earth are introduced gradually. First, we see the earth **rotating** around its own axis and then we see it **revolving** around the sun while it is **rotating** around its own axis. We see the sunlit side of the earth and the trace of its orbit around the sun.
- While the children are watching the film, draw their attention to two things: a) That **it is the earth that moves around the sun and not the sun around the earth** (this is something that the children have already seen and talked about with the first video episode) and b) that **as the earth rotates around itself the sun lights only on the side that is facing it.** Ask the children to observe, in addition, that **the side of the earth that is not facing the sun is dark**.
- After they have watched the film ask them to describe a) the motions the earth traces and b) what they observed about the illumination of the two sides of the earth depending on their position in relation to the sun.
- Ask the children to describe, or to show in any other way they like, the particular motion of the earth that makes the different parts of the planet have **day or night.**
- When all the children have described this motion, show them photographs like those in Figure 3.1.

Figure 3.1. Sunlight falling on half the earth and half the moon.

- Ask the children to describe what they observe in this Figure and to say why they think half the earth is dark – that is, why it is nighttime there – while the rest is illuminated.
- Ask the children to comment on all the views expressed. It might be useful to replay the relevant video episode while this discussion is going on. During this process the children will decide which of these views are correct, and will explain why.
- End the discussion by going back to their initial descriptions of the change in the strength of the light that falls on the earth over a twenty-four hour period, and have them interpret these in the light of their new knowledge about the rotation of the earth.

<u>*Note*</u>

If the children mention or wonder about the curving red lines representing the orbits of the earth and the moon in the 2nd video episode, explain that these lines do not exist in reality but have been drawn on the picture to illustrate exactly how these bodies move.

Sample guidance questions

- Which do you think turns around which, our earth around the sun or the sun around our earth?
- Have you noticed, on a sunny day, how the light changes from the morning when you wake up to the time when you go to bed?
- Why do you think that we have day and night on the earth?
- How do you think that day and night come about?

Implementation – actual classroom practice and experience

Before the activity

In some schools, before beginning the activity, the teachers gave the children a top to play with and observe how it spins around (see Figure 3.2). This was a useful preparation for the screening of the film, since in this video episode the motion of the earth around its axis resembles that of the spinning top.

The discussion

In all the schools the activity began with the children describing how the light changes over the course of a day. Some typical descriptions are given below:

- *Early in the morning there is just a little light, and later when it is noon it is very strong and later in the evening it grows darker again but it is not night yet and then the night comes and there is no light at all. Only if there is a moon is there a little light.*
- *In the morning the light is normal, at noon it is very strong and later, as it begins to get dark, it gets less and less until the nighttime when it is completely gone.*

Some children used different words to describe the strength of the light: *it is brighter, the light goes grey,* etc.

After the children had given their description, some teachers showed the group books about day and night with illustrations showing the gradual change in light. In some kindergartens books of this kind were placed in the library corner where the children could look at them themselves.

In one of the schools the teacher showed the children pictures of different times of day and asked them to say, judging by the light, whether it was dawn, morning, noon, evening or night.

Figure 3.2. The children played with the top and observed its motion

The children's views and questions

After this, the teachers asked the questions **"why does the light on our earth change the way it does?"** or **"why is it that we have day and night?".** The children's answers reflected different notions.
The first question elicited a variety of answers:
- I don't know.
- Because at first the sun is not very strong and later it gets stronger, but afterwards when the day is over it gets weaker again
- Because in the morning it doesn't have much light and later it has more and then before night comes it loses its light again, etc.
Another kind of answer made reference to the motion of the sun. The dialogue below is a typical example:
Child: *The sun moves across the sky.*
Teacher: *You mean it is the sun that moves?*

Child: *Yes, it rises slowly higher and higher and then it goes down again.*

This answer reflects the notion that it is the sun that moves in the sky and not the earth, which coincides with the corresponding alternative view mentioned in the literature.

The children's answers to the second question (why we have day and night) expressed two kinds of notions. These included various kinds of alternative views, several of them matching or are similar to those cited in the literature, e.g.:

- *So we can sleep.*
- *Because the sun loses its strength.*
- *Because the sun hides behind the mountains.*
- *Because the sun goes to another country, and not only to ours.*
- *Because the earth turns around the sun and where it shines on it there is day and where it doesn't shine on it there is night, etc.,*

as well as more scientific notions, e.g.:

- *The earth turns and day comes only on one side of it. On the other there is night.*
- *The earth turns and the sun does not shine on all of it.*
- *Because the planet turns and its dark side comes round.*

Showing the video

After the discussion, the teachers screened the second video episode. Bearing in mind the views that the children had expressed, the teachers made the observations suggested above and also, in order to focus the children's attention on the points they wanted to talk about, asked questions that elicited responses while they were watching the film, as in the examples below:

- *Look at the earth now, is there light everywhere?*
- *Only on the part that is facing the sun.*
- *And the side of the earth that is not facing the sun?*
- *It's dark.*

After the film

It was clear from the discussion and the descriptions that followed the video that most of the children had satisfactorily understood the motions of the earth and the phenomenon caused by its rotation.
Using the photograph in Figure 3.1 as a talking point, the children gave some interesting explanations.
- it is lighted because the sun hits it there..
- the sun doesn't see the dark part and so it is night there..
- yes, it is very beautiful the way it looks.. it is not always day on one side, it changes as the earth turns..
- there is light only there where the sun sees the earth, the other side has night..
- like the top, as it turns the light goes everywhere but in the order that the earth turns..
- if the sun doesn't see half the earth how can it be day there? it will be night..

In any cases where the children had misunderstood something or where they expressed differing views, the teachers played the video again, pausing for a few seconds at different points (e.g. as shown in Figure 3.3) to let the children observe them and compare them to the photograph. This helped the children gain a better notion of what led to the result shown in Figure 3.1 .

As expected, in several cases the children asked about the red lines that appear in this episode of the video. The teachers explained that these lines were not really there, but had merely been added to show the orbits of the earth and the moon. This explanation pleased the children, some of whom said things like: *Yes, it is very nice how they have shown it.*

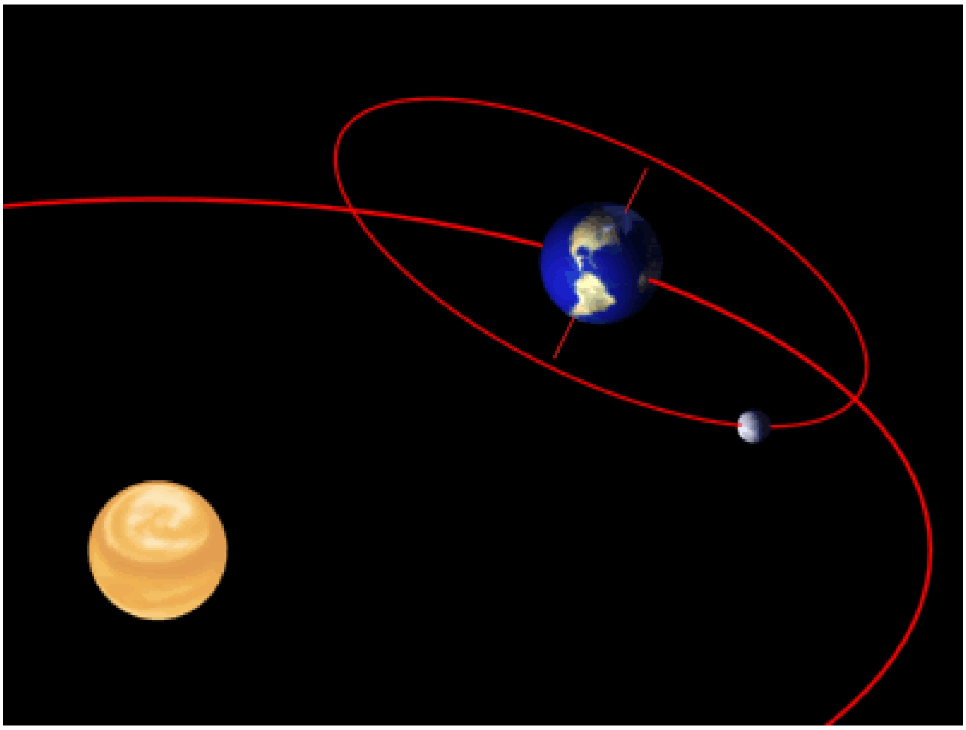


Figure 3.3. One phase of the motions presented in the second episode of the educational video

In some schools the children asked about the duration of the earth's rotation around its axis. Examples of the answers given, either by the teacher or by the children with her help, are: *One day and one night, a full day and night, 24 hours during which time we have both day and night.* One little girl asked the question: *Does the earth turn at the night and we don't know it?* Her teacher explained that *the earth never stops turning, it's just that it turns so slowly that we don't realise it.*

After the discussion some children wanted to act out the motions of the earth.

The activity ended with drawing. One particularly interesting depiction of the rotation of the earth is reproduced in Figure 3.4. This drawing shows the three heavenly bodies – sun, earth and moon – in proper proportion one to the other. The child explained to his teacher that the little arrows he had drawn around the Earth represent its rotation.

Figure 3.4. The rotation of the earth indicated by small arrows

Activity 2

Investigation

How night comes to a place where it is daytime.

Materials

One real and one artificial (wooden or plastic) apple (or other fruit) as shown in Figure 3.5; a globe; an ordinary-sized globular light bulb, screwed into a socket on a long flex that can be plugged into a wall outlet (or alternatively, a powerful flashlight).

Note

Given that in this activity the light source represents the sun, it is better to use a globular bulb that, because of its shape, will shed light in all directions.

Figure 3.5. Real apple and artificial apple.

Skills

Observation, comparison, communication, drawing conclusions.

Sequence

- Gather the children into a circle, and begin by introducing the concept of a model, using the real and the artificial apple.
- First, give the children the apples to hold and feel, so they can get a sense of each one.
- Explain that the plastic apple *represents* the real apple, that it is in other words a *model* of the apple.
- Once the apples have been passed around the circle, cut the real apple into slices and let each child eat one, to reinforce their sense of the difference between the real thing and a model.
- Then show them the globe. Explain that just as the wooden or plastic apple represented the real apple, i.e. was a *model* of a real apple, so the globe is a model of our earth, i.e. represents the planet on which we live.
- Discuss whatever reactions, ideas and questions the children may have.
- Then show the children the light bulb or flashlight, and explain that you will be using this to represent the sun: that is, that it will be the model of the sun for the purposes of the activity you're going to do. Point out that your model sun will not be the right size

in relation to your model earth, because there doesn't exist a light bulb big enough.

- Divide the children into groups. Give the globe and the "sun" to each group in turn (if you are using a light bulb, for safety's sake be sure that the group is closely supervised by the teacher).
- Ask the children to select a place on the surface of the globe, and say that it is daytime there. Have them show how night will come to that place (you may want to use something, perhaps a sticker, to mark the place they have selected).
- Have each group explain the process to the others.
- After all the groups have had a turn, let them comment on and talk about what each group showed them.
- Help the children draw conclusions.
- Then play the third video episode. In this episode, which shows how the surface of the earth is illuminated differently as the planet, rotating around its axis moves around the sun, the observer has the chance to see closely the totally dark side of the earth.
- To round off the activity, have the children draw pictures of the sun and the earth, shading the part of the earth that they think is in darkness and using bright colours for the part where it is daytime. Ask them, in addition, to trace the path – the orbit – of the earth.
- Finally, have the children show their work to the class, and conduct a general discussion.

In classrooms where a light bulb is used to represent the sun, the following supplementary phase can be used as an intermediary step before the class watches the third episode of the video:

- Suspend the light bulb above the floor at a height where it will be level with a globe held up by a child.
- Gather all the children into circle, and give one of the children the globe. Then ask the child:
  - A) First, to **make a circuit** around the "sun" while holding the globe still, i.e. **without rotating it**. The same part of the globe will thus always be facing the light and will be illuminated continuously.
  - B) Then, to stand still facing the "sun" and **rotate** the globe around its axis.

♦ Ask the children to say which of these two motions they think results in the creation of day and night in a given place on the earth (it is helpful to specify a place and mark it, perhaps with a sticker, on the surface of the globe).

Implementation – actual classroom practice and experience

The activity began with the teacher presenting the globe and the source of light (light bulb or flashlight) to the class and a discussion of what each one represented. In some kindergartens the children were already familiar with the globe, having previously used one in other activities, and knew that it represents the earth.

After this presentation of the model sun and earth, the children were divided in groups of two or three. The teachers set the problem "How night comes to a place where it is daytime" for investigation, and helped the children mark the place they selected on the globe.

In one kindergarten two groups of three children chose to mark Greece. At each stage of the motion of the globe around its axis the children said what time of day they thought it was in Greece when it was in a specific position in relation to the sun. The teacher reported that: *They managed to identify when it was afternoon, night, morning, noon.*

The children worked together very smoothly and with great interest. They also planned how they were going to present their work to the rest of the class.

The group presentations showed that the children had understood, at least at the model level, the process by which day and night succeed one another in a place on the earth's surface. The teachers reported that the children were delighted both with solving the problem and with presenting their findings to the class. One particularly successful presentation is given below: *The earth turns around itself like this (showing how), the part that is facing the sun is illuminated, and it is daytime there. As it turns (showing the motion), the part that is illuminated leaves and goes behind. It is not facing the sun and is not illuminated, it is night there.*

Afterwards (continuing to rotate the globe) it comes back opposite the sun and is illuminated again. That is, it is daytime again.

(a)

(b)

(c)

Figure 3.6 (a), (b), (c). The children used the globe and the flashlight or the light bulb to investigate "How night comes to a place where it is day".

In general the teachers reported that both kindergarten and pre-kindergarten children responded very well to the activity. Some children expressed their satisfaction spontaneously, with exclamations like: *Now I understand why we have night and day!* There was, however, a certain percentage, albeit very small, that did not respond satisfactorily. Although they were very interested, they did not manage to answer correctly. In some isolated instances the children were more interested in what was on the earth than in the specific topic of the activity. There were also some children who watched attentively but did not want to take part in the presentation phase.

After watching the final ideo episode, the children drew pictures, using crayons, cut-outs, or a combination of the two. In the picture reproduced as Figure 3.7, the child cut out the earth from a photocopy of Figure 2.1 that his teacher gave him and stuck it on a piece of white paper, then drew the sun and coloured in the parts of the earth facing the sun with bright colours and the parts on the other side with black.

Figure 3.7 Collage picture**:** The sun illuminates the parts of the earth that are facing it.

Figures 3.8 and 3.9 reproduce similar pictures drawn with crayon. The child who drew the picture in Figure 3.8 made an attempt to show the heavenly bodies pictured in correct proportion.

Figure 3.8. The sun illuminates the parts of the earth that are facing it. The sun has been drawn significantly bigger than the earth.

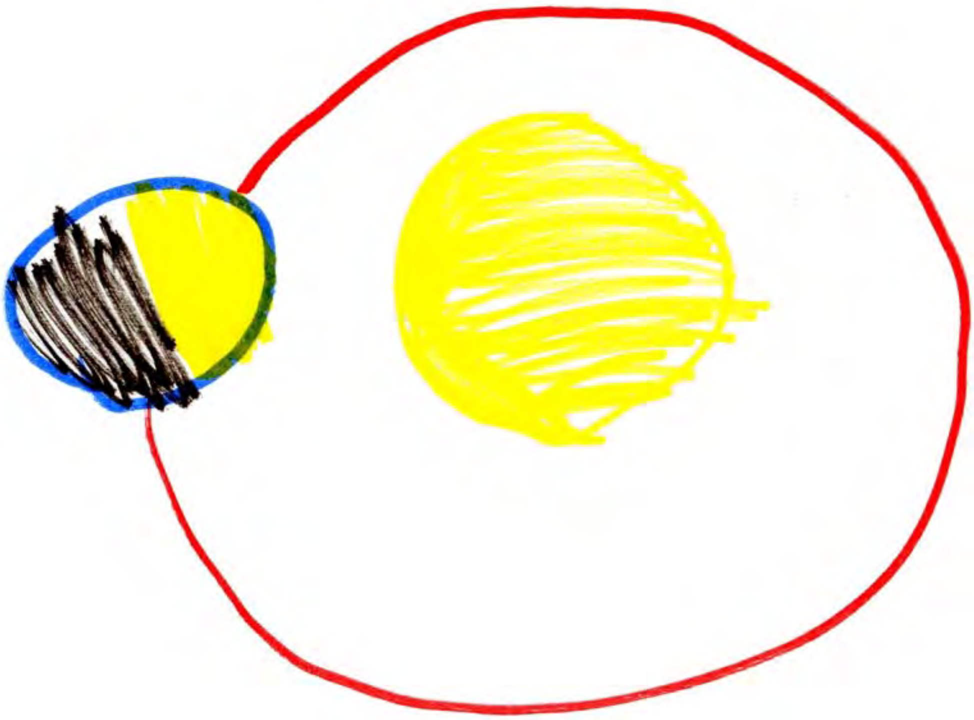


Figure 3.9 "As the earth turns around itself like a top whatever part of it is facing the sun has daytime". This was the explanation that the child who drew this picture gave his teacher. He has included in his drawing the earth's orbit around the sun.

Assessment

The assessment should be done individually. The procedure requires a globe, a flashlight with a powerful beam or an electric light bulb (use the same one you used for the activity), and the photograph in Figure 3.1, showing the earth and the moon half sunlit and half dark.

- Start by giving the children the photograph and a picture of the sun. Ask them to place the sun in the correct position.
- Then, give the children the globe and flashlight or light bulb, reminding them that the light represents the sun and the globe the earth.
- Show them a point on the globe, and mark it. Ask them to use the flashlight to make it daytime in that place, and as they are doing so to explain why.
- Then ask them to demonstrate how night will come to the places where they have shown it to be daytime and, conversely, how day will come to those where it was night.
- Finally, ask them to explain the process, as they demonstrate which motion of the earth causes the phenomenon of the day/night cycle.

Assessment Results

All the teachers assessed the children in their classes individually, proceeding as described above. The children placed the sun facing the illuminated side of the heavenly bodies in the photograph and easily demonstrated the motion of the earth that results in the alternation of day and night. They also gave an oral explanation of what they were demonstrating: *It is day in this place because it is facing the sun and is illuminated.* [Turning the globe] *it is night there now because it is not facing the sun and is not illuminated.*

A relatively small number of children, of different ages, experienced difficulties. There were also a very few who gave egocentric or irrelevant explanations, such as:

- *Night comes because we have to sleep*, or

- If we didn't have day and night the astronauts wouldn't go to see the sun.

Related family activity

The activity can be continued at home. If a globe is available, the parents can ask their child to describe and then to show them how the day/night cycle occurs. They can also discuss their own related notions with them, as well as any shared observations and experiences, e.g. if they have ever watched a dawn or sunset together, they can talk about the gradual change in the light. If the children have never watched this, it is better to conduct the observation in the evening.

GENERAL COMMENTS AND REMARKS

The qualitative analysis of the children's descriptions and the results of the individual assessments revealed a grasp of concepts and phenomena relating to our solar system in a substantial majority of these youngsters. Above and beyond this, there were other elements that indicated the entrenchment of knowledge in their long-term memory, whence it could readily be retrieved: for example, long after the activities had been concluded, the children in several schools were observed, during free playtime, acting out the motions of the earth, twirling around as they moved in a circle around a classmate playing the part of the sun. In addition, months later, at the beginning of the new school year, the older children in some schools explained the motions of the earth to new children in the class. Their assimilation of the knowledge is also evident in the suggestions some children made to classmates: *You have to spin around, too, not only turn around the sun.*

The second thing that is worth noting – apart from the cognitive results of the programme – is the working method followed in these activities, which constitutes a model application of the systems described in the teaching notes in the theoretical section of this book. The implementation of the activities, using elements of scientific method, shows, through specific examples, how scientific skills were employed in the classroom. That is perhaps their greatest contribution to introducing children to the scientific way of thinking and working. We must not forget, however, that in investigating the natural world content and process are always connected. We believe that it is the combination of the two, coupled with the interaction among the children and between the children and their teacher, that constitute the key to the children's interest in the subject matter of the activities and the factors that led to such encouraging learning outcomes. We also believe that the children will have recourse to the knowledge and skills thus acquired when in the future they are called upon to interpret more complex concepts and phenomena relating to outer space. This is perhaps a good place to point out that, for the teacher who wishes to follow the project method, the activities proposed in this book and the method described for implementing them constitute a scientific foundation that he/she can use in addressing the children's interests and handling their questions. Also, we recommend that teachers using this method give the material they have selected to stimulate the children's interest to the class in the sequence described in this book, so that their activities constitute a structured series, each part building on previously acquired knowledge and experience, designed to enable them to form logical correlations between concepts and phenomena.

Another thing that has an important role in reinforcing the children's knowledge and interest is the family environment. Children transmit their experiences and knowledge to their families; as many parents of children who took part in these activities told us, they feel the need to tell others what they have learned and to seek confirmation of their newly acquired knowledge by asking older family members questions about it. Children whose parents talk to them and discuss natural science topics with them will very likely have a better grasp of these subjects. Experiences gained outside school influence and shape the knowledge and the skills that the children bring with them into the classroom.

In closing, we would like to comment on what is perhaps the most significant experience the teachers gained from this work, namely the enthusiasm the children displayed and the interest they developed in the subject matter on which the activities focused, often expressing a wish do them again and again. The eagerness with which the children carried out the activities and the successful outcomes achieved were a huge stimulus and great moral satisfaction for the teachers.

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APPENDIX

Sources of material for the educational video

Visual material

NASA's Office of Space Science (OSS) Education Support Network: http://teachspacescience.org/cgi-bin/ssrtop.plex

NASA Educational Network: http://amazing-space.stsci.edu/

NASA Space Grant Consortium: http://www.spacegrant.hawaii.edu/

Cosmic Zoom: The National Film Board of Canada

Music

Pachelbel: Canon in D minor

Vangelis Papathanasiou: Pulstar, from his *Albedo* album

Strauss: Polka

Synthesis by 'Air

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