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B. Martinez Pena; M. J. Gil Quilez

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The importance of images in astronomy education

B. Martínez Peña and M. J. Gil Quílez, Dpto. Didáctica Ciencias Experimentales, Universidad de Zaragoza, Spain

The abundance of images concerning textbooks doesn't always facilitate the understanding of the concepts. In this study, the phases of the moon, the images shown in Primary and Secondary textbooks, the relationships between the written theoretical content and its illustration, as well as the problems of comprehension of some images, are studied. We worked with 78 students in the third year of a university teacher-training course. The images used to illustrate the phases of the moon are not, by themselves, sufficiently explanatory. Students haven't a clear idea of the Sun/Earth/Moon model and they lack some concepts with which to build it. They have also difficulty in expressing themselves in diagrams. Very strong inducements to attract attention are required in the written text, as well as specific instructions on the part of the teacher, if learning is to take place.

Introduction

Astronomy is one of the recurrent contemporary issues in the mass media where news related to comets, new stars, satellites, space tests, etc., frequently appear. Because of this, students at all levels are especially motivated to work in astronomy education. Nevertheless, the students' interest, together with all the information they get from different sources, doesn't increase their knowledge about the most elementary and common aspects of these subjects. On the contrary, alternative conceptions are frequent. There are several studies about these misconceptions in astronomy, such as the classic ones carried out by Fernández and Morales (1984), Jones and Lynch (1987), Baxter (1989), Nussbaum (1989), Lanciano (1989), Vosniadou and Brewer (1990) and others more recently (Alfonso *et al.* 1995, Camino 1995, De Manuel 1995, De Manuel and Montero 1995, García Barros *et al.* 1996, Domènech and Martínez 1997, Lanciano 1997, Moreno 1997, Navarrete 1998, Parker and Heywood 1998, Stahly *et al.* 1999). All of these and other proposals for teachers (Ten and Monros 1984, Domènech *et al.* 1985, Zugasti 1996, Moreno and Gutiérrez 1998), insist on the need for activities for the students to perform that allow them to modify their alternative ideas. Anguita (1995) includes a list of activities concerning the Earth and Space that students should have carried out by the time they finish Secondary school which include, amongst other things, observations and interpretations of the movement of the planets and the moon.

Astronomy is a subject of study throughout the different levels of Primary and Secondary education. It can be found in textbook, organized and sequenced according to the criteria of the different publishing companies. In other words, not only the courses, in which the different material is included, can vary but also

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the contents itself. In some cases, only the phases of the moon are explained, whilst in others, the ecliptic or the seasons, are explained.

García Barros *et al*. (1997) have analysed the treatment that is given to this subject in Primary textbooks in Spain and indicate, amongst other things, that too much value is given to theoretical questions. This is to the detriment of procedural aspects, such as the observation of the sky and the working out of orientations in space or the use of simple models, that facilitate the theoretical understanding of terrestrial movements. Such a theoretical treatment causes difficulty in understanding of phenomena, given that a purely academic study leads to a loss of the initial motivation in the students (Moreno 1998).

Nevertheless, there is a great proliferation of photographs, drawings, diagrams and graphics, etc., in textbooks which, without doubt, make them much more attractive and should aid the communication process. But this abundance of images doesn't always facilitate the understanding of the concepts, as there are many factors that influence learning and, moreover, the complexity of the images on many occasions does not correspond to the interpretative skills of the students (Bowen and Roth 1999). Students find diagrams more useful than photographs—attractiveness is less important to them than usefulness (Kearsey and Turner 1999).

Some studies even claim that, on many occasions, the images produce a contrary effect to that which is traditionally attributed to them (Reid 1990, Reid and Beveridge 1990, Jiménez *et al*. 1997, Pérez de Eulate and Llorente 1998). One must also add to this the difficulty of using in two dimension images to illustrate space-filling models (Pérez de Eulate *et al*. 1997). In this case, putting each of these objects in their correct position within a three dimensional system of co-ordinated axes is of a great importance in the understanding of the concepts which are being worked on. At the same time, a correct relationship between the conceptual model and its representation through drawings, which is not always adequate, is fundamental, given that the correct graphic representation signifies a suitable structuring of the conceptual model. The above is shown in the different investigations into astronomical events where the students' ideas are interpreted from the graphs they produce (Jones and Lynch 1987, Baxter 1989, Nussbaum 1989, Lanciano 1989, Vosniadou and Brewer 1990).

In this study, starting from the phases of the moon, the images shown in textbooks, the relationships between the written theoretical content and its illustration, as well as the problems of comprehension of some images, are studied. These problems manifest themselves in the written and graphic representations made by the students.

Methodology

The study had two parts, which we believe to be closely related:

(A) Analysis of the images concerning the phases of the moon that appear in Primary and Secondary textbooks.
(B) Analysis of the conceptions and graphical representations of 78 students in the third year of university (teacher training) within the subject 'Environmental Knowledge and its teaching and learning'.

This is the analytical framework for A:

(1) The entire components (Earth, Sun, and Moon) figure in the illustration, the different phases are indicated and the relative position of the components is correct;
(2) The existing relationship between the drawing and the text i.e. whether the text refers to the diagrams and whether the text explains what they represent; and
(3) Whether the drawing allows the student to construct of the concept being worked upon, according to the answers given in part B.

In relation to the students' conceptions (B), firstly they answered an initial questionnaire (nine items) about elementary aspects of the movements of the Earth and their relationships with the other components of the solar system, the Sun and The Moon (see Appendix). In this study, only the first question is analysed: 'Make a diagram of the location of the Sun-Earth-Moon indicating their relative movements in such a way that the phases of the Moon are clearly laid out'.

Afterwards, we went on to work with the students on the basic notions of astronomy, using texts and images from both Primary and Secondary textbooks. Finally, a problem was put to them with the aim of checking not only if they are capable of explaining the phases of the Moon, but also if they can apply their knowledge to a new situation, using the appropriate concepts. In this case a graphic demonstration and explanatory text was required:

> You're in Zaragoza (Spain) and call a friend who is in a spaceship. You tell him to pop his head out of the window so that he can see the beautiful Full moon at the same time as you. But he answers that what he sees are a beautiful moon in its final quarter. Do you think that is possible? Justify your answer with the help of drawings.

Results

Textbook analysis

Primary and Secondary textbooks from different publishing companies have been analysed, focusing on the images and the explanations that figure in the text. In general it can be said that the images to illustrate the phases of the moon are not, by themselves, sufficiently explanatory, as commented upon later.

On the other hand, neither is the written text sufficient to facilitate the students' learning process. At the same time, the illustrations are similar in all the different textbooks; that is to say there is no adaptation to the different levels required. This problem has already been detected in the images illustrated in the textbooks for other scientific subjects (Pérez de Eulate and Llorente 1998). The necessity to rethink the didactic transposition of images from the scientific field has been suggested (Johsua and Dupin 1993). That is to say; the images illustrated in a scientific treatise (for instance, of star movement, images of the cellular membrane, action of the HIV on T cells ... etc.) cannot be transferred directly to textbooks. They must be adapt to the corresponding level of study. In the case of the phases of the moon, the diagrams that appear in the scientific treatise are the same as those appearing in the textbooks (Primary and Secondary), but the text must allow an understanding the diagrams change according to the different levels: simple in Primary and more complex in Secondary. It can be affirmed that there is

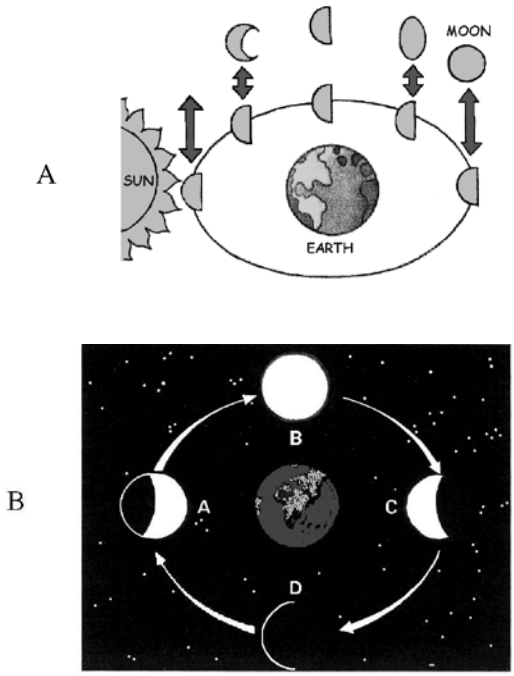

Figure 1. Textbook images, A) the three bodies are aligned in such a way that the position of the full moon is the same as that which gives place to an eclipse of the Moon (textbook for students of 10 years), B) the phases are drawn in such a way that they are seen from the Earth (textbook for students of 12 years).

a transposition of the text but only a diagram transcription. A strategy to adapt the images could be the illustrations made by the students themselves as those compiled in different research studies (Jones and Lynch 1987, Baxter 1989, Nussbaum 1989, Lanciano 1989, Vosniadou and Brewer 1990)

The most significant results of our study are shown below:

- The Sun's position is not indicated in some, and in others the Earth and Sun are missing;
- In the Sun/Earth/Moon model representation, the three bodies are aligned in such a way that the position of the full moon is the same as that which gives rise to an eclipse of the Moon (figure 1A);
- In the Sun/Earth/Moon model representation, the phases are drawn in such a way that they are seen from the Earth. However it is not explained to the pupil that he/she is observing the drawing that must be imagined mentally from Earth, in order to understand it. (figure 1B);
- The relation between the duration of the phases of the moon and the weeks of the month is not explained;
- The text that accompanies the figure is a mere description of the phenomenon (when the moon is round the full moon is represented. If a half-moon is seen, the waxing or waning moons are shown. If nothing can be seen the new moon is illustrated) not an explanation (that is to say, the moon always

has half its surface illuminated and, depending on its position in relation to an observer on the Earth, the different phases can be observed) and in some textbooks either descriptive and explanatory texts are missing;

- A mnemonic rule (The moon is a liar: when the crescent is **C**-shaped the moon is **D**ecreasing i.e. a waning moon. When the crescent is **D**-shaped it is in**C**reasing i.e. waxing moon) is given to help remember if the Moon is in its fourth phase or its waning phase. But it hasn't been made clear that this rule doesn't apply to the Southern Hemisphere.

Initial questionnaire

Student answers show that they do not have a clear idea of the Sun/Earth/Moon model and that they are lacking some concepts to build it. In general, there is:

- Difficulty in expressing themselves in diagrams;
- Some students don't draw the diagram even though it has been expressly asked for. They only give a written explanation;
- Diagrams are confused—it is not evident which are their constituents and/or how they move to bring about the phases (titles and arrows are missing);
- Only the Sun, the Earth and the full Moon are drawn, but not the remaining phases;
- Standard drawings, which figure in textbooks, are made i.e. the Sun, Earth and four moons in the positions, which correspond, to the four phases;
- Their indications of the relative movements are mistaken (the Sun revolving around the Earth);
- They frequently confuse the positions of the full moon and the new moon, sometimes, because they consider the phases to be fixed (a new Moon on the left and a full one on the right), independent of the relative position of the Sun. Other times, they confuse them because they explain the new Moon as an eclipse, through the projection of the Earth's shadow. This conception is one of the most often recognized in previous research (Camino 1995). Novak and Gowin (1988), whilst working with students on the construction of concept maps to show up incorrect conceptions, also identify this idea that it is the shadow of the Earth, when the Moon changes position, that is the cause of the phases.

The problem of the astronaut

The results obtained are richer than those from the question of the initial questionnaire are. Because, on asking the students to develop an image referring to a concrete problem, they must activate their own mental representations and manipulate their own model in order to find a solution. This allows us access to interesting information on the existence of alternative ideas with regard to the Moon's phases and to errors relative to some of the related concepts. There are some students that solve the problem correctly in a geometric way (figure 2A).

The alternative diagrams and mistakes detected are the following:

- The concepts of projection and reflection are confused: 'The phases cause the projection of the sun around the Moon', 'The Moon is veiled by the

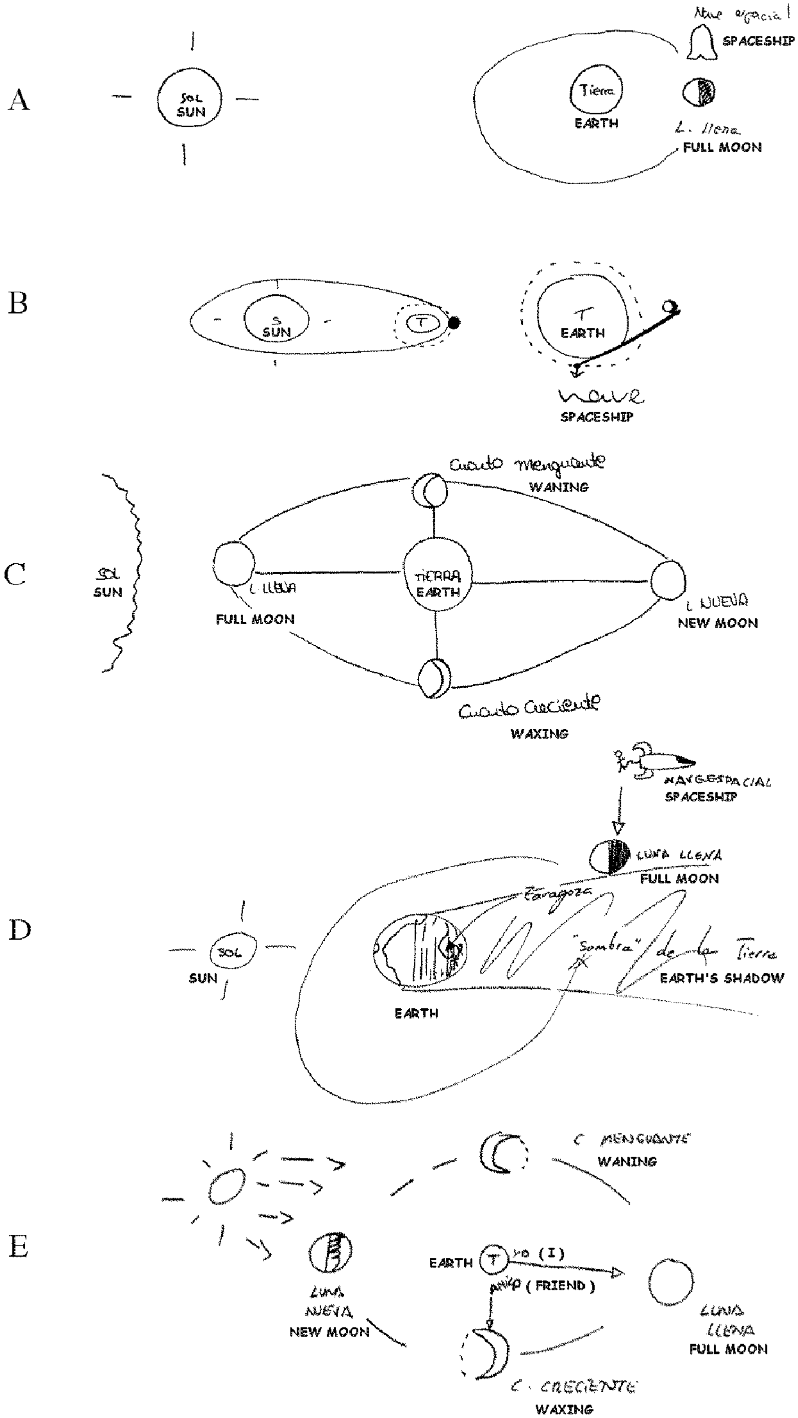

Figure 2. Student representations, A) correct answer, B) the Earth covers part of the Moon, C) mistake in the position of the new Moon and the full one, D) correct position but incorrect explanation, E) four moons coexisting, in four fixed positions.

sun's rays', and 'The Sun's rays influence the Moon', 'The Moon reflected by the Sun';
- When the moon is in its fourth crescent (or the waning phase), only a quarter of the Moon is seen;
- The Moon can only be seen at night: 'The rotations of the Earth around the Sun is important because, in order to see the moon, it is necessary to be night'. As Camino (1998) noted, the majority of people believe in the 'Sun during the day, Moon at night' dichotomy, in spite of the fact that the Moon spends as much time in the nocturnal sky as the daytime sky. As well as this, rotation and passage are confused;
- They comment that it is a problem of relative positions, but they don't explain this and don't know where to place the astronaut in the drawing;
- They explain that when the Earth covers part of the Moon, the astronaut sees only the final quarter. 'We see it full because my friend is in another place and he sees a final quarter because the sun only lights up a quarter of the Moon and the Earth covers the rest' (figure 2B);
- They confuse the position of the new Moon and the full one because they attribute the new lunar phase to the shadow that the Earth projects over it when it gets in front of the sun. 'It only influences the Earth in the phases, depending on whether the Moon is in front or behind' (figure 2C). That's to say that no change has occurred with regard to the answers obtained in the previous questionnaire.

One case is particularly interesting where a student, who makes a drawing with the correct position of the astronaut, explains that 'From here (the astronaut) would see the Moon from one side and that could induce him to error, given that he would see the Moon partially illuminated instead of darkened by the shadow that the Earth projects' (figure 2D).

These phases are only attributed to the displacement of the Moon, in the way that it has different positions-when full, or when waning etc. It seems as if the position of the Moon was integrated with its phase and, in this way, if there is a full Moon, it will be seen as full from any position. Stahly *et al.* (1999) have detected the idea that only the rotation of the Moon around the Earth is influential and what determines the phases is only a question of perspective.

They consider that the phases happen as a result of Earth's rotation (as if there were four moons coexisting, in four fixed positions, each one its own phase, figure 2E). One student explains that the phases depend on the location of the observer on Earth, which implies that the Moon doesn't move. In their diagrams, this conception is reflected when they draw the astronaut over the North Pole i.e. between the Earth and the position of the Quarter crescent of the standard drawing. The student vision of the Moon is always the same, whether they be on Earth or in space.

Comparing the results obtained from the problem to those of the previous questionnaire, it can be observed that the difficulty persists of expressing oneself through diagrams and that there is still confusion between the position of the full moon and the new one. This confusion is due to the persistence of the model that claims that the Earth shadow projects over the Moon.

The deeply rooted idea that they have concerning the standard image of the Moon's phases (the standard diagram consists of a representation of the Sun, Earth and the four phases of the Moon) is striking and leads to errors such as considering that it is the rotation of the Earth which is the cause of us seeing different phases. So that, in one day the four phases could be observed, or rather, observers situated in different places on Earth would be looking at different phases. This case concerns an error caused by teaching, as show from the results of the analysis of textbooks, the illustration is accompanied by a text that is descriptive, not explanatory. In no case are activities, suggestions or questions that facilitate the use of the model and its total comprehension, set. For that reason and in order to solve the problem, they use the model in a simple memorized way but not correctly. That is to say it is useful to describe the phase of the moon but not to resolve the problem of the astronaut

It is interesting to note that, apart from the cognitive difficulty of the subject, there are also other related difficulties (Nussbaum 1989). For example, it was found that students were not familiar with optics, geometry and light and confuse terms such as projection and reflection. At the same time, there are commentaries on the necessity for it to be night in order to see the Moon—a very deep-rooted conception that contradicts observation, but which is never commented on expressly in textbooks. In the same way, students' explanations of the significance of the first quarter (they think that only a quarter of moon can be seen, when, in reality, the term refers to the four quarters of the cycle), is also a result of there being an absence of any explicit reference in the textbooks.

It should also be pointed out that the quality, as a capacity to communicate a concept, of the student drawings is low. Probably due to the fact that the students are not used to working with this form of communication and, therefore, although the importance of images in a concrete subject has been insisted upon, they don't perceive it in this way.

Discussion

Primary and Secondary school children have drawn and painted since they were infants and relate this activity to game-playing as an expression of their way of being and how they see the world. As the child passes through the educational system diagrams acquire other functions: they motivate, they illustrate concepts, they are a source of questions etc. And appear in these ways in the childrens' textbooks. The task of analysis and elaboration of images at school should be tried not always associated with enjoyable activities. The diagrams' role as that of a mechanism by which knowledge can be communicated should be valued, and therefore taught and learned, in the same way as oral and written communication. The student should try to develop his/her own iconic skills to explain the concepts and use also images whenever possible in tasks of evaluation. All of this is highly important in teacher training since the images are going to be one of the most frequent tools they are going to use. Thus, it is necessary to be especially careful when preparing a drawing that helps to capture the reality of the physical world. Although it can be said that an image is better than a thousand words, the contrary claim is also valid-an incorrect drawing is more harmful than a thousand words.

On the other hand, one mustn't simply consider the images as a medium to communicate knowledge. As Mottet (1996) states, they must also be used to develop the knowledge through activities, related to them, which call up and activate existing mental models. The function of the images should serve as a way of applying these activities (observation, the establishment of relations and the construction of sense) in order to activate mental representations, and allow the students to use abstract entities. The graphics would be 'supports' which would allow the visualisation, understanding and use of mental representations. In order to make sure the images in the textbooks are inspected in detail and processed in depth by the student, very strong inducements to attract attention are required in the written text as well as specific instructions on the part of the teacher. This would allow the establishing of routes of thought that the images make possible. That is to say, the students are able to describe the elements contained in the diagram, to explain the relations represented among the different elements and also establish the relationships that are not represented in the diagram (for example, situations like 'The problem of the astronaut').

The study of students' ideas about a concept and their diagrammatic representation and the analysis of the way the textbooks treat this concept, give us more detailed information about the possible problems of its didactical transposition. A study of the mental models and the students' graphical representations of concepts in natural sciences (circulatory and gas exchange systems, hydrological cycle, seasons, etc.) would be interesting in that it would allow us to know more about the degree of correspondence between the two. This knowledge would allow us to investigate whether the difficulty lies in the mental model or the students' ability to represent it graphically.

References

ANGUITA, F. (1995) Las ciencias del espacio en la víspera de 2001: didáctica de una frontera científica. *Enseñanza de las Ciencias de la Tierra*, 13(2), 66-72.

ALFONSO, R., BAZO GONZÁLEZ, C., LÓPEZ HERNANDEZ, M., MACAU, M. D. and RODRÍGUEZ PALMERO, M. L. (1995) Una aproximación a las representaciones del alumnado sobre el universo. *Enseñanza de las Ciencias*, 13(3), 327-335.

BAXTER, J. (1989) Children's understanding of familiar astronomical events. *International Journal of Science Eduation*, 11, 502-513.

BOWEN, G. M. and ROTH, W. M. (1999) Inscriptions and their interpretation in schools and at work. In M. Kommorek, H. Behrendt, H. Dahncke, R. Duit, W. Gräber and A. Kross (eds) *Proceedings Second International Conference of the European Science Education Research Association (E.S.E.R.A.). Research in Science Education Past, Present, and Future*, 2, 417-419.

CAMINO, N. (1995) Ideas previas y cambio conceptual en astronomía. Un estudio con maestros de primaria sobre el día y la noche, las estaciones y las fases de la luna. *Enseñanza de las Ciencias*, 13(1), 81-96.

CAMINO, N. (1998) Un palimpsesto en el cielo nocturno. In E. Barret and A. De Pro (eds) *Investigación e innovación en la enseñanza de las ciencias*, 91-101.

DE MANUEL, J. (1995) Por qué hay veranos e inviernos?. Representaciones de estudiantes (12-18) y de futuros maestros sobre algunos aspectos del modelo Sol-Tierra. *Enseñanza de las Ciencias*, 13(2), 227-236.

DE MANUEL, J. and MONTERO, A. M. (1995) Dificultades en el aprendizaje del modelo Sol-Tierra. Implicaciones didácticas. *Enseñanza de las Ciencias de la Tierra*, 3(2), 91-101.

DOMÉNECH CARBO, A., DOMÉNECH CARBO, M.T., CASAUS LACOMA, M[a] E. and BELLA NICOLAS, M[a]. T. (1985) Apuntes para una programación didáctica de la astronomía. *Enseñanza de las ciencias*, 3(3), 204-208.

DOMÉNECH, A. and MARTÍNEZ, B. (1997) The Teaching of the Earth-Sun System in the Secondary School. Paper given at First Conference of the European Science Education Research Association, Roma.

Fernández Uría, E. and Morales Lamuela, M.J. (1984) La astronomía en el bachillerato: diferentes enfoques. *Enseñanza de las Ciencias*, 121-124.

García Barros, S., Mondelo Alonso, M. and Marínez Losada, C. (1996) La astronomía en la formación de profesores. *Alambique. Didáctica de las Ciencias Experimentales*, 10, 121-127.

García Barros, S., Martínez Losada, C., Mondelo Alonso, M. and Vega Marcote, P. (1997) La astronomía en textos escolares de Educación Primaria. *Enseñanza de las Ciencias*, 15(2), 225-232.

Jiménez, J. de D., Hoces Prieto, R. and Perales, F. J. (1997) Análisis de los modelos y los grafismos utilizados en los libros de texto. *Alambique. Didáctica de las Ciencias Experimentales*, 11, 75-85.

Jones, B. L. and Lynch, P. P. (1987) Childrens' concepts of the Earth, Sun and Moon. *International Journal of Science Education*, 9(1), 43-53.

Joshua, S. and Dupin, J. J. (1993). *Introduction a la didactique des sciences et des mathematiques* (Paris: Presses Universitaires de France).

Kearsey, J. and Turner, S. (1999) How useful are the figures in school biology textbooks? *Journal of Biological Education*, 33(2), 87-94.

Lanciano, N. (1989) Ver y hablar como Tolomeo y pensar como Copérnico. *Enseñanza de las Ciencia*s, 7(2), 173-182.

Lanciano, N. (1997) Obstacle conceptions and didactic obstacles in Astronomy experence fields. Paper given at First Conference of the European Science Education Research Association, Roma.

Moreno Lorite, M. (1997) Secuenciación de contenidos y enseñanza de la astronomía: 'La Tierra en el Universo'. *Alambique. Didáctica de las Ciencias Experimentales*, 14, 61-71.

Moreno Lorite, M. (1998) A cielo abierto: una experiencia de aprendizaje de la astronomía. *Alambique. Didáctica de las Ciencias Experimentales*, 18, 75-83.

Moreno Lorite, M. and Gutiérrez Goncet, R. (1998) Propuesta para optimizar las secuencias obtenidas a partir de la teoría de la elaboración: aplicación a los contenidos relativos a la 'Tierra en el universo'. In E. Barret and A. De Pro (eds) *Investigación e innovación en la enseñanza de las ciencias*, pp. 96-104.

Mottet, G. (1996) Les situations-images. Une approche fonctionelle de l'imagerie dans les apprentissages scientifiques à l'école élèmentaire. *Aster*, 22, 15-56.

Navarrete Salvador, A. (1998) Una experiencia de aprendizaje sobre los movimientos relativos del sistema 'Sol/Tierra/Luna' en el contexto de la formación inicial de maestros. *Investigación en la Escuela*, 35, 5-20.

Novak, J. D. and Gowin, D.B. (1988) *Aprendiendo a aprender* (Barcelona: Martínez Roca).

Nussbaum, J. (1989) La Tierra como cuerpo cósmico, In R. Driver, E. Guesne and A. Tiberghien (eds) *Ideas científicas en la infancia y la adolescencia* (Madrid: MEC, Morata).

Parker, J. and Heywood, D. (1998) The earth and beyond: developing primary teachers' understanding of basic astronomical events. *International Journal of Science Education,* 20(5), 503-520.

Pérez de Eulate, L. and Llorente Cámara, E. (1998) Las imágenes en la enseñanza-aprendizaje de la biología. *Alambique. Didáctica de las Ciencias Experimentales*, 16, 45-53.

Pérez de Eulate, L., Llorente, E. and Andrieu, A. (1997) Las imágenes en los libros de texto de ciencias: un estudio en la educación primaria. In A. San Martín (ed.) *Del texto a la imagen* (Valencia: Nau Llibres).

Reid, D. (1990) The role of pictures in learning biology: Part 2, picture-text processing. *Journal of Biological Education*, 4(24), 251-258.

Reid, D. and Beveridge, M. (1990) Reading illustrated science texts: a micro-computer based investigation of children's strategies. *British Journal of Psychology*, 60, 76-87.

Stahly, L. L., Krockover, G. H. and Shepardson, D. P. (1999) Third Grade Students' Ideas about the Lunar Phases. *Journal of Research in Science Teaching,* 36(2), 159-177.

Ten, A. E. and Monros, M. A. (1984) Historia y enseñanza de la Astronomía. Los primitivos instrumentos y su utilización pedagógica. *Enseñanza de las Ciencias*, 43-56.

Vosniadou, S. and Brewer, W. F. (1990). A cross cultural investigation of children's conceptions about the Earth, the Sun and the Moon: Greek and American data. In H. Mandl, E. De Corte, N. Bennett and H. F. Friedrid (eds) *Learning and Instruction. European Research in an International Context* 2.2, 605-629 (Oxford: Pergamon Press).
Zugasti Arbizu, M. P. (1996) Tratamiento de la astronomía en la enseñanza primaria. *Didáctica de las Ciencias Experimentales y Sociales*, 11, 3-9.

Appendix

Questionnaire previous

Draw a scheme of the Sun-Earth-Moon situation and show their movements so that justifies the phases of the Moon.

- Why isn't it dawning at the same timing everywhere on the Planet.
- Why is it day and night?
- Why does the Sun rise in the East and set in the West?
- During the night, have the constellations the same position?
- Why are the days shorter in winter than summer?
- Explain why shadows are of different lengths according to whether it is summer or winter, when it is the same time of day?
- Why is it summer in the Southern hemisphere when, in the Northern hemisphere, it is winter?
- How could we not have seasons on the Earth?