Teaching Physics and Astronomy in the Early-Years

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Content of the presentation

1. Why science in early years
2. Aims and approaches of early-years science education
3. Early- years teachers' problems and difficulties
4. Possible ways to overcome them
5. Two sequences of activities related to physics and astronomy

Early-years in education

- Include ages 4-8
- Presentation will focus on children aged 4-6 and their educators

A frequently raised question

- Why teach science in early years?
- Contradictory arguments
- Elementary and pre-primary teachers' negative attitudes towards science

Reasons for early-years science education

- Children begin to construct science concepts of increasing complexity
- Early exposure can lead to better understanding
- Students can develop positive attitudes towards science
- Use of scientifically informed language:
  - Influences the eventual development of scientific concepts
  - Might assist in developing patterns of *scientific thinking*

Reasons for early-years science education

Brain research and modern neuroscience has shown that **timing is crucial**:

- Learning in specific domains occurs most efficiently within a critical period called ‘windows of opportunity’
- For essential science skills ‘windows of opportunity’ begin to close earlier than the age of 9

Approaches in early-years science education

Inquiry: One of the most prominent reforms in science education

- Aims at enabling young pupils to obtain experiences that are authentic to scientists' experiences
- Is thought to:
- ✓ Make pupils learning more meaningful
- ✓ Improve their scientific understanding
- ✓ Assist them in logically relating evidence and explanations
- ✓ Assist them in communicating scientific arguments

Can pre-primary children understand and think scientifically?

- Young children of 4 and 5 years of age:
  - Can think abstractly
  - Can form inductions
  - Can reason
  - Can distinguish between conclusive and inconclusive tests of hypothesis
- However
  - Often children under five are indeed being undereducated

Educators' role

- Teachers should provide children with materials and developmentally appropriate activities progressively increasing in conceptual depth and complexity
- Teachers need themselves to have understanding to guide children to materials and activities which develop their understanding

Educators' knowledge and understanding in science

International research has shown:

- Early-years and primary educators' background knowledge of and understanding in science is rather weak
- Possession and use of alternative, anthropomorphic, animistic, theocratic and pseudoscientific conceptions
- These conceptions most evident in physics including aspects concerning earth and space

Supporting early-years teachers in their professional upgrading in science

The teachers of the lower grades of education:

- Need to have a sound background knowledge in a number of disciplines
- To maintain such a background knowledge engage teachers in activities which are interesting for them

Supporting early-years teachers in their professional upgrading in science

A project in Greece:

- The idea was **to motivate** the teachers by:
  - Making them members of an **action research group** [Action research: Cyclic processes including: acting-recording, reviewing-reflecting, acting]
  - Have them contribute substantially to the development of curriculum materials **meaningfully engaging them in their own learning**

The project and the work group

- Long term project
- Aiming at the development of curriculum activities for the initiation of children aged 4-6 into selected concepts and phenomena of physics and astronomy
- Was carried out by a group of 6 early-years teachers and of a researcher/ facilitator
- Comprised individual class and group work

Results

Project Resulted in :

- Production of usable sequences of activities in physics and astronomy
- Teachers':
- Considerable improvement of their knowledge
- Significant changes in their alternative conceptions
- Development of ability to transform content
- Improvement of teaching practices

Children's ideas

- An individual's prior knowledge and conceptions influence subsequent learning
- Children come to school with ideas about concepts and phenomena of the natural world
- Most of children's ideas do not coincide with the generally accepted scientific ones

Aims of early-years activities in science

- One of the aims of early-years science activities is to assist children to replace their alternative ideas with more scientific ones through understanding and scientific reasoning
- Pre-primary children might not grasp immediately the precise scientific ideas
- However these experiences will develop their background and assist them to form 'precursory' concepts which will contribute to grasping more complex scientific concepts and ideas later on

Aims of early-years science activities

- However children may ignore contradictory evidence
- Ability to understand in science may depend on the ability to carry out process skills

Process skills

- Science process skills are mental and physical skills that scientists use when they study the natural world
- For young children these skills include:

- observing,
- hypothesizing,
- predicting,
- investigating,
- classifying,
- measuring,
- interpreting and
- communicating

Investigation through experimentation

- Assists children to be critical
- Should include such skills as:
  - Identifying relevant variables
  - Gradually manipulating them
- Process focuses children's attention on the meaning of variables

Physics

Floating and sinking

Children's ideas

- Children relate bodies' floating and sinking to their size or to their weight
- Some of the most important children's beliefs:
  - Heavy bodies sink while light float
  - Big bodies float while small sink but also the opposite
  - Mixed explanations

The design of the activities

- Activities were oriented to conceptual understanding

- Had taken into consideration children's prior ideas

- The approach to learning can be characterized as socially constructed:
  - ✓ adults and children worked together
  - ✓ children collaborated with peers sharing opinions and knowledge

- Whole class discussions

The teaching sequence

- Comprised two groups of activities:
  - Solid bodies: Three investigations
  - Hollow bodies: One investigation
- Activities were implemented in a total of 104 children

Solid-body activities

- Three variables:
  - Shape
  - Size (volume)
  - Material (density)
- Depending on the aim of the activity some of the variables were kept constant and some were changed

Solid-body activities

- *Activity A:*

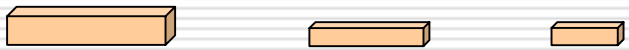
Investigation: How do solid bodies that are made of the same material and have the same shape but different size (volume) behave when put in the water?

Bodies' characteristics

Solid bodies	Same shape	Same material	Different Size (volume)

Solid-body activities

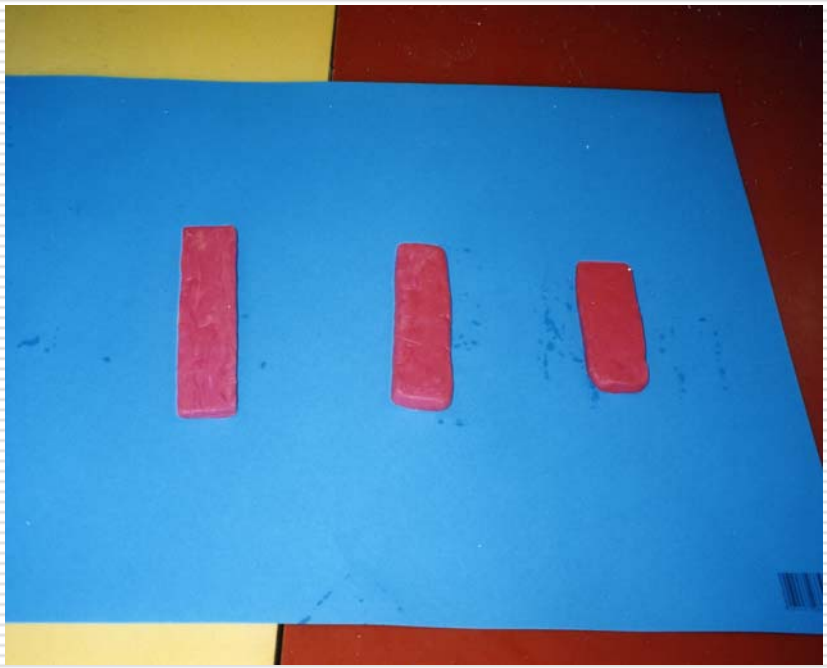
- Group 1: Bodies that float



- Group 2: Bodies that sink

Solid-body activities

- Blocks made of play dough



Solid-body activities

- Classifying and seriating the bodies

Solid-body activities

- Working with wood: Comparing the bodies weight

Solid-body activities

Testing and predicting

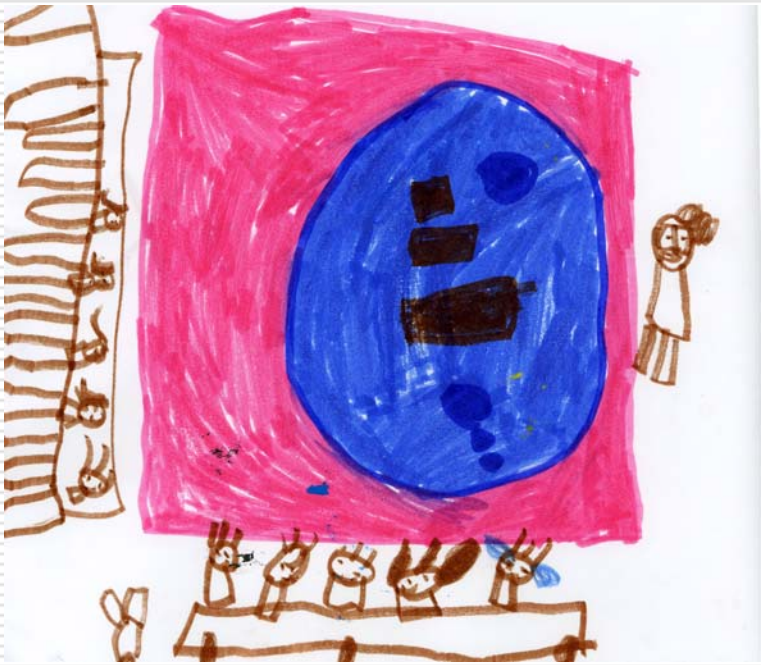
- Children's predictions: *expressed similar ideas with those found in literature*
- Children's testing of predictions
- Discussion of results
- Procedure was repeated for the play-dough blocks

Solid-body activities

- **Children initiated** experimentations

Solid-body activities

- Children's representation of the phenomenon



Solid-body activities

- *Activity B:*

Investigation: How do solid bodies that are made of different material and have the same shape and size (volume) behave in the water?

Bodies' characteristics

Solid bodies	Same shape	Same size (volume)	Different material

Solid-body activities

Bodies made respectively of:

- Play-dough
- Wood
- Marble
- Foam-rubber

Solid-body activities

Activity process:

- Children's observation and description of all objects
- Objects were used in pairs
- Children's comparison of objects
- Children's predictions
- Children's classification of objects in 'floaters' and 'sinkers'
- Whole class discussion of *similarities* and *differences*
- Conclusions

Solid-body activities

Testing predictions

Solid-body activities

- *Activity C:*

Investigation: Very big bodies that are made of materials which float, will float while very small bodies that are made of materials which sink, will sink when placed in water

Bodies' characteristics

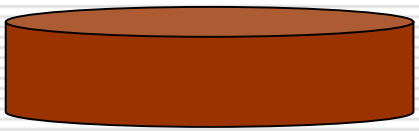
Solid bodies	Same shape	Different size (volume)	Different material

Solid-body activities

Bodies respectively made of:

- Wood
- Play-dough

Wood



Play-dough

Solid-body activities

Procedure:

- The children:
  - Observed the objects and named their materials
  - Compared their size and then their weight

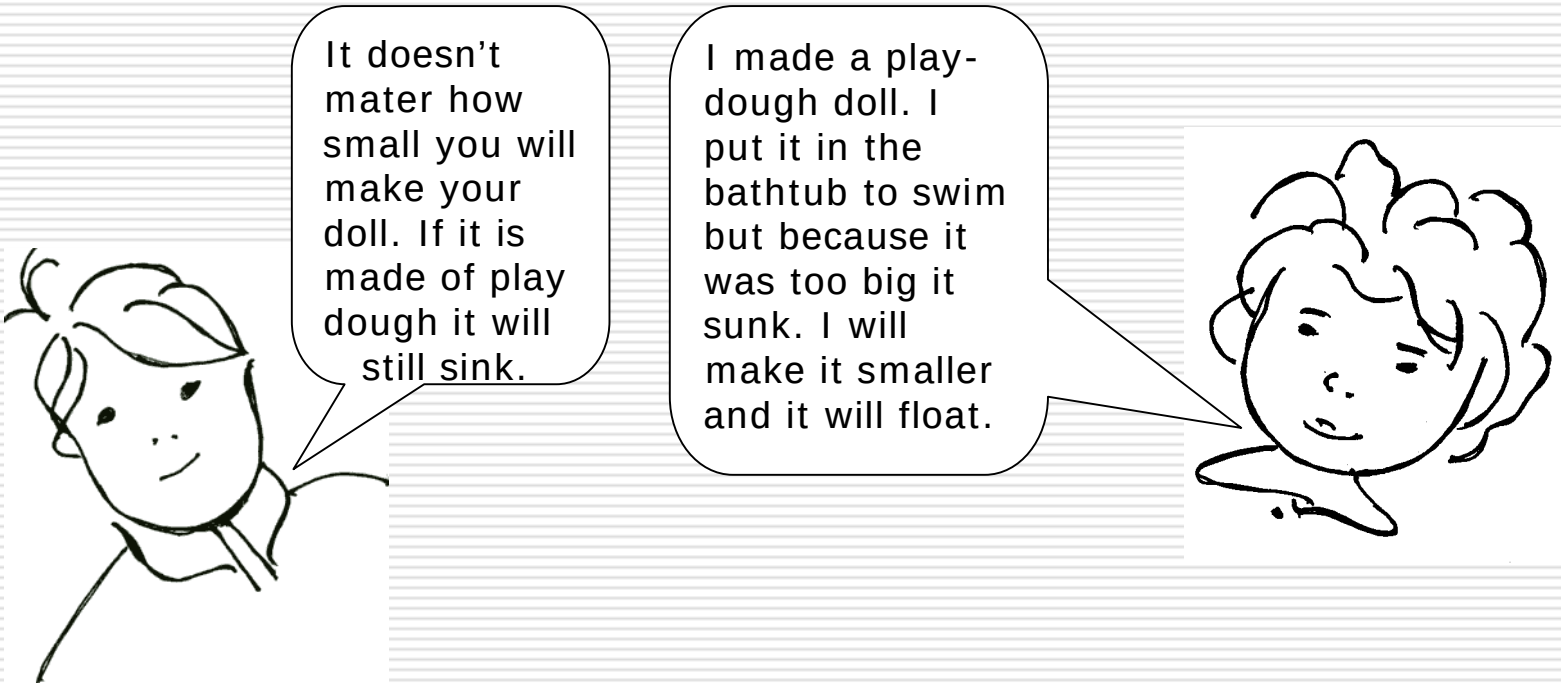
Solid-body activities

A big piece of fire wood and a small piece of play-dough of the same shape as the wood

Solid-body activities

- Testing of predictions
- Tracing back the bodies' behavior
- Children's reasoning
- ***Linking the phenomenon with real situations: big tree trunks can float in the rivers***

Assessment


It doesn't mater how small you will make your doll. If it is made of play dough it will still sink.
I made a play-dough doll. I put it in the bathtub to swim but because it was too big it sunk. I will make it smaller and it will float.

Hollow bodies

Outer space

Astronomical concepts and events awareness for young children

Background

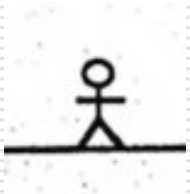
- Children hold different ideas on:
  - Shape of the earth
  - Position of the earth in space
  - Day/night cycle

Children's ideas

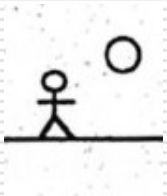
- The phenomenon of day and night:
  - Sun is regarded as a living with anthropomorphic habits
  - Day/night cycle attributed to:
    - The rotation of the sun around the earth
    - The earth's rotation around the sun once a day
    - An upward and downward motion of the sun

Children's ideas

- The shape of the earth:

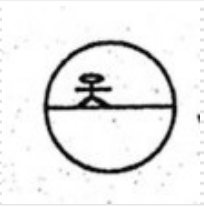


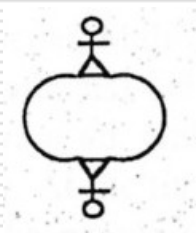
- The flat earth: The earth has the shape of a disk



- The double earth: Two earths exist. One is flat and the other has a spherical shape and is located in the sky.

Children's ideas

-  The hollow Earth: Is shaped like a sphere but is hollow and has an upper and a lower hemisphere.

-  The flattened sphere: The Earth is shaped like a 'thick pancake' surrounded by sky.

Children's ideas

Diverse research results:

- Certain studies using different methodology from others in the field found that children's views regarding the shape of the earth completely disappeared

Knowledge and instruction

- Few studies have paid attention to the *effectiveness of instruction*

The present study:

Developed three units of activities aiming at initiating children aged 4-6 into fundamental concepts and events:

- The spherical shape of the earth
- Its movements
- The shape of the sun and the moon
- The relative position of these bodies
- The phenomenon of day and night

Methodology and sample

- The study was carried out by the same study group
- Action research processes were used
- Activities were implemented in a sample of 104 children
- Approach to learning can be characterized as socially constructed

The development of activities

- Students were presented with appropriate information along with conceptual tools (an instructional video and a globe).
- The design of the activities and the instructional video took into consideration the following research findings:

The development of activities

- Some children believe that the earth or other celestial bodies are supported in space
- Children may become confused by the two simultaneous movements of the earth
- A non-stationary sun may impose an unnecessary challenge for children of this age

The activities: Unit 1.

- Includes three activities

- Aim: Familiarize children with the appearance and shape of the sun and moon

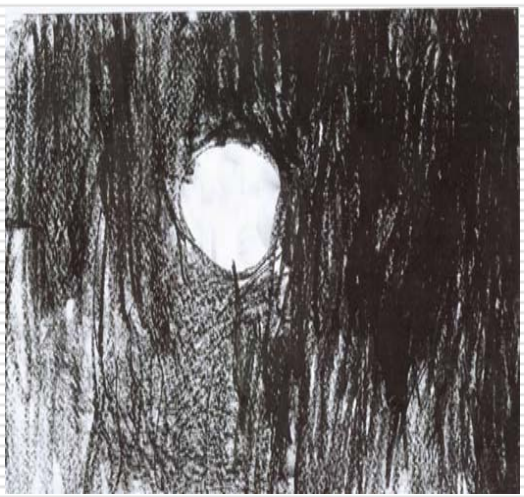
The activities: Unit 1.

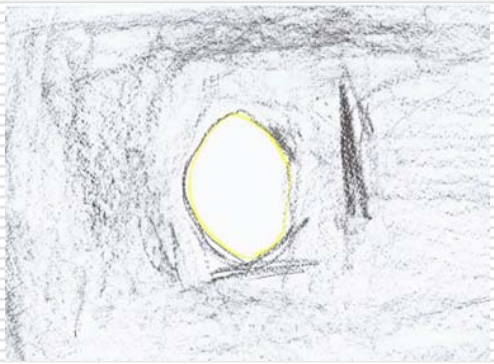
Activity 1: Children's direct observation of the sun

- Children's surprise and wonder

The activities: Unit 1.

- Children's reports of observations
- Whole class discussions
- Children's representations





The activities: Unit 1.

Activity 2: Observation of the night sky

- Involvement of the family
- Children's recording of observations

The activities: Unit 1.

Activity 3: Review of day and night observations.

- Children's presentation of the night observations.
- Emphasis was placed on the shape of the full moon.

- Whole class discussion of what was totally observed

The activities: Unit 2.

- Includes three activities.
- Aim: Acquainting children with the shape of the earth, its movements and the shape and movement of the other celestial bodies of our solar system.

The activities: Unit 2.

Activity 1: “Our Earth is shaped like a sphere”

- Children’s drawings of the shape of the Earth
- Whole class discussion of earth’s photos as it looks from space
- Children’s comparisons with shape of sun and full moon

The activities: Unit 2.

Activity 2:

- Introduction of the new knowledge:

  Earth moves in space.
- Discussion of children's ideas on this issue.
- Show of the 1rst episode of the educational Video.

The activities: Unit 2.

- Children's ascertainments:

➢ Earth becomes "round" or "spherical" as one moves away from the ground:

- *Everything is getting smaller and smaller*
- *Look the Earth has become round. It was flat and now is round*
- *Now that is getting closer is becoming flat again*

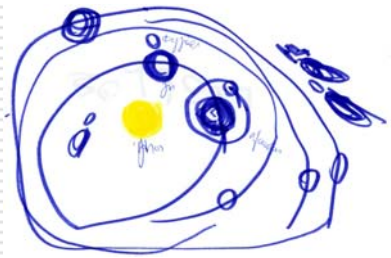
➢ Earth is not supported in space:

- *You mean the Earth is in the air? Is it not resting on anything? Is it not supported?*

The activities: Unit 2.

- Children's representations:
- Most children drew Earth spherical

- In most representations Earth and planets are moving around the sun.



The activities: Unit 3.

- Includes two activities.
- Aim:
- Acquainting children with the movement of the earth which causes the alternation of day and night.
- Explore how night comes to a place which has day

The activities: Unit 3.

Activity 1:

- Children's description and reasoning on the changes of the intensity of light on Earth during 24 hours
- Play of the second episode of the video
- Attention was focused on:
  - It is the earth that moves around the sun
  - The sun lights the side of the earth that is opposite it

The activities: Unit 3.

Activity 2:

- Investigation: "How the night will come to a place that has day"
- Use of a globe
- Children worked in groups
- Each group explained the process to the rest of the class

The activities: Unit 3.

- Closing: Play of the third episode of the Video

- Third episode: The observer enters the totally dark side of the earth

Assessment

- Assessment was done at least two weeks after the end of the activities
- It was individual
- Comprised:
  - Children's oral descriptions and reasoning
  - Children's construction of play- dough models
  - Children's handling of the constructed models, of pictures and of artefacts (globe).

Results

- Shape of the earth and the sun:

Of the assessed children:

- 92% modeled sun and earth as spheres.
- 8% modeled earth flat and sun spherical.
- 89.5% correctly showed movement around sun
- 85% showed both movement around sun
- and around axis at the same time

Results

- The earth turns around itself and around the sun

Results

- Phenomenon of day and night

➢ Of the assessed children:

- 86% showed correctly how the night will come in a place that has day.
- 14% gave oral explanations that:

✓ Were ‘egocentric’

✓ Were ‘irrelevant’

✓ Attributed the phenomenon to the rotation of the earth around the sun

Results

- Important findings from qualitative analysis of teachers' lesson recordings and field notes:
  - Long after the activities:
    - Children were observed enacting the movements of the earth
    - Older children were observed explaining earth's movements to newcomers
  - Children had developed a great enthusiasm and interest for the subject

Conclusions

- High percentages of awareness among the children of the concepts and events that the activities dealt with
- Children's storage of the new knowledge in the long-term memory and easy retrieval of it
- The latter and the encouraging results of children's evaluation can both be attributed to *the structure of the activities, the instructional approach* and *the instruction materials*.

Conclusions

- Methodological part: The *action research* processes proved very useful for appropriately shaping the activities and the instruction materials.

Summary of important points

- For essential science skills ‘windows of opportunity’ **begin to close early in life**
- Approaches to early-years science education **play an important role**
- Teachers’ role **is central**
- Teachers’ knowledge and classroom practices **are essential**
- Educating teachers: **innovative approaches are needed**

Summary of important points

- Our Action Research group developed sequences of activities aiming at:
  - Acquainting children with basic scientific ideas
  - Improving teachers knowledge and practices
- The sequences of activities included topics in **astronomy** and **physics** from the areas:
  - Mater and its properties
  - Mechanics
  - Heat and temperature
  - Magnetism

THE END

- THE END

References

- **References**
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- Gramann, J. (2004). Windows of Opportunity in Early Learning**.** *Literacy Links,* Volume 8, No. 3, Texas Center for the Advancement of Literacy and Learning.
- Nash, J.M. (1997). Fertile minds. *Time* 3, 49-56
- Shore, R. (1997). *Rethinking the Brain: New Insights into Early Development*, New York, Families and Work Institute.

Children's ideas

- Certain studies used different methodology from others in the field:
- They introduced the scientific concept of the earth-shape at the outset in the form of a geographical globe.
- Found that children's views regarding the shape of the earth reported by others completely disappeared.
- Therefore: Research results are diverse

The development of activities

- Was done collaboratively by the researcher/facilitator (R/F) and the early-years teachers (e-y-t).
- The R/F initially designed the activities.
- Teachers implemented activities.
- Work group used action research processes.

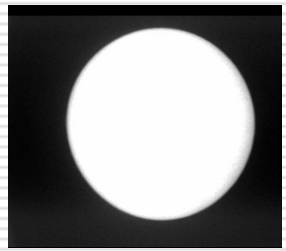
The development of activities

- Students were presented with appropriate information along with conceptual tools (an instructional video and a globe).
- The design of the activities and the instructional video took into consideration the following research findings:

The activities: Unit 1.

Children's reaction:

- Surprise for the appearance and color.



- *Oh Dear!! It is white and not yellow*
- *It is perfect, it is magnificent, it is glorious*

- Wonder about the identity of the observed body
- *Is it really the sun or it is the moon?* (taking off their glasses)
- *No it is the sun but it looks like the moon with these glasses*

The activities: Unit 2.

- Children's descriptions of their observations related to:
- The shape of the earth and the other bodies
- The movements of the earth.
- Whole class discussion of them focused on two issues:
- Earth is spherical
- The Earth moves around the sun and not the sun around the Earth

The activities: Unit 3.

- Children describe:
- The two movements of the earth.
- The lighting on both sides of the Earth depending on their position in relation with the sun.
- Children describe or show in any way they want the movement of the Earth that makes the different places on it to either have day or night.

The activities: Unit 3.

Children's reactions:

- Most of them described correctly both earth's movements.
- Some acted the movement of the Earth that causes alternation of day/night.
- Others explained it verbally and acted at the same time:

- *The Earth rotates around itself. As it rotates the side that has day sees the sun and the other doesn't* (child was turning around herself).
- *Well, since the Earth rotates like a spinning top every place gets light in its turn.*
- *If the sun doesn't see a place how could it have day?*

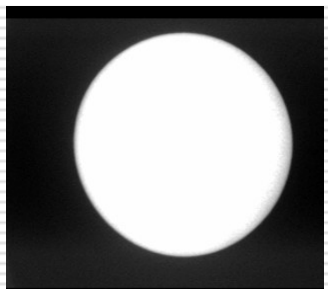
Results

- Using pictures and making drawings

The activities: Unit 1.

In the classroom:

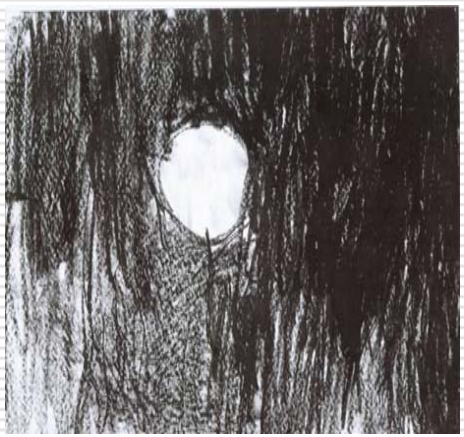
- Children reported and discussed observations

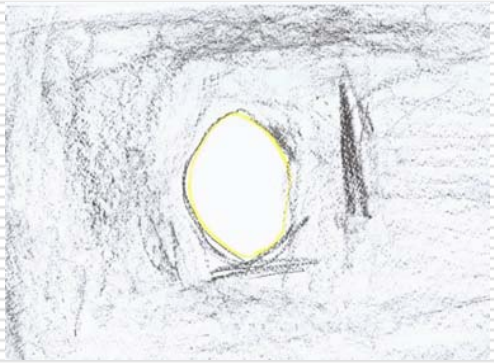


- Whole class discussions of the observations

The activities: Unit 1.

- Children's representations of the sun





- Discussions of the sun's shape: Most children used the word round, few the word sphere

The activities: Unit 3.

- Teachers provided the picture for discussion

- Video was played again for comparison with the picture

Results

- Results on four different issues:
- Shape of the earth and the sun.
- Earth’s movement around the sun (movement a).
- Earth’s movement around its axis (movement b).
- Day/night cycle.

Adults continue to learn but…

Approaches in early-years science education

- Children should have the opportunity to use scientific inquiry
- Develop the ability to think and act in ways associated with it:
  - Conducting investigations
  - Using appropriate tools and techniques to gather data
  - Thinking critically and logically
  - Relating evidence and explanations
  - Communicating scientific arguments

How could young children be assisted to develop understanding?

- Investigation of scientific concepts through experimentation
- Investigation should include such skills as:
  - ✓ Identifying relevant variables and gradually progressing to manipulating them
  - ✓ Altering one or more of them in ways that influence the phenomena under study
- Above processes focus children's attention on the meaning of variables
- Allow them to reflect on problems that can arise from these alterations

Educators' concerns and self perceived needs

Difficulties related to:

- Their knowledge of the subject matter especially in physics
- Their Pedagogical Content Knowledge
- Educators expressed two types of needs:

➢ Educational, referring to the improvement of different aspects of their knowledge especially in physics and topics of outer space

➢ Needs referring to the support and guidance of their work in science by specialists in science and pedagogy

❖ Educators noted: Science in the lower grades is a multidisciplinary matter

The works

- The project comprised individual class work and group work

- In class the teachers implemented sequences of pre-designed by the researcher science activities
- In group teachers' reviewed their class work and reflected on their practices

Results

- Teachers' Pedagogical Content Knowledge: Significant improvement of different components
  - ✓ Transformation of content
  - ✓ 'Knowledge of pupils': personal ideas, abilities, developmental level, attitudes, motivations
  - ✓ 'Knowledge of context': cultural and social factors which shaped the teaching processes
- Teachers' better understood their teaching practices

Hollow-body activity

Investigation: How do bodies which are hallow and are made of material that sink behave in the water?

- Activity materials:
  - Solid:
    - One piece of metal
    - One of glass
    - One of play-dough
  - Hallow:
    - An empty glass vase
    - An empty metal container

Hollow-body activity

Procedure:

- Children observe the solid materials and name them
- Predict their behavior in water
- Test predictions and record the results
- Whole class discussion of the results in relation to predictions

Hollow-body activity

- Children observe the hollow objects
- Record similarities and differences from the solid made of the same material
- Discussion of children's observations in the group
- Introduce the terms "hollow and cavity"

Hollow-body activity

- Experimentation: Solid metal and empty metal container, solid glass and empty glass vase

Hollow-body activity

- Problem solving: How can you make a play-dough ball float

Hollow-body activity

- ***Linking the phenomenon with real situations: big ships float in water***