Co-funded by the Erasmus+ Programme of the European Union

OPEN DISCOVERY OF STEM LABORATORIES

Teacher Summer School, 17-22 July 2017, Acicastello (CT) – Italy

CONCEPTUAL LABS OF OPERATIVE EXPLORATION (CLOE) IN PHYSICS TO BRIDGE RESEARCH AND PRAXIS

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Proposed activity

An introduction to scientific learning and PER: the CLOE with some example of activities, strategies and tool for research approach.

Goal is to activate reflection on three aspects suggested for the Group work.

1) how research based conceptual labs for operative exploration (CLOE) of physics phenomena
    1) **play the role to organize the student reasoning engagement** and
    2) **to create an environment for cooperative learning based on student active work?.**
2) How to monitor learning progress of students?,
3) How CLOE produce situated learning for involved teachers?

Contents

- The main problems in scientific culture and T/L physics
- The role of teaching strategies and methods
- The learning and the PER

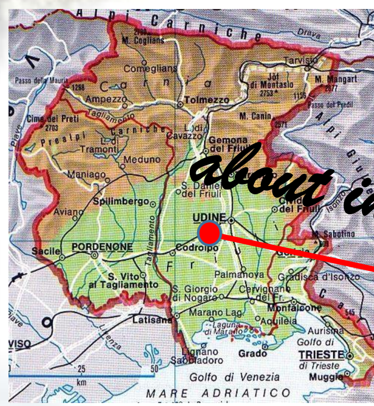
45 minutes

- Our research approach
- CLOE Labs: Approach, strategies, instruments and methods
  - ojectual models to bridge common sense ideas with scientific models

    The cases of fluids, falling bodies, java modelling
  - The role of representations
    - Magnetic phenomena and field lines
    - electrical charge and macro / micro representation
- ICT for a thermodynamic approach to Thermal phenomena

- Your experiments with materials
- Your reflection for MOOCμLABS

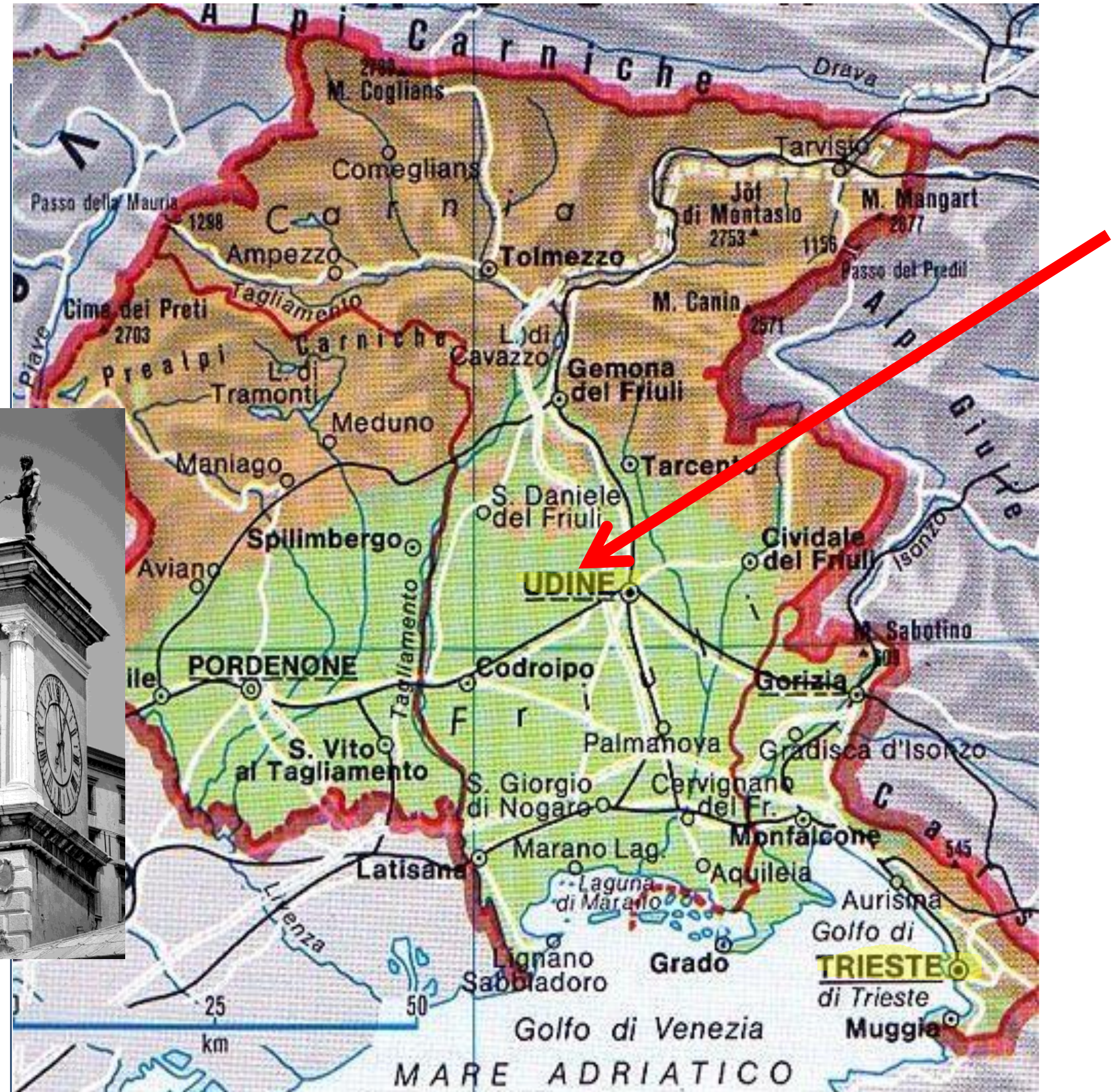
Udine is in Friuli Venezia Giulia Region, close to Venice



about in the centre of Europe

Udine is in Friuli Venezia Giulia region of Italy

far Nord-East



University of Udine - Rectorate in Florio Palace

Udine – Freedom street

Rizzi – scientific campus

Udine Physics Education Research Unit

- Marisa Michelini – Full professor in Physics Education
- Lorenzo Santi – Associate professor in general physics
- Alberto Stefanel – Researcher in physics education
- Diego Cauz – 50% Researcher in physics education
- Boscolo Ilario retired full professor, still working
- **2 PhD Students**: Daniele Buongiorno, Giacomo Zuccarini
- **8 post doc:** Sri Prasad Challapalli, Giuseppe Fera, Mario Colombo, Alessandra Mossenta, Giovanni Tarantino, Stefano Vercellati, Rossana Viola, Italo Testa
- **15 Teachers Researchers**: …more G Burba, A Borgnolo, M Gervasio, C Grosso, F Leto, L Marcolini, R Maurizio, GP Meneghin, L Sabaz, I , Sciarratta, ML Scillia, E Vidic
- **30 teachers cooperating**

URDF Research is carried out in:

- **IDIFO Project (1996-2019): 20 Italian Universities cooperating – UD leader (+25 Regional Projects)**
- **9 EU Projects**: Eupen, Steps1-2, **Secure**, Supercomet 1-2, Mosem1-2, **Hope (+15 EU partners, 71 EU Phys Deps) + Interreg Projects:** Italy-Slovenia **(partners)**
- **EU cooperations (Projects and Ersamus):**
  - **France:** Paris VII, Marseille
  - **Germany:** Dresden
  - **Czech Republic:** Ostrava, Brno
  - **Poland:** Torun, Warsaw, Wroclaw, Kracow
  - **Spain**: Orihuela, Barcellona,, San Sebastian
  - **Greece:** Patras and **Malta:** La Vallette
  - **Romania**: Iasi, Bucarest, Costanta

International cooperations:

in the frame work of GIREP, ESERA and AAPT, APS, EPS, IACPE, ICPE, LAPEN, LASERA, MPTL, PESJ (Univ Washington, Mexico, Oregon, Sao Paulo, Guadayaqui)

Basic assumpions

PREMISE

The complexity of the socio-cultural and working context

outlines the request for

new formative modalities

in which

Knowledge should NOT be seen as static and definite,

but in a progressive and continuous evolution,

without separating the product from its process,

with a tight correlation

between the many dimensions of knowledge.

in which

subject knowledge is presented as a cultural object

that the teacher offers to the students

not so much for them to be reproduced,

but most of all,

for them to be used in a creative way

to face the problems always coming out from the rapid evolution of society.

In this perspective

disciplines assume the form of "maps":

- **conceptual ones for understanding and**
- **organizational ones as a direction in the interpretation of experience.**

Disciplinary knowledge

- **is activated in a way that is functional to the need and**
- **has an operative capacity in the different contexts**
- **In an interdisciplinar perspective**

For scientific learning

Attention should focus on setting up strategies to achieve conceptual change

from common sense → to the scientific knowledge

from hypothesis in phenomena exploration → to interpretative models

PRODUCE LEARNING IN SCIENTIFIC EDUCATION

is a challenge

which involves

the possibility to transfer to the future generations

a culture
in which science is an integral part, not a marginal one

it involves

the possibility to give students

the fundamental elements of scientific education
in a way

that allows the students to manage them
-> in games

-> in stories

-> in the curious questions

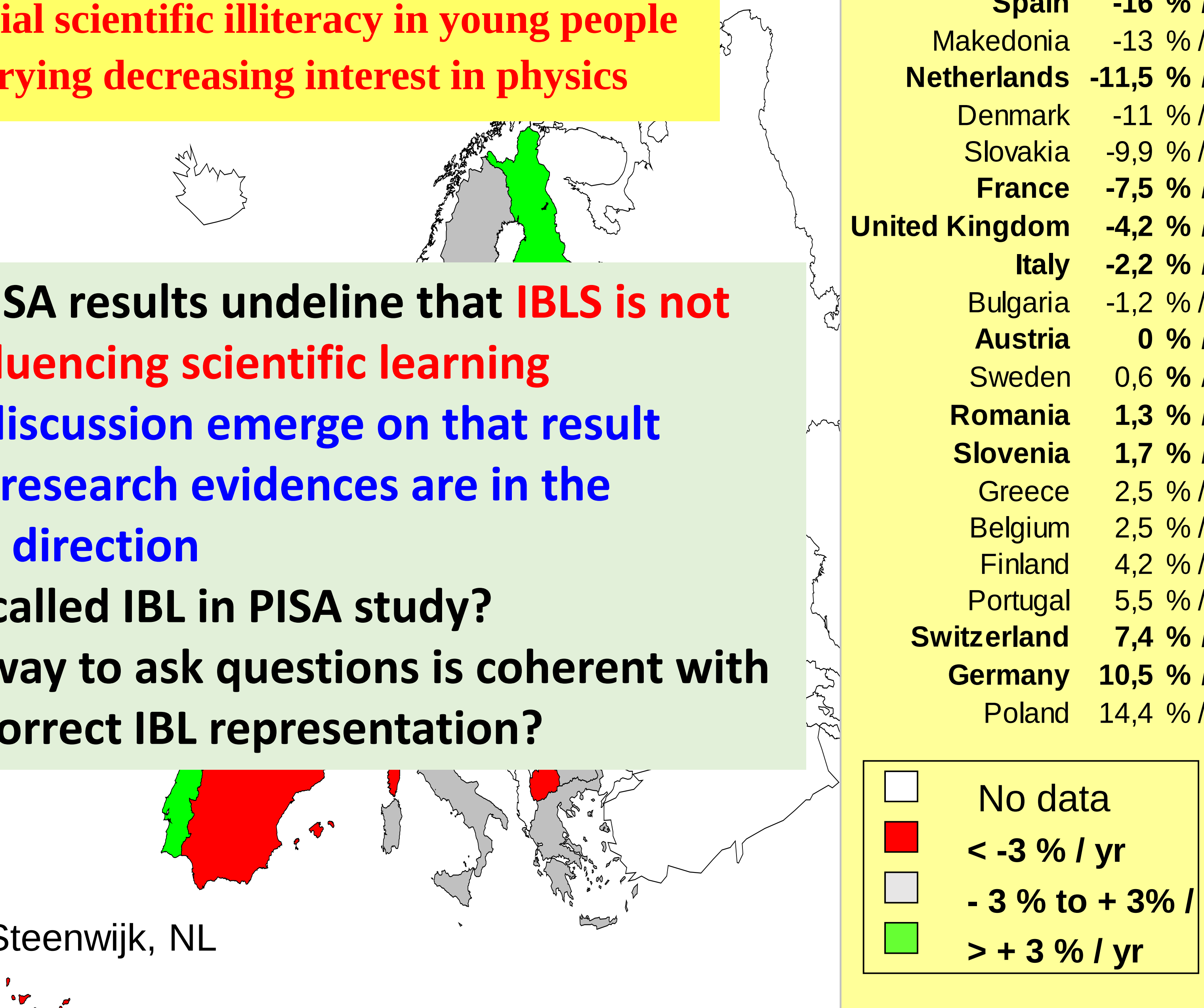
-> in moments of organized analysis
-> in every day life

The first PISA Project was a shock because shows that there is

- •a substantial scientific illiteracy in young people
- •and a worrying decreasing interest in physics

Trends in new enrollments in physics (1998 - 2002) - Uppsala 14.9.03

Spain	**-16 % / yr**
Makedonia	-13 % / yr
Netherlands	**-11,5 % / yr**
Denmark	-11 % / yr
Slovakia	-9,9 % / yr
France	**-7,5 % / yr**
United Kingdom	**-4,2 % / yr**
Italy	**-2,2 % / yr**
Bulgaria	-1,2 % / yr
Austria	**0 % / yr**
Sweden	0,6 % / yr
Romania	**1,3 % / yr**
Slovenia	**1,7 % / yr**
Greece	2,5 % / yr
Belgium	2,5 % / yr
Finland	4,2 % / yr
Portugal	5,5 % / yr
Switzerland	**7,4 % / yr**
Germany	**10,5 % / yr**
Poland	14,4 % / yr



The 2017 PISA results undeline that IBLS is not positive influencing scientific learning

- **A great discussion emerge on that result because research evidences are in the opposite direction**
- **What is called IBL in PISA study?**
  - **The way to ask questions is coherent with the correct IBL representation?**

Frank J. van Steenwijk, NL
EUPEN WG4

Marisa Michelini
Research Unit in Physics Education
University of Udine

The learning challenge: a bridge between everyday experience and scientific knowledge

Improving the way of teaching physics - HOW?

It is necessary to overcome the two main consequences of the method used up to now.

1. It is necessary to start science education very early, together with the first experiences in observing and representing the sorrounding world, during the years of primary school.

2. The perspective have to be to promote learning (not to teach) in different ways according to the context, overcoming the lazy and self-referring habit of always using the same fundamental module.

Attention should focus on teacher professional development and RESEARCH BASED APPROACHES FOR SCIENTIFIC LEARNING

THE BIG PROBLEM / NEED is TO IMPROVE the way of teaching physics

We all still paying for the scarce amount of attention given in the past to the didactic aspects of the teaching of physics.

We have made some tremendous mistakes, which are a burden to the image of physics discipline:

We taught it in the same way in all schools and at all levels.

- We privileged results instead of the processes involved.
- **We used physics models in ideal abstract contexts, without thinking of their use in the real world.**
- The process of formalization was hardly ever made explicit.
- The approximations and simplifications were declared, but not properly motivated.

Physics is therefore considered as a discipline that deals with things that don't exist (the material point, the perfect gas, …), using difficult laws. Its beauty, usefulness and the possibilities to apply it in everyday life don't come out during taught courses.

- **It has been taught too late (only after full competence in maths has been acquired)**

… the vast and demanding work carried out in the field of PER to overcome conceptual knots and promote ConCeptual Learning does not have enough influence.

PER: Different kind of researches

- **Curriculum: structure, managment and contents**
- **Methods: Group work role, home work role, … ICT contribution for learning**
- Conceptual Aspects: relative to the subject and to the conceptual development (role of: context, representation, argumentation, story telling, … analogies and metaphore)
- Learning paths and learning progression (strategies, IBL..,standard and formative assessment)
- New experiments and tools: prototypes
- Multimedia tools and ICT

Main research context discussion

girep

International Research Group on Physics Teaching/Learning
68 Countries

EUROPEAN SCIENCE EDUCATION RESEARCH ASSOCIATION ESERA

EARLI *European Association for Research on Learning and Instruction*

LASERA

EPS-DD

MPTL

AERA 100 AMERICAN EDUCATIONAL RESEARCH ASSOCIATION 1916-2016

AAPT PHYSICS EDUCATION

APS - PysTEC

ICPE on IUPAP

IACPE, CIAREF LAPEN

iSER, PESJ

PER – Physics Education Research

- **Should not to be** confused / replaced with pedagogical research
- **Pedagogical Researches on teaching**
- **Psycological research on individual learning**
- **Sociological studies on the school activities organization**
- It is linked to the building of competences to produce specific disciplinary and interdisciplinary LEARNING (learning of Subject Matter) FOCUSING ON CONTENT

Learning difficulties

They are caused by the missing connection between

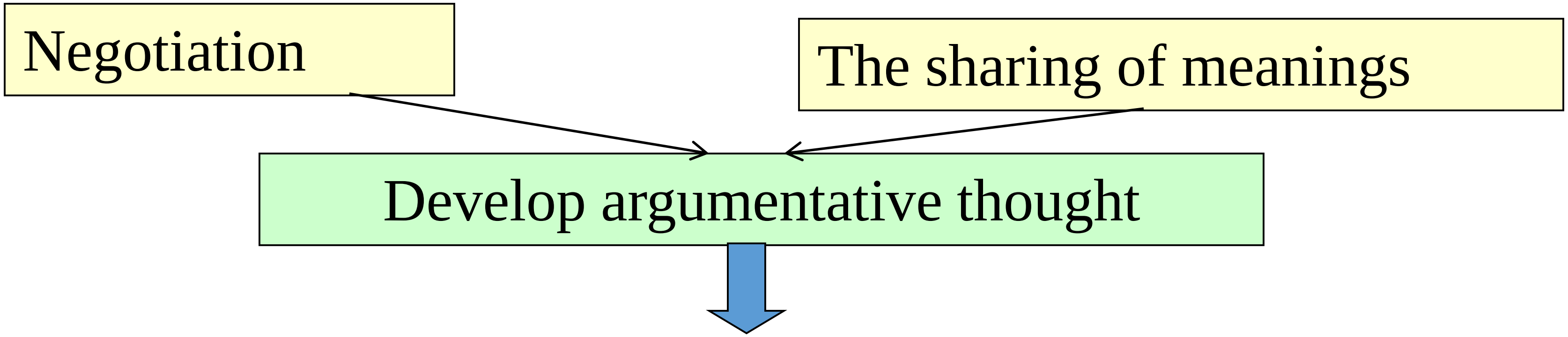
Everyday experience ⟷ Scientific interpretation of phenomena

There is the need for

- **continuity between conceptual models**
  - personal
  - of the knowledge to acquire

- **connection between knowledge and the context of its use** (situation - learning)

- **its sharing**



Didactic activity should therefore foresee:

- **personal operative involvement (hand-on /minds-on)**
- **explorations of ideas and realities**
- **application of hypotheses**
- **the use and comparison of interpretations**

The learning challenge: a new perspective for teachers

Their task is not to teach but to produce learning

Our Research approaches

- **The first step in research task is**
  - **to rethink scientific content as a problematic issue,**
  - **to rebuild this with an educative perspective.**
- **This task is often integrated with**
  - **empirical research on student reasoning and T/L paths**
  - **action –research in a collaborative dialectic between school and university**
- **The approaches in our work are therefore not purely based upon disciplinary content** (Fischer 2005) **in order to identify strategies for conceptual change** (Vosniadou, 2008)**.**

the research approach on learning processes

- **Rather than**
  - **general results or**
  - **catalogues of difficulties,**

  we are interested in the obstacles that must be overcome to reach a scientific level of understanding and the construction of formal thinking.
- **We are interested in**
  - **the internal logic of reasoning**
  - **Spontaneous *Mental Models***
  - **their dynamic evolution following problematic stimulus (inquiry learning) in proposed path.**
- **Research-based experimentation allows us to explore the contribute for learning of the proposals of T/L paths in an operative way.**

Physics Education Research

in Udine University

Our main research fields

*** Innovation in physics Teaching and Learning (T/L)** with methodologies of research and development (R&D):

- **New topics** as QF, Superconductivity, background physics in research methods (RBS, TRR, Electrical Transport Properties of materials…)
- **New hw&sw systems**: sensor on –line hw&sw systems via USB

*** Methodological aspects** such as

- the role of the ICTs in overcoming conceptual knots,
- **the processes of constructing formal thinking,**

*** Informal learning**

Spontaneous models and reasoning

the role for learning of games, playing, models

* **Teacher Education:** pre-in service

Physics Education Research

in Udine University

The building of formal thinking in our researches

is in 3 directions

1. **Informal Learning, Learning processes and role of:**
   1. **Operativity: hands-on & minds-on to interpret phenomena**
   2. **Objectual models: tools to bridge common sense to physics ideas**
2. **ICT contribution: RTL & modeling**
3. **Building theoretical way of thinking: a path inspired of Dirac approach to QM**

THE CONTEXT of Informal learning research

comes from

an operative proposal with

- Poor materials, easy to reproduce
- computer on line sensors as sense extensions

the exhibit Games Experiments Ideas (GEI)

250 experiments to do not only to see

- An open environment to

play and do experiments

Exploring ideas

Using ideas to explore phenomena

GEI – A learning environment of
- poor materials
- significance experiments
- opportunities to explore

Exploring ideas … to undestand phenomena

Exploring phenomena … to interpret its

…to play *minds – on* to learn

Play not game … to think
and not only to play
STRUCTURING THE WAY OF THINKING

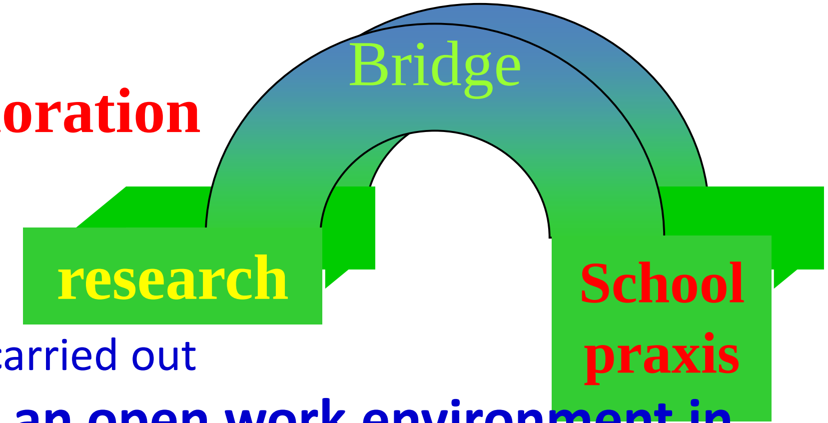
The ludic context of playing offers a great opportunity
for subject development and learning
providing the transition from (Vygotskij):
- The concrete context of action
- The abstract thinking

The de-contextualization of play
stimulates and activates personal learning processes and
achieves a connection with ludic-symbolical abilities.

Playing the learner amplifies its vision of the world and
learns the way in which thought is structured
in relation to the experience
the place of experimentation becomes the place of learning (Bateson)

CLOE
Conceptual Labs of Operative Exploration

A. Maps
B. Contexts analysis
C. Problem-solving



CLOE Labs are carried out

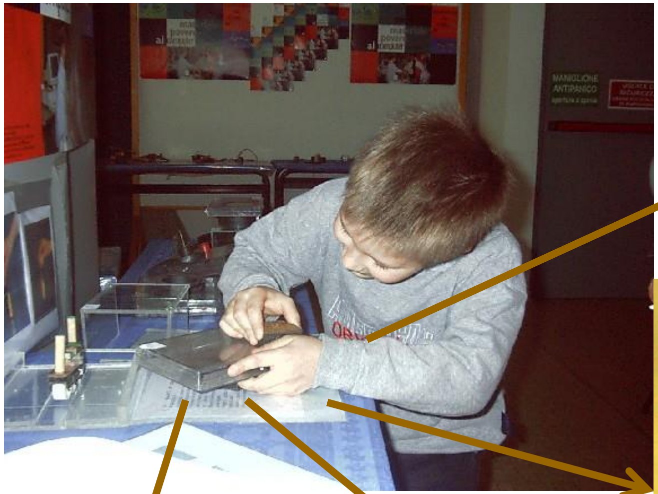
- **providing an open work environment in which students have an operative role**
- **proposing problematic situations on specific different topic,**
- **using semi-structured interview and Task-worksheet to explore ideas**

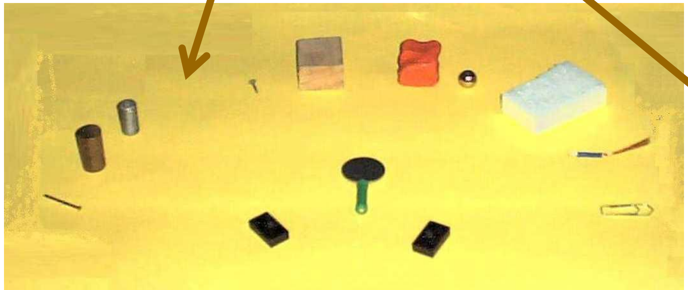
Monoconceptual explorations

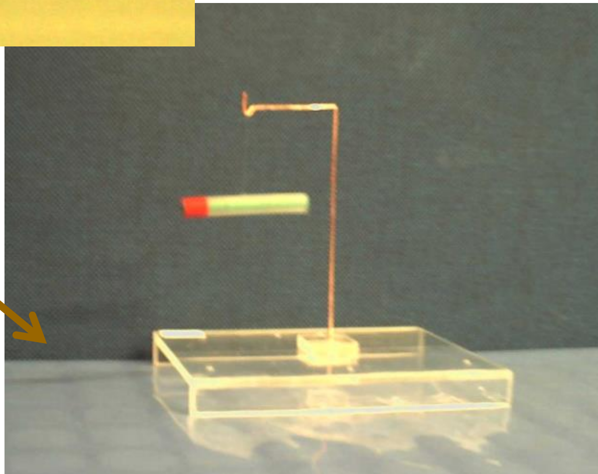
Carried out with different modalities

The case of magnetism

Individual exploration



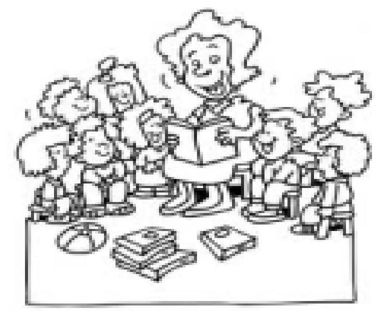




CLOE Labs

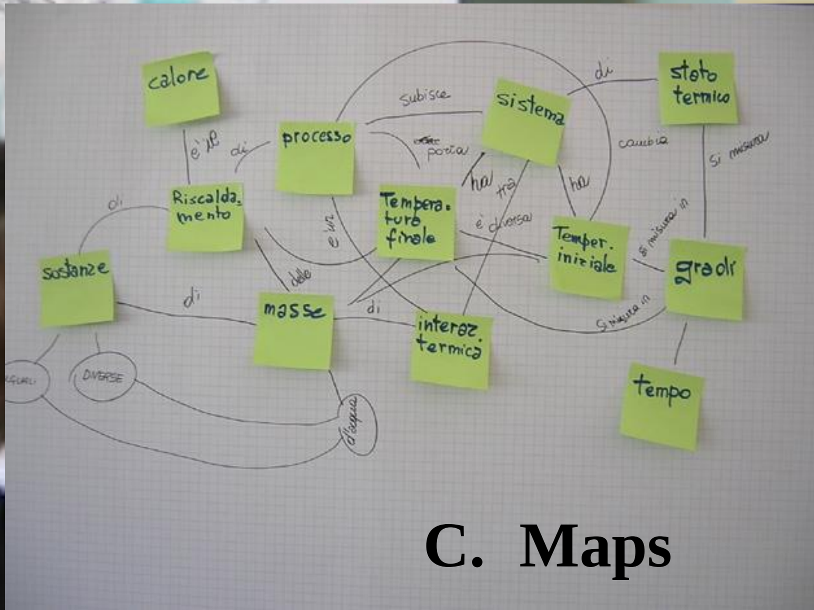
Different modalities

Interactive explorations and discussions



Group work discussion of ideas

Spontaneous MAPS production

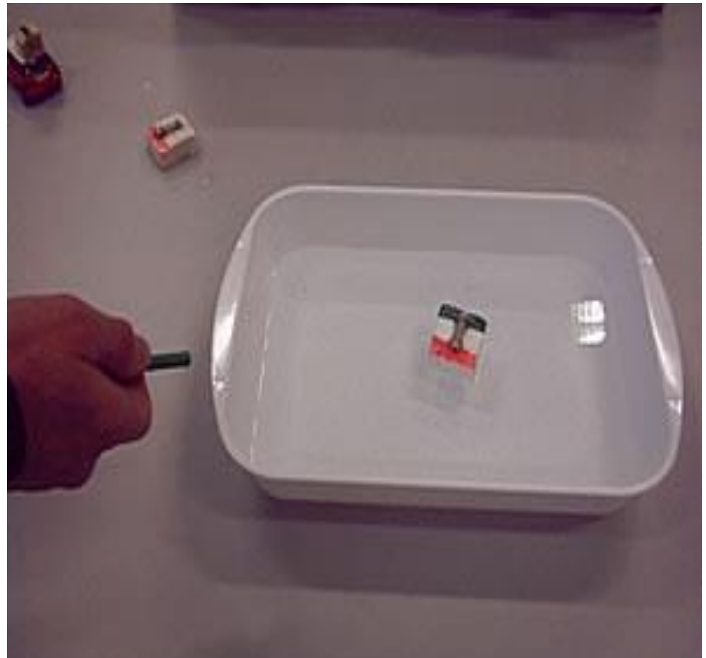


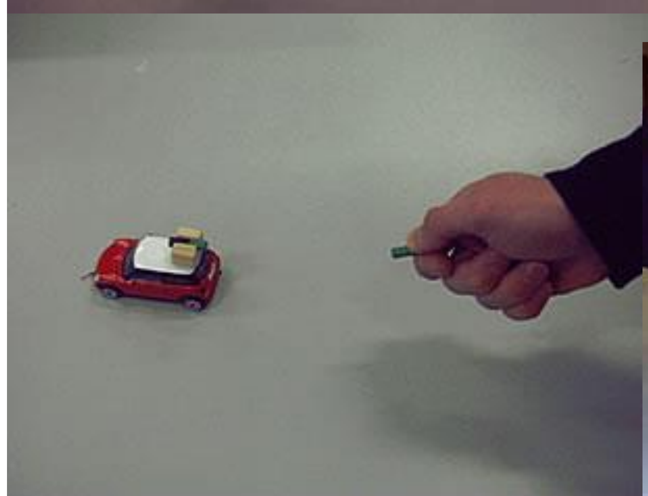
C. Maps

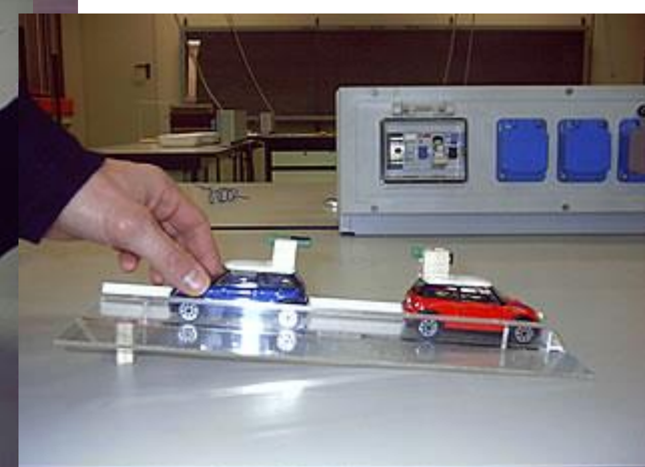
In CLOE conceptual Labs

Research Questions in learning process

- *The Role of:*
  - *Operativity*
  - Personal involvment in phenomena exploration
  - Context
- Reasoning in phenomena interpretation
- Kind of formalisation







- Phenomena analysis PLANS:
  - Descriptive
  - interpretative.
- Models used in the different situations
- Representations adopted

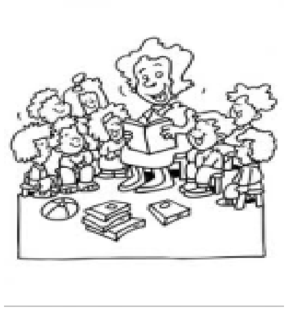
MONITORING LEARNING PROGRESS

Data collection is carried out by means of

- Test in-out
- IBL Tutorials monitoring learning process

- Interviews
  - Semi structured
  - Rogersian interviews

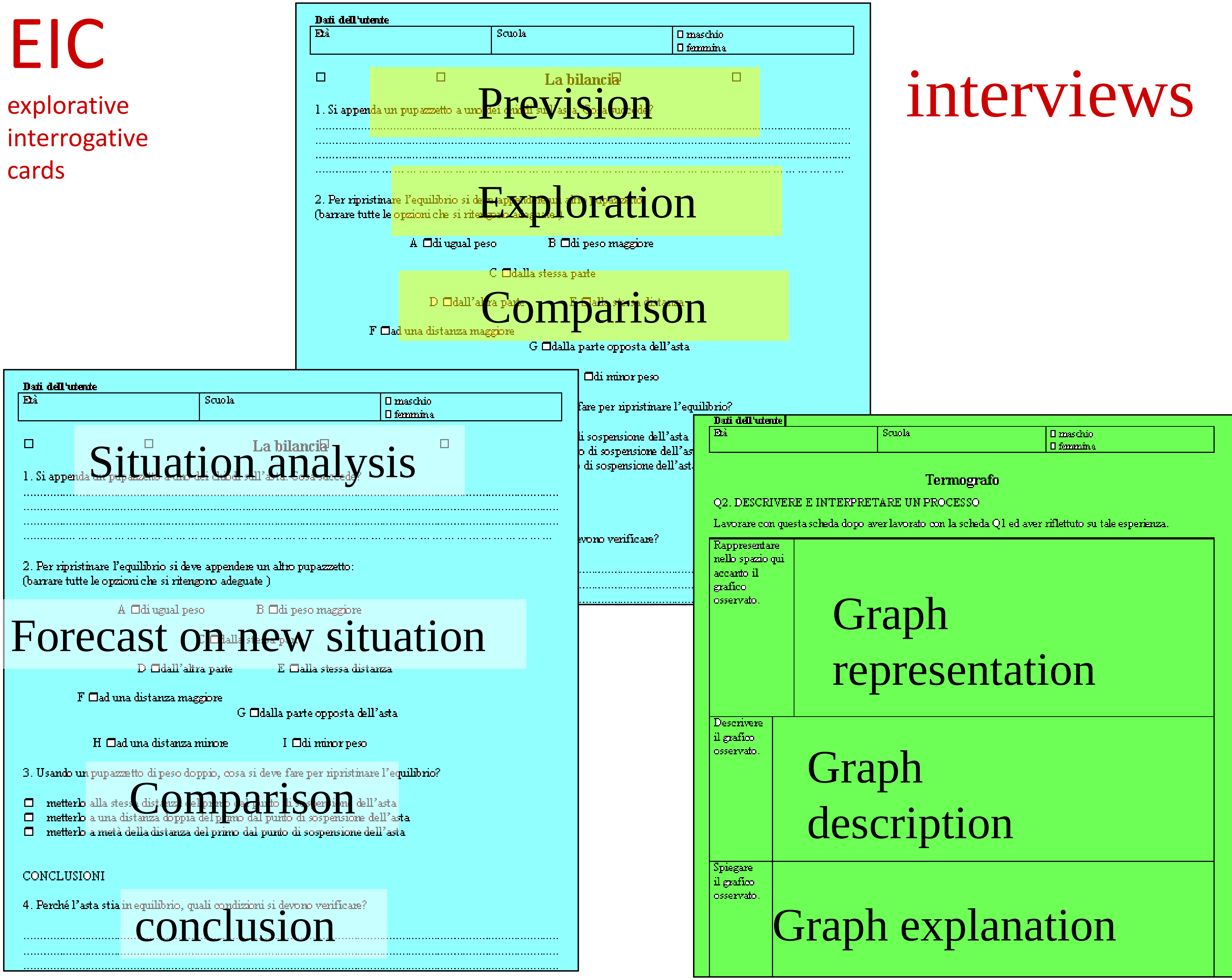
- Video-recording of
  - Small group discussions
  - large group interactions



EIC

explorative
interrogative
cards

interviews



Resources environment of professional materials for teachers

-Experiments, Educational path, research outcomes on learning processes, assessment materials, Java applets for modeling

- documentation of teaching experiments on innovation in T/L

The objectual models

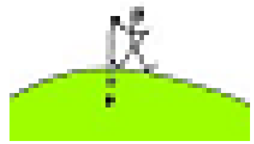
Conceptual referent for learning

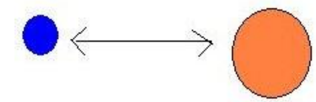
Mental, analogical and objectual models

- The capacity to read, to influence, to control, to interpret a physics phenomenon depend from the construction of a partial interpretative model of the phenomenon.
- **A mental model is “ A personal, private, representation of a target” (Gilbert and Boulter 1998).**

- Reaching a scientific level requires the overcoming of obstacles of a various nature, such as that of **attributing a material nature to physics quantities**.
- Our research found that **objectual models** were useful, in that they represent aspects of a phenomenology that may be used to test one’s own ideas.
- Let me mention several examples taken from our research at primary school level.

Free fall





1. **Children interpret the free fall phenomenology as local**.
2. Children representation are always **partial** and can evolve towards a more global vision, by promoting **reasoning sequences** by means of:
    1. **individual reflection** about local and global elements
    2. **argumentative discussions** to **compare ideas**.

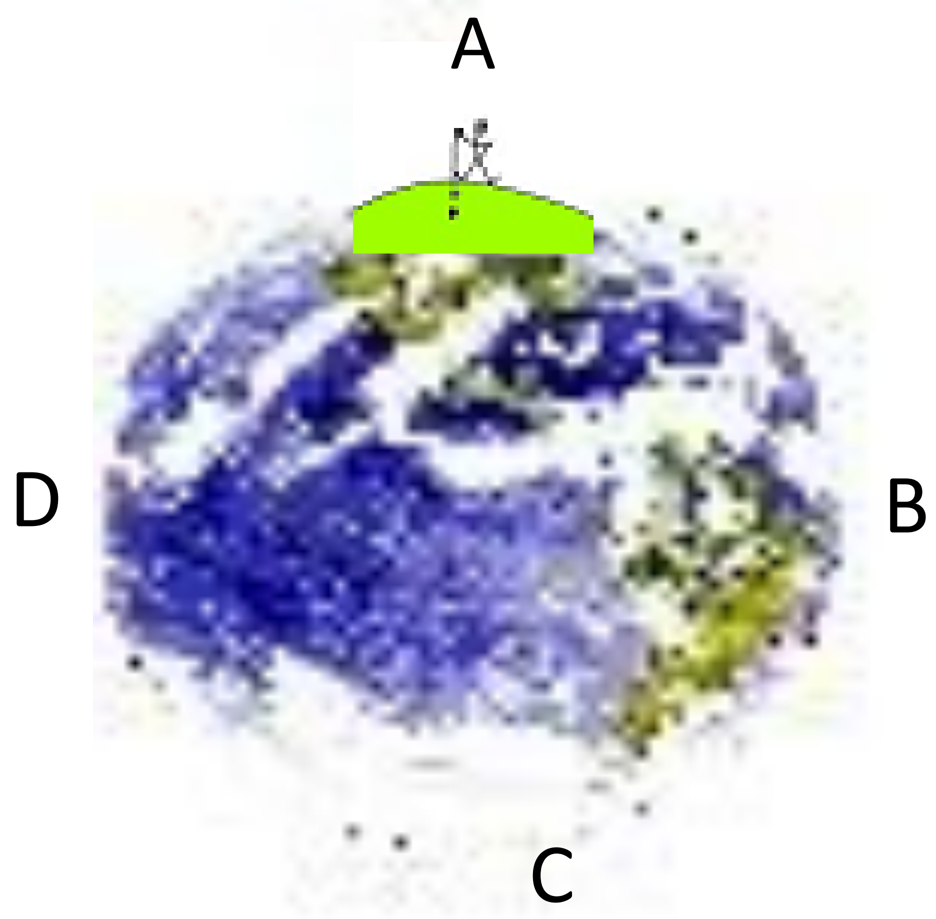
on an objectual model of global situation

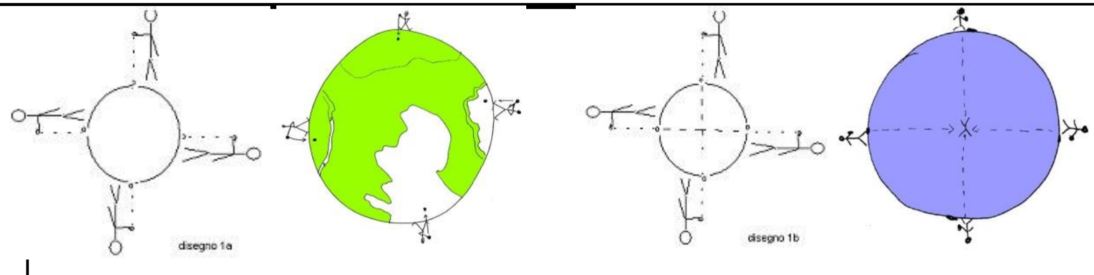
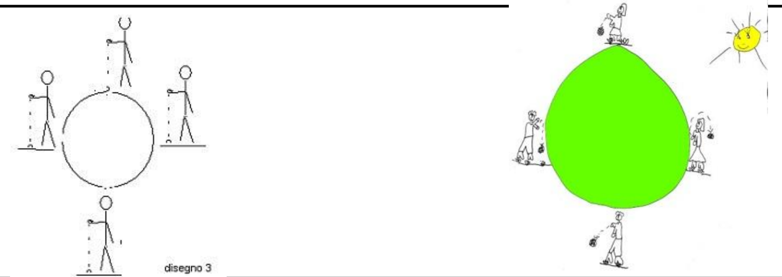
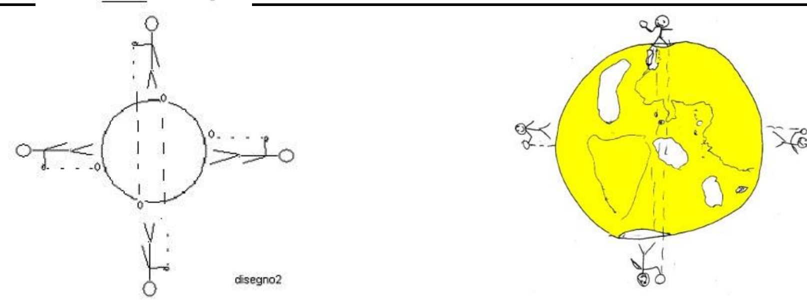
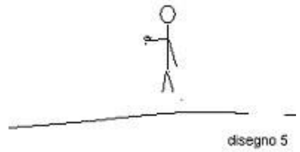
TRY

DRAW the free fall of a ball in 4 points of the Earth

TRY

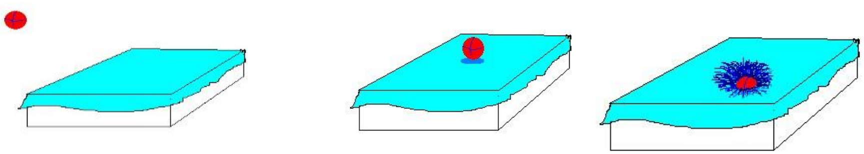
DRAW the free fall of a ball in 4 points of the Earth: A, B, C, D



Radial simmetry 44,6 %	
Local vision 21%	
Local in global 18,9 %	
Kinematics vision 6,8 %	
Flat Hearth 12 %	

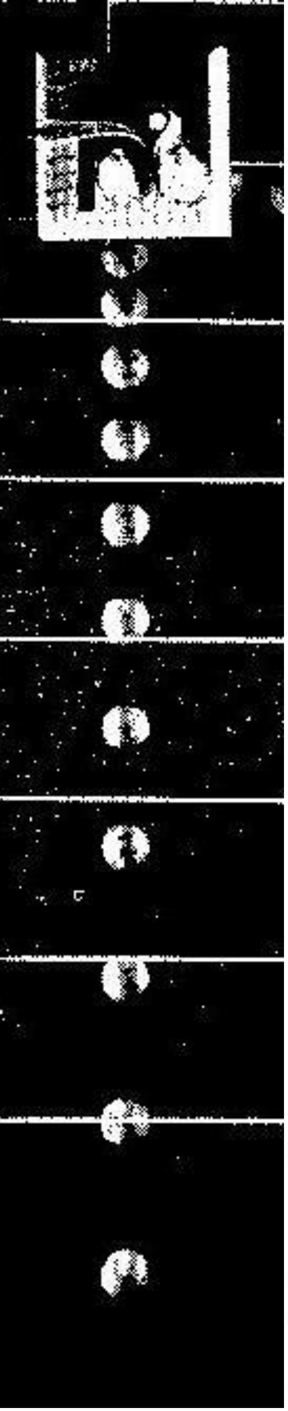
CLOE and The objectual model

A sheet of elastic cloth attached to a square frame became Eddington's model for the study of falling bodies with a variation in initial conditions



- It represent for the children the space at two separate alternatives ways:
- a) small distance from Earth (free fall),
- b) planetary level (interaction between masses).

When we considered ball motion on the region of field represented by the model then childrens pass from local to global vision.

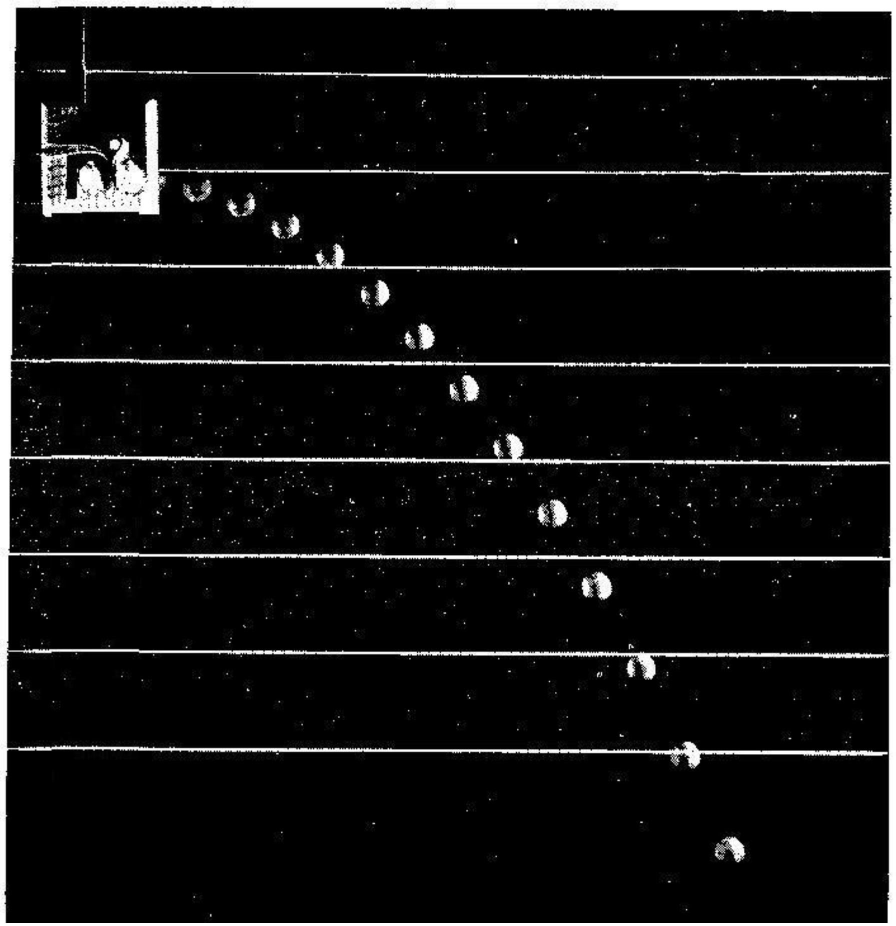


The falling

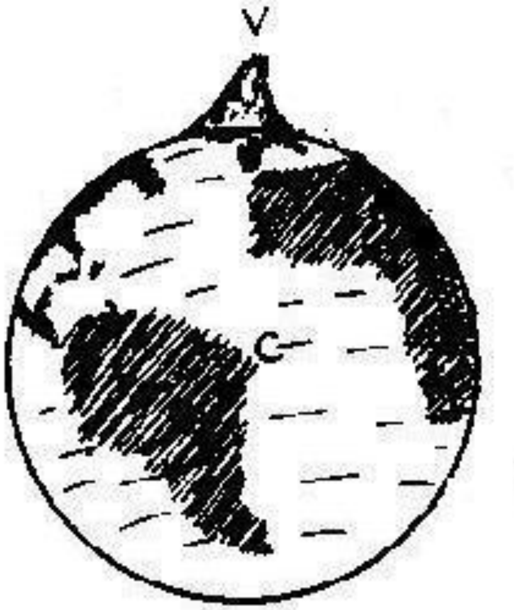
The dynamic case

Earth and a big mountain
(Newton mental model)

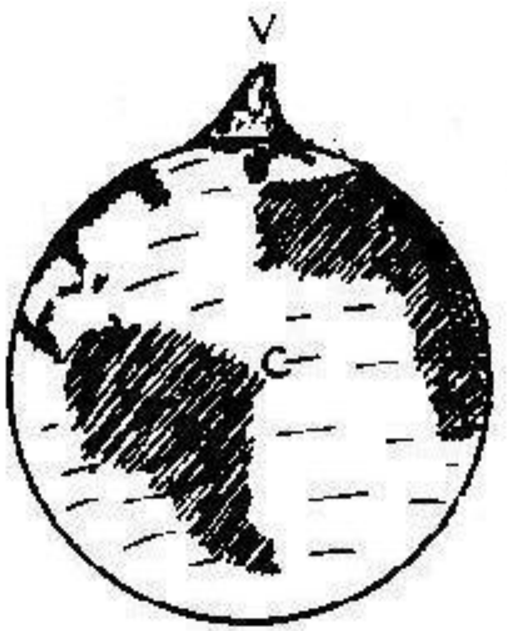
LOCAL situation



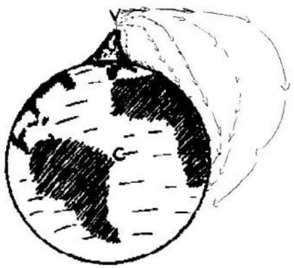
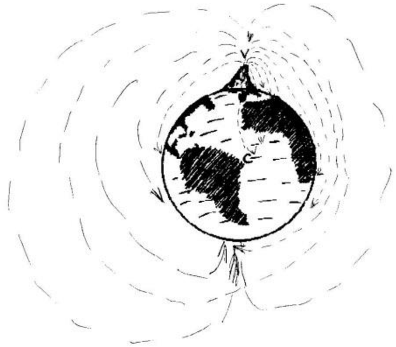
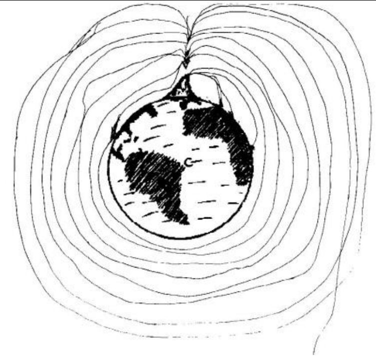
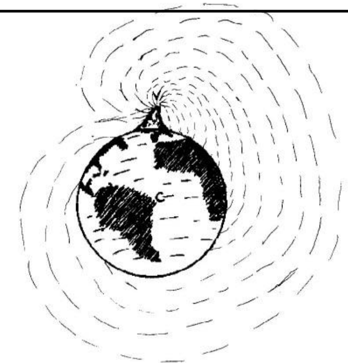
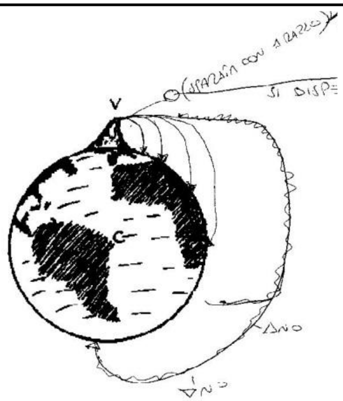
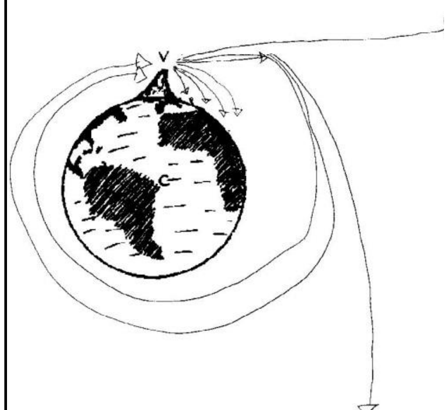
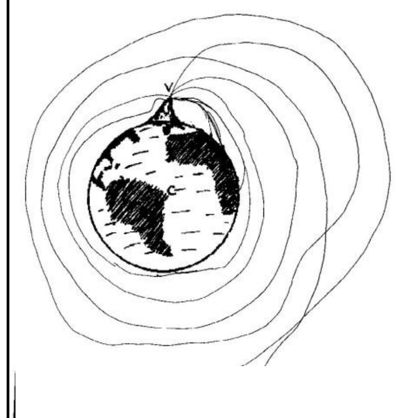
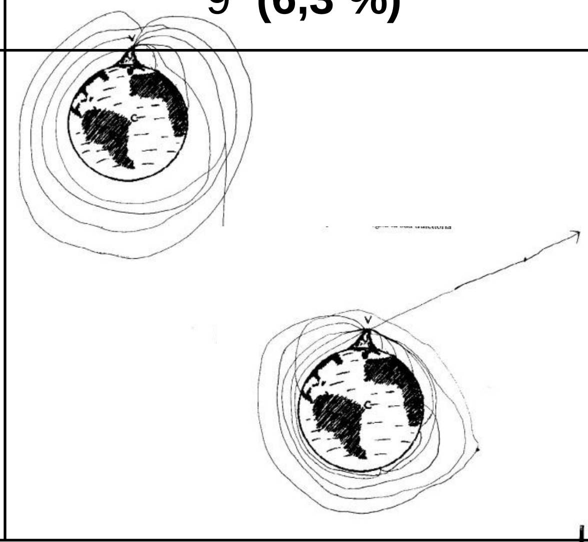
GLOBAL situation



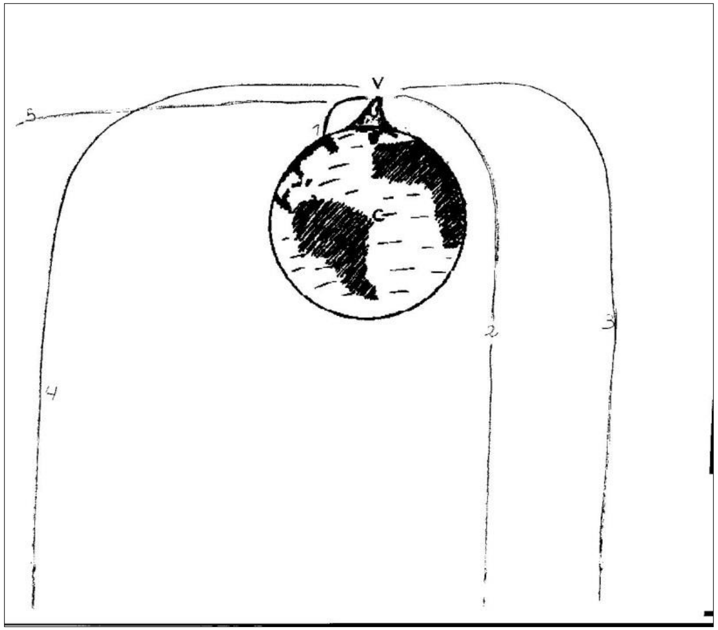
The Earth and a big mountain



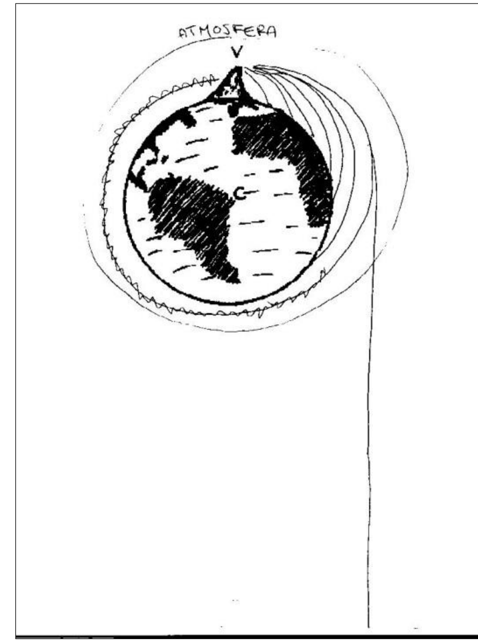
Children previsions

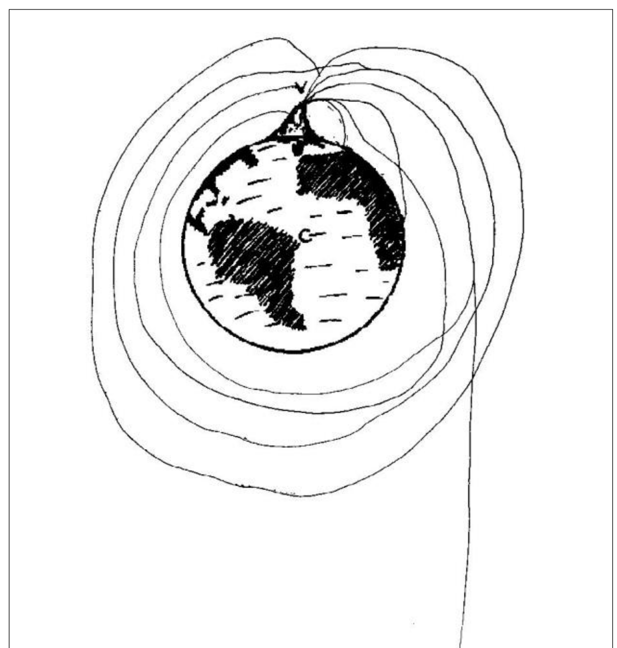
Local vision	Bipolar vision	Monopolar vision	
68 (**47,2 %**)	8 (**5,6 %**)	14 (**9,7 %**)	14 (**9,7 %**)
			
2 possibilities	3 possibilities	not yet the orbit	circular orbit
10 (**6,9 %**)	18 (**12,5 %**)	4 (**2,8 %**)	9 (**6,3 %**)
			

Examples of children reasonings



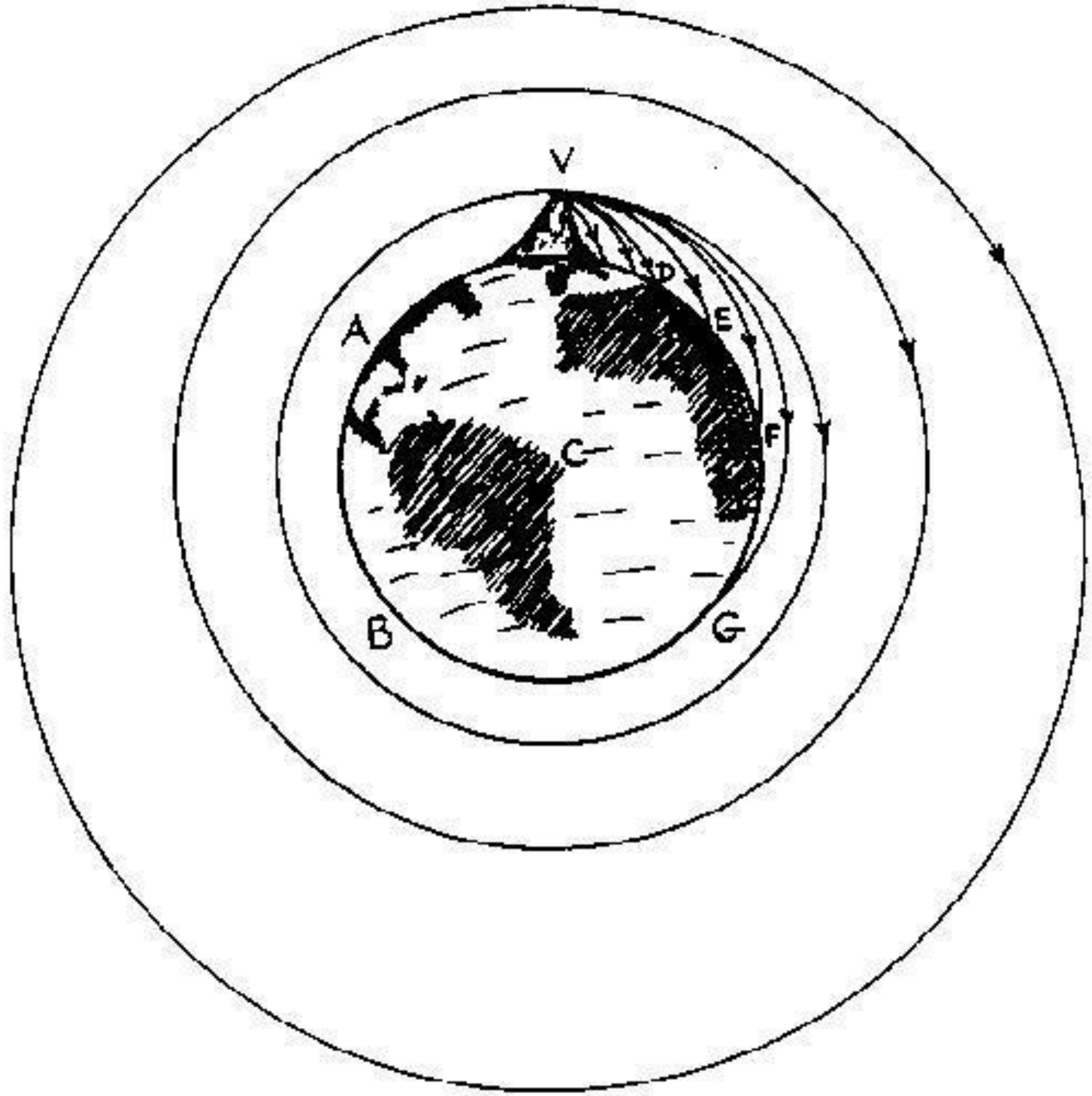
local vision





Prevision of the circular orbita

Newton



Gravity and free fall

Objectual model of an Elevator and VIDEO

A transparent shirt box, inside of which we have placed various systems: a mass hanging from a vertical spring, objects sitting on the base, a pendulum, which became an elevator for the observation of free fall and reasoning on gravity


Finestra anteprima
0 0,0 00 00


0 0,0 00 56


0 0,0 00 64