Meteorites in Education

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Introduction

Scientific concepts in Planetary Science are in large part based on theories and models. These theories are changing with new observations or models that describe reality better that previous ones. System of major theories – called paradigmes [1]– are changing when new observations and better models made majority of scientists abandon an earlier system of theories. This event is called a paradigm shift.
Such systems of theory also exist in the minds of everyone. Concepts of a phenomenon – meteorites, for example – are different in the mind of a 5-year old child and a grown-up. During someone's education, "paradigm shifts" occur concerning these concepts, but these systems are not as coherent as scientific paradigms and not always fit the current scientific frames. Such change of cognitive schemes were first described by Piaget [2].
Mapping these mental concepts from kindergarten to university level reveal (1) the change in personal (more or less coherent) explanations of things (mostly in childhood), the effect of education: (2) in one part, the material the student memorized and the extent of distorsion of the memorized curriculum; and (3) the impact of popular media: press, movies, books etc. From these three sources sometimes conflicting theories can be found in the concepts of students, one often not being able to erase or overwrite the other. Materials learned through formal education often results in passive knowledge that can not be used for solving real, practical problems or linking the memorized material to scenes seen at the cinema.
In formal education and also in scientific outreach – including press releases – it is essential to know the prior knowledge, concepts and misconceptions of the potential reader (in schools: student). Without having a picture of these, educational and outreach materials may be not effective.
The research of the conceptual framework (including preinstructional and informal knowledge) and misconceptions has a rich literature. Several research was made about the mental concepts and naive models of the Earth, Sun, Moon and the Day/Nigh cycle [3, 4, 5, 6].

Mapping concepts and misconceptions about meteorites

Large part of previous research concentrated on the ages of 3 to 12 years. The research presented here has the goal to map concepts and misconceptions from 3 to 23 years, from kindergarten to university level. The research was conducted in Budapest and Piliscsaba (the capital of Hun-

gary and a small town 30 km North of Budapest).

In the research knowledge about meteorites was mapped. Since meteorites are part of the popular culture, children from very early age has a concept about them. This concept is well grounded from an early age and is refined with new elements during the years of education (a good example to this refinement is the knowledge of the building material of meteorites). However, in a later stage new misconceptions may come in.

Questions

In the research we used informal discussion in kindergarten (audio recorded and typed later) and questionnaires for older students. For the older students, new questions were added.

The basic questions were the followings:

– *What is a meteorite?*
– *What are meteorites made of?*
– *What is the size of meteorites?*
– *Where can you find meteorites?*
– *What happens when a meteorite reaches the surface of the Earth?*
– *What is the difference between meteorites and meteors?*
– *What is the relation of falling stars and meteorites?*
– *Which are the best known meteorites?*
– *What is the goal of the scientific research on meteorites?*
– *Draw the timeline of the life a meteorite.*

Results

– children from a very early age have a general concept of what a meteorite is
– at high school level even the difference of meteorites and meteors are clear to some of the students
– there are clear age categories when a new information is built into the knowledge of meteorites
– in several cases the answers reveal basic contradictions
– the word “meteorite” can refer to asteroids, comets, meteoroids, meteors, meteorites or “transient” planetary bodies (Fig.1.) or even craters to many students
– There is a confusion about where one can find a meteorite: in space or on Earth
– At kindergarten level, falling stars and meteorites are clearly two separate phenomena. For some 15-16 years old, these two are “similar”, to other 15-16 years old they have “no connection”.
– The extinction of dinosaurs are usually not linked to meteorites or and impact event at kindergarten; but they have other explanations.
– Several students related the goal of meteorite research to avoiding large impact to Earth.

The last result is not surprising, since the goal of real scientists of a particular field of study is often
poorly known by students, even at university level.

This and other results show the topics that should be explained or clarified and stressed in educational and outreach materials for the various ages. Visualization of such problems (like “the life of a meteorite”) is essential in this.

METHODS. The reserach was made by audio recording and transcripting at the 3-6 year age in Hétszínvirág Kindergarten, Piliscsaba, Hungary; by reading questions aloud and aswering by filling out forms by 8 years old students at Jókai Mór Elementary School (2nd grade) Piliscsaba, Hungary, by forms by 14-15 years old students of Jókai Mór Elementary School (8th grade) Piliscsaba, Hungary, and by 18-20 years old students of Katolikus Egyetemi Ginmázium, Budapest, Hungary (9th and 12th grade), by the Eötvös Loránd University communication and liberal arts major students (1st grade, 19-21 years old), Eötvös Loránd University geography/environmental science/geology students (various grade 19-21 years old) and at the older generations the forms were completed by parents or gradparents of students, relatives and friends. The survey is a not representative, qualitative one.

What is a meteorite?

At kindergarten age there were some who has not heard the word meteorite, but even those knew about falling stars.

What is a Falling star
Age 3-6 (answers)
Falling speadily from the sky
We can wish something from it
They fall TO the sky
A star falling to the Earth or to Sea
Stars are planets, but falling stars are not

What is a Meteorite:
Age 3-6 (answers)
An other planet
Big fiery sphere
Fire shaped
A (small) piece is broken from a planet which piece is falling into the Earth

Age 8
Piece of the Sun
A Stone
It is floating, broken from planets
Falling star
Glowing sphere/body

Age 14-15
Impacted/fallen meteor/stone (to the Earth, or to a planet), made of iron/ice/
Speeding piece of stone in space
A celestial body
Which is broken from a meteor
"soft snowball"
Flying stone
Fast moving celestial body made of stone/iron

Age 18-20, high school
Flying stone
"crater body"
piece of stone
pieces broken from something
interstellar trash
pieces of planet/stones flying in space
pieces from stars
landed stone from space
irregular shaped celestial body

Age 19-20, art university
planetary piece made by impact or destruction
impacted meteor
space debris

Age 19-21, geography major university
Stone piece from space fallen to a planet
meteor entered to the atmosphere
falling star, burning in the atmosphere
a broken piece of stine reaching the surface
piece of a larger celestial body
stone piece from space
piece of stone

Age 30-40
stone impacted to the Earth
stone wandeing in space
meteor fallen to Earth
stone made from a meteor
stone fallen to the Earth or other planet which remained after its burning
broken piece of stone
a piece of stone fallen from Space

Age 60-70
pieces of a blasted star (falling star)
small part of a star

Meteorites are made of...

Age 8
stone

Age 14 (elementary school)
stone
iron

Age 15-16 (high school)
meteor fragments
frozen gas, stone
metal, stone
stone broken from stars
ice, coal
stone

Age 18-20, high school
stone
rock
earth
metal
iron core+rock

Age 19-20, art university
stone, gas
atoms
dust, stone

Age 19-21, geography major university
metals, silicates
iron
minerals, iron, rocks
rock
dust particles
iron, stone, condrite
rock, ice

Age 30-40
stone, coal, iron
star fragments
stone, metal
mainly rock, some metal
rock

Age 60-70

rock

Best known meteorites

Age 8
—

Age 14 (elementary school)
“I saw one at the rock shop”

Age 15-16 (high school)
Eros
Helios

Age 18-20, high school
Which made Superman
Halley
Kaaba-stone
Kaaba in Mecca

Age 19-20, art university
–

Age 19-21, geography major university
Kaaba-stone
Shergotty, Nakhla, Le Fayette
Kaba (Hungary), Nakhla, Shergota, Chassigny, ALHA
SNC
Antarctic, Arizona
Lionides
Kaaba, Tunguz
Kaba (Hungary)

Age 30-40
Tunguzka
Tunguz, Arizona, Ries
in USA, China
Kaaba stone, and which was found by Exupery in Sahara Desert

Age 60-70

–

What is the goal of the scientific research on meteorites?

Age 8
money

Age 14 (elementary school)
money
lot of money
earn lot of money
know how it looks like when impacted
know more about their origin
because it may impact

Age 15-16 (high school)
know why dinosaurs are extinct
its material
filter which are coming in our direction
resrearch of things beyond Earth
to be able to determine where it will impact
to know when it will impact which may cause end of the world
know what is in space
to avoid an impact/catastrophe

Age 18-20, high school
study rocks
they may carry life
calculate impact
infer ancient times
discovery of new elements

Age 19-20, art university
retrieve unknown minerals
information about space
know how close and when they approach Earth

Age 19-21, geography major university
Age and state/materials of early Solar System
Formation of the World
may carry elements that can contain information of other lifeforms
know its composition
know Solar System, how we have been created
study other planets
study of Extraterrstrial life
study of extraterrstrial rocks

Age 30-40
material of the univers
infer past of solar system
they show origin of the world and Earth
like other reserach: know more about the world, our curiosity

Age 60-70
know materials of the space
know its composition

Where can you find meteorites?

Age 8
Museum
space

Age 14 (elementary school)
space
anywhere
cosmos

Age 15-16 (high school)
in craters
galaxy main plane, outside solar system
On Earth
space
meteor: space, meteorite: impacted
near planets
where a meteor has been fallen down

Age 18-20, high school
space
asteroid belt, oort could

Age 19-20, art university
space
between planets and on planets
in the soil
space, sometimes impacted

Age 19-21, geography major university
Greenland, Antarctica, theoretically anywhere
near impacts
anywhere if impacted Earth
desert, ice desert
space
on any planet
Moon, Bay of Mexico, Meteor crater
Antarctica, E-Siberia

Age 30-40
surface of Earth, mineral shop
Surface of Moon, Mars
space or impacted on Earth

Age 60-70
on any continent
Siberia, museums

What happens when a meteorite reaches the Earth?

Age 8
we die
nothing

Age 14 (elementary school)
starts burning
impacts
explodes

Age 15-16 (high school)
burns as it interacts the atmosphere
impacts, making crater
glows in the air and impacts or burns in the atmosphere
impacts
burns or impacts
it does not reach the surface because it burns in the atmosphere
burns away
catastrophe

Age 18-20, high school
burns or impacts
boom
impacts, making shock wave and crater
impacts and cools

Age 19-20, art university
depending size it impacts and makes energy wave
impacts
impacts or sometimes burns in the air before it could reach surface
starts burning before impact
impacts or burns

Age 19-21, geography major university
impacts, crater
impacts
glows, explodes, impacts
interacts with the atmosphere
if reaches surface, impacts

Age 30-40
makes a hole
glows, burns
destruction
becomes a meteor
makes heat, some say such exterminated dinosaurs
impacts, depending its size make small or big crater

Age 60-70
impacts, making crater
impacts

Meteor / Meteorite / Falling Star difference

Age 8

meteor/meteorite	*meteorite/falling star*
shape	nothing
	m. bigger
stone/earth(soil)	

Age 14 (elementary school)

meteor/meteorite	*meteorite/falling star*
in space/on earth	
	f. not explodes
	speed
house size/walnut size	

Age 15-16 (high school)

meteor/meteorite	*meteorite/falling star*
not impacted/impaced	impacted/orbiting in space
	both burn in the air
	m reaches surface, f. not
in space/impacted	none
meteor bigger	
	same

Age 18-20, high school

meteor/meteorite	*meteorite/falling star*
	f. burns in the air, m not
size	both falls
	same
meteor reaches surface	
meteorit reaches surface	
meteorit landed meteor rock	

Age 19-20, art university

meteor/meteorite	*meteorite/falling star*
tail?	
meteor is a meteorit reached the atmosphere	
one in sky other on Earth	same
f. reached the atmosphere	
meteorite is broken piece of meteor	
	both fly

Age 19-21, geography major university

meteor/meteorite	*meteorite/falling star*
	m reaches ground, f. not
size	same
meteorit reaches ground	
	ligh phenomena is a f.
	f. is a folk name for falling m.
	f. dust particle, m. larger

Age 30-40

meteor/meteorite	*meteorite/falling star*
falls/stone	f. becomes m.
meteor on earth	f. reached the atmosphere
m. flies, meteorite stone made of meteor	
meteor never reaches ground, lives in the sky	
fallen f.=meteorite	

Age 60-70

meteor/meteorite	*meteorite/falling star*
size	f. reaches atmosphere

Conclusion

The mental concept of meteorites is being mapped from kindergarten to university level. Several misconceptions and conflicting concepts have been found. The research revels topics that should be clarified or that should have more emphasis in educational or outreach materials from elementary to university level. The word meteor, meteorit is cofused with large impacting bodies, at an early age pieces of stars. The falling star phenomena is usually linked with landed meteorites. The concept of meteor swarm or cometary origin was never mentionned. The difference between falling and crater producing impacting was never mentionned. It is often confused if a Tunguz event or a crater making impact event can be a finding place of meteorites or not.

One of the most interesting result is about the goal of meteorite research in general: students have a poor understanding about what meteorite researchers are doing. Many young studenst see its purpose solely on earning money, later avoiding a catastrophiong impact event becomes dominant conecpt.

As a conclusion, the use of terms, the form of words (meteor, meteorite, impact of meteorite, meteor crater) often creates its own meaning, which is not similar to the meaning used by scientists, as terminus technicus. Therefore in education and outreach, popular science publications the teachers/authors should concentrate on the explanation of the scientific concepts and differences between these confusable terms and concepts, mentionning also what a meteor/ite is NOT, i.e. mentionning the misconceptions, in order to indentify them by the audience.

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