The outer Universe and the inner...
-What is the connection?

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Space ’n stuff
Space ’n stuff

- Astronomy is exciting regardless of age and background!
- But also hard to understand...
- It is so **BIG** and **EMPTY**!
- **3D** (or 4D?)
- **LOOK UP!**
- **DISCERN!**
- **CREATE MEANING!**

Josh Worth animation
Some exemples
Don’t we just love all these images?!
Difficulties?
Difficulties?

• Distance determination!
Difficulties?

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• Vision - to see
• binocular and monocular
Difficulties?

• Distance determination!
• Vision - to see
• binoculär and monocular
Difficulties?

- Distance determination!
- Vision - to see
  - binoculär and monocular
- The brain
Difficulties?

- Distance determination!
- Vision - to see
  - binocular and monocular
- The brain
- Perception!
Difficulties?

- Distance determination!
- Vision - to see
  - binocular and monocular
- The brain
- Perception!
- Motion parallax
Motion parallax

Observer movement

Fixation star

A

B
What has been done?
What has been done?

• Very much research on human difficulties concerning perception connected to the 3D structure of the Universe focusing on The Earth, the Moon and the Sun.
What has been done?

Mental Models of the Day/Night Cycle

Stella Vosniadou
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and University of Illinois at Urbana-Champaign

William F. Brewer
University of Illinois at Urbana-Champaign

This article presents the results of an experiment which investigated elementary school children's explanations of the day/night cycle. The children were asked to explain three phenomena: the sun during the night, the disappearance of the moon, and the alternation of day and night. The majority of the children in our sample used a number of relatively well-defined mental models (e.g., at a certain time the sun rises, at another time the sun goes down, and in between the sun is stationary) to explain the day/night cycle. These mental models were empirically accurate, logically consistent, and drawn from everyday experience (e.g., the sun clouds cover the sun). The older children constructed a mental model of the day/night cycle that was based on everyday experience (e.g., the sun rises over the horizon and sets over the horizon). The older children's mental models were more complex and consistent with aspects of their initial models. A few children have constructed a mental model of the day/night cycle with a hierarchical structure of constraints, some of which emerge later out of the structure.

Pupils' explanations of seasonal changes: age differences and the influence of teaching

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Background. Pupils have consistent everyday astronomical explanations, some of which, e.g., distance theory, are very resistant to change. The reasons

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What has been done in research on human difficult using perception connected to universe of the Universe focusing on The Earth, the Moon and the Sun.

- All results show that the representations used in eg. books are insufficient, inadequate (2D) and incorrect...
Sometimes it gets really confusing...
Sometimes it gets really confusing…
Cosmic Epochs

- Big Bang
- Radiation era
- ~300,000 years: "Dark Ages" begin
- ~400 million years: Stars and nascent galaxies form
- ~1 billion years: Dark ages end
- ~4.5 billion years: Sun, Earth, and solar system have formed
- ~700 million years after the Big Bang
- Galaxy A1689-zD1
- 13.7 billion years: Present
3D is what it takes!
3D is what it takes!

3D models or simulations. Preferably both!

Planetaria provides these possibilities!
Possibilities!

• Astronomical objects must be possible to see from different angles and in motion => Motion parallax!

• Planetaria provides!

• Not to forget: Physical 3D objects…
Possibilities?

- What about 3D renderings in planetaria using 3D glasses?
- Not much research on that jet...
Simulating 3D in planetaria
Simulating 3D in planetaria

• Easy to simulate e.g. the Sun, the Earth and the Moon
• Phases of the Moon...
• Seasons...

• ... but only few have experienced our universe’s 3D structure firsthand...
Simulating 3D in planetaria

• Easy to simulate e.g. the Sun, the Earth and the Moon

• Phases of the Moon…

• Seasons…

…but only few have experienced our universe’s 3D structure firsthand…
Simulating 3D in planetaria
Simulating 3D in planetaria

• But is it really 3D?
• 2D on a curved surface
• Immersive

• So, the visitor will need to extrapolate three-dimensionality in their minds from the 2D immersive input.
Simulating 3D in planetaria

- But is it really 3D?
- 2D on a curved surface
- Immersive
- So, the visitor will need to extrapolate three-dimensionality in their minds from the 2D immersive input.

- How good are people at doing that?
The inner Universe
The inner Universe

• What do people notice, or *discern*, when looking at our planetarium presentations?

• Very little...

• **Motion; Distance; Relative sizes; Structural detail; Change of perspective; and 3D.**
The inner Universe

• What do people notice, or discern, when looking at our planetarium presentations?
• Very little...
• Motion; Distance; Relative sizes; Structural detail; Change of perspective; and 3D.
The inner Universe

• What do people notice, or **discern**, when looking at our planetarium presentations?

• Very little...

• **Motion; Distance; Relative sizes; Structural detail; Change of perspective; and 3D.**

• BUT! With a little help (scaffolding) people discern much more and build a better understanding of the multidimensional structure of the Universe.
Disciplinary discernment

- What is important to look at and discern?
- How do one know?
- Very large differences in what movies and experts discern
- The Anatomy of Disciplinary Discernment (ADD) (Eriksson et al. 2014)
Spatial thinking

- Very hard to imagine what an object in space look like in 3D(4D).
- Again large differences between novice and expert
- Extrapolating 3D in ones mind from a 2D representation
- Motion parallax may be the key to success!
An example from the planetarium - the Solar System
Exempel på vad man kan göra

- Från simuleringsprogrammet Uniview
- Solsystemet
- Galaxen
- Planetariebesök
Exempel på vad man kan göra
• Från simuleringsprogrammet Uniview
• Solsystemet
• Galaxen
• Planetariebesök
An example from the planetarium
-Our galaxy
Intergalactic journey
Intergalactic journey
What did you discern?

- What does a planetarium visit offer?
- Astronomical object?
- Properties?
- 3D?
- 4D?
- Differences between inner and outer universe?
The Spiral of Teaching and Learning

Eriksson (2014)
Discussion

• How can planetaria be used for formal learning of astronomy and astrophysics?

• Research informed approaches exist (Eriksson, 2014; Yu et al., 2015, 2016, 2017)

• Astronomy education research (AER) is a growing field - However, not much done on formal learning in planetaria.

• The questions is how to use the technology in the best possible way to create learning experiences and avoid cognitive overload (Mayer, 2009) - the ”Star War” effect…
Conclusions
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- To understand the Universe one need experiences and disciplinary knowledge!
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• It is first then that one starts to notice things and differences between things and build a 3(4)D understanding of the Universe in ones mind.
Conclusions

• It is not easy to understand either the outer or the inner Universe!

• To understand the Universe one need experiences and disciplinary knowledge!

• To experience the Universe one need to open ones’ mind and ”look up”!

• It is first then that one starts to notice things and differences between things and build a 3(4)D understanding of the Universe in ones mind.

• Then the gap between the outer and inner Universe diminishes.
Finally…
Finally…

KEEP LOOKING UP!
Thanks for discerning!

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