Universität Münster

CERGY PARIS UNIVERSITÉ

“Walk of the Planets”

Students' concepts of the solar system

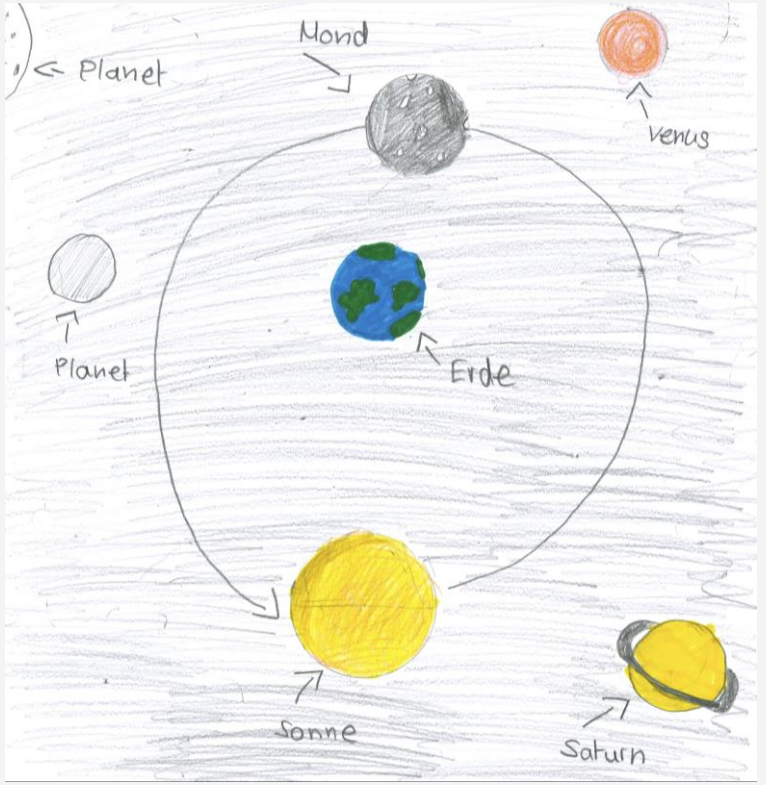
living.knowledge

Motivation

"The Mars is red because its full of lava!"

The solar system is part of many curricula.

"Polar lights is when there is a Sandstorm on the Sun."



State of the art

- J. Nussbaum and J.D. Novak, *An assessment of children's concepts of the earth utilizing structured interviews.*, Sci. Ed. ,(1976)
- Sneider, C.I. and Ohadi, M.M. (1998), Unraveling students' misconceptions about the earth's shape and gravity. Sci. Ed., 82: 265-284.
- M.S. Ubben and P. Bitzenbauer, *Two Cognitive Dimensions of Students' Mental Models in Science: Fidelity of Gestalt and Functional Fidelity.*, *Educ. Sci.*, 2022,

Research Questions

1. What types of mental models about the solar system do students possess ?
2. What influences do different teaching artefacts have on these models?
    1. The Human Orrery
    2. Common Astronomy Education
    3. **AR**istarchus - App

Research Questions

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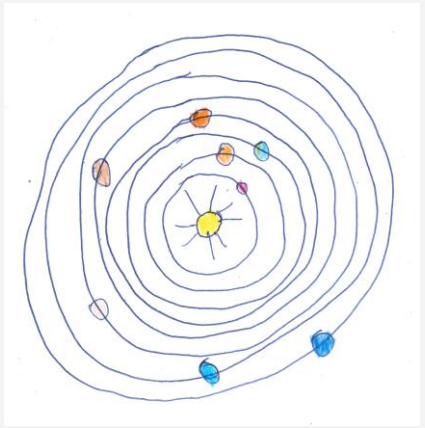
    2. Common Astronomy Education
    3. **AR**istarchus - App

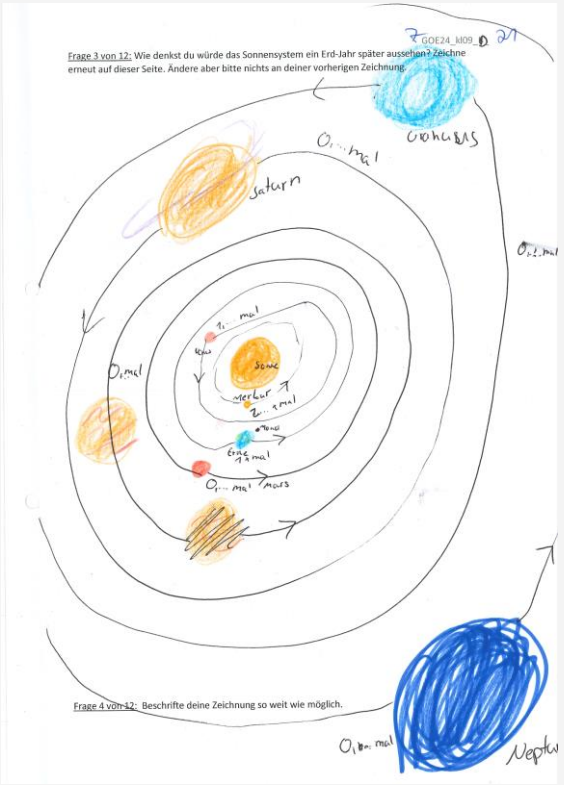
What is a mental model?

„Mental models are individual types of mental modal patterns (shape) that have a functional potential (functionality) and are based on external experiences."

Ubben(2020, p. 14)

Mental Models (The Glimpse that we can get)





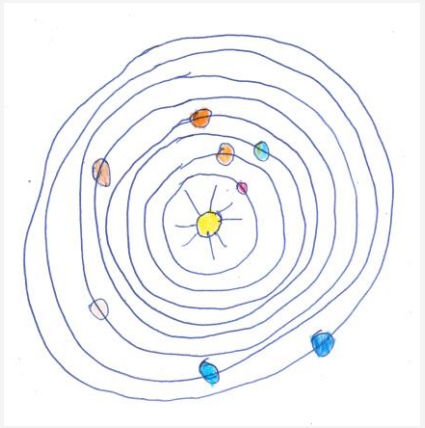
Two Core Aspects

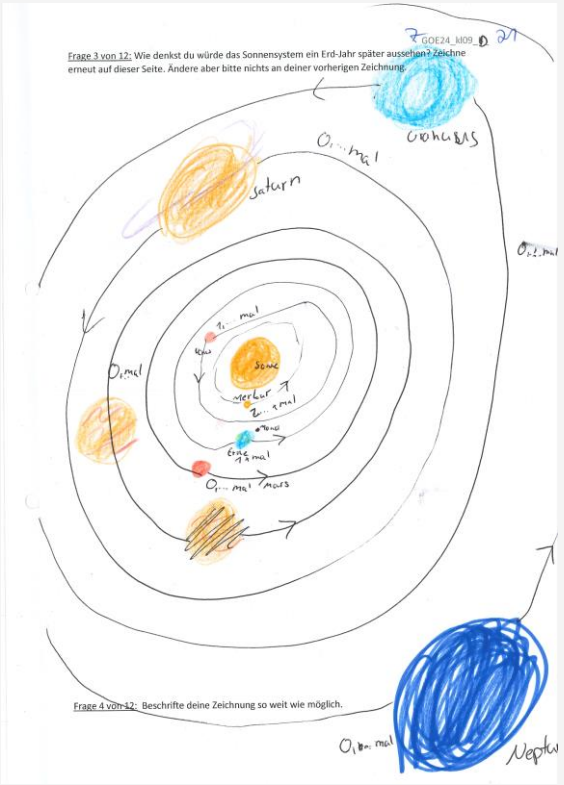
1. „Gestalt“

Colourful discs on lines

Colourful discs on lines

Mental Models (The Glimpse that we can get)





Two Core Aspects

1. „Gestalt“	Colourful discs on lines	Colourful discs on lines
2. Functionality	------	movement, size difference, ratios(of years)

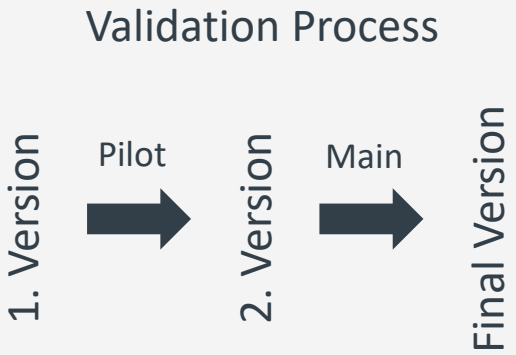
Methodology

Pilot Test:

- Approx. 100 students
- Only Gestalt

Main:

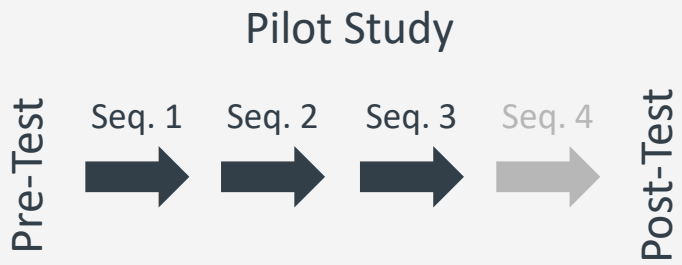
- Approx. 350 students so far, (500-1000 intended)
- Gestalt and functional fidelity
- Different countries and school types
- Younger students due to unfinished models



Methodology

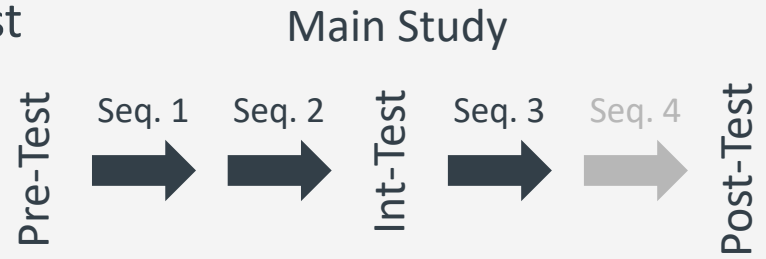
Pilot Study: (N=100)

- Pre-Test -> Intervention of 3-4 sessions a 45-90min -> Post-Test



Main 1: (currently N=350, estimated N=500-1000)

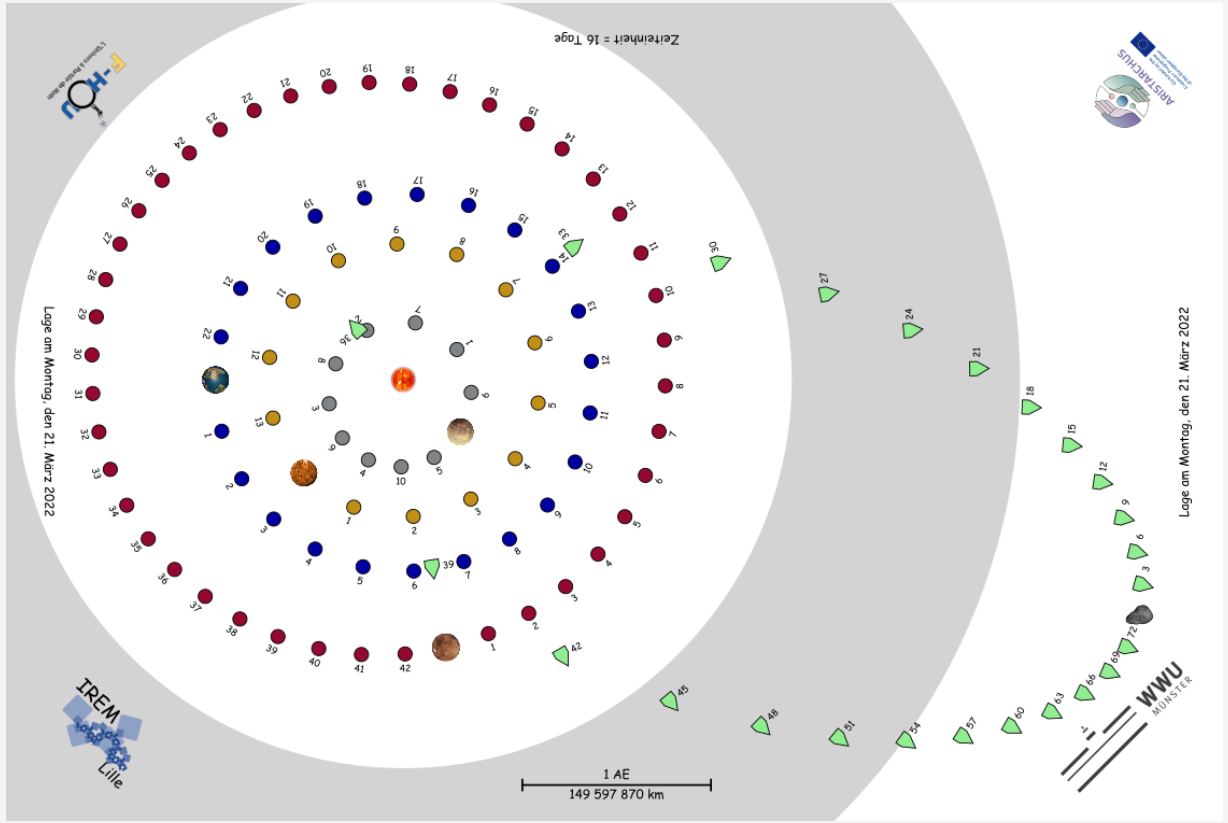
- Pre-Test -> Session 1 and 2 -> Int-Test -> Session 3 (and4) -> Post-Test
- Int-Test introduced to verify influence of Sequences 1 and 2

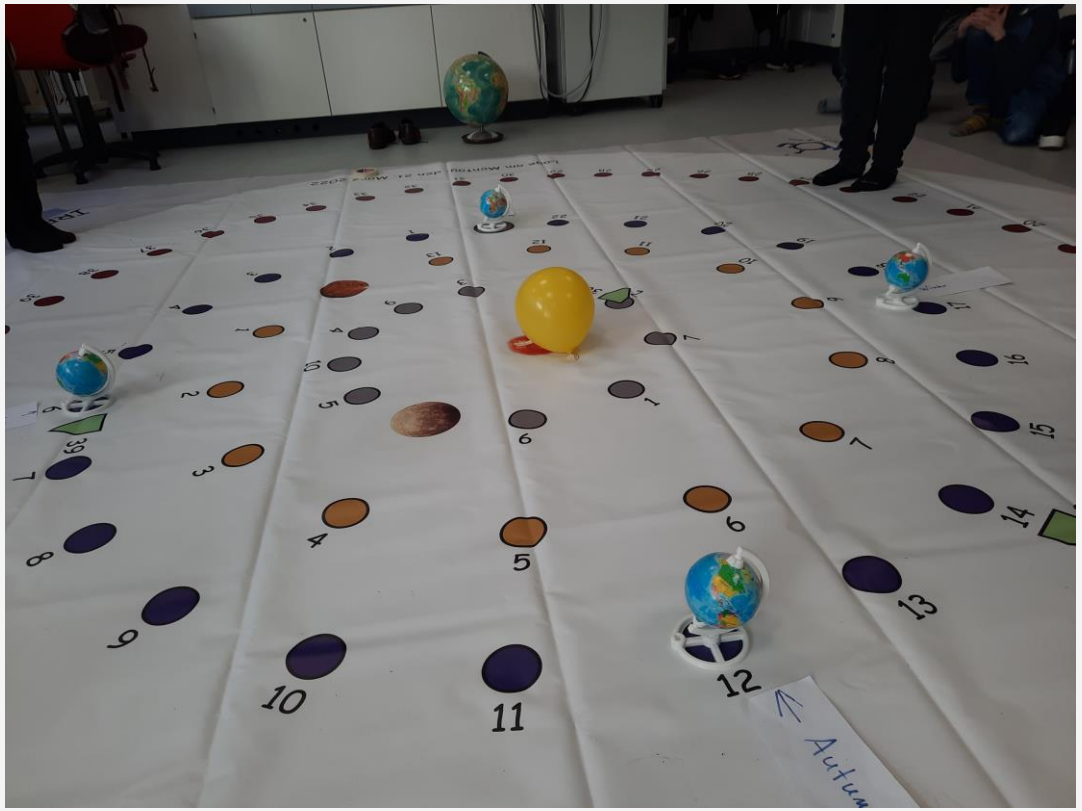


Main 2: (unknown N)

Potentially with added AR- App

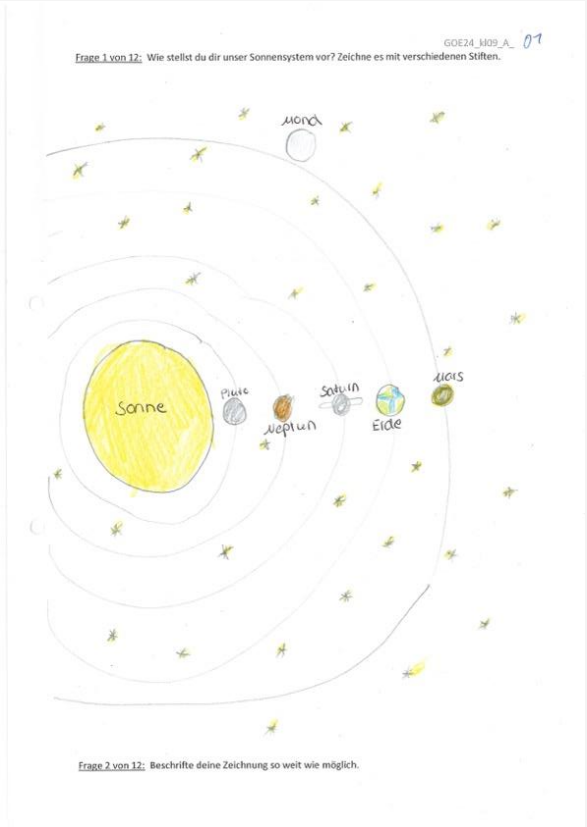
Intervention (Human Orrery)





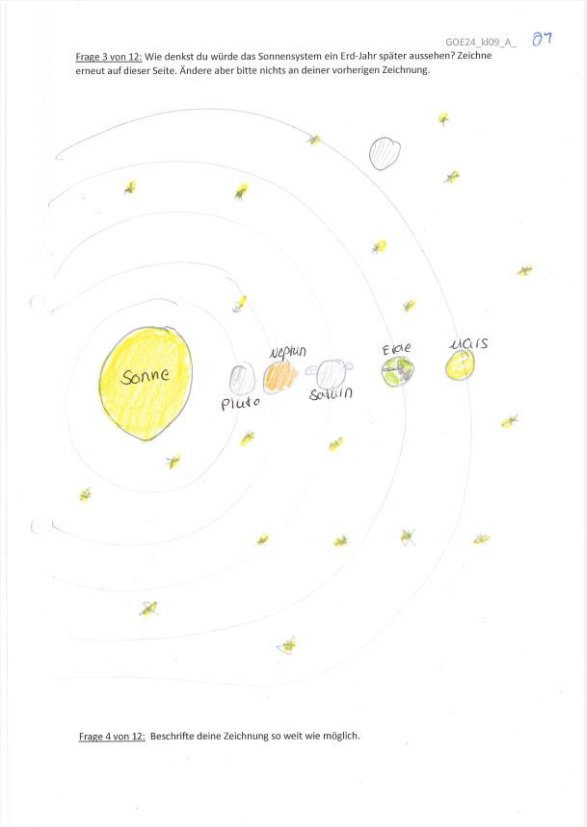
Intervention

The questionnaire


GOE24_kl09_A_ 07

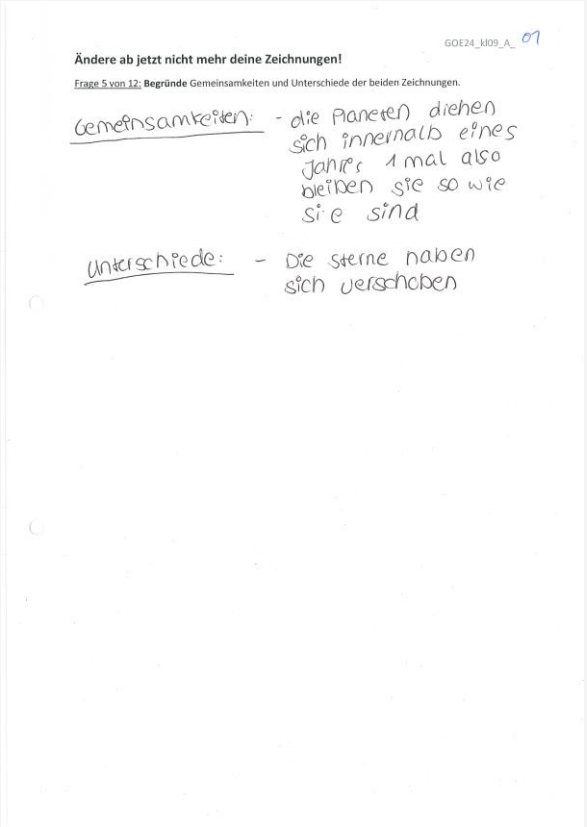
Frage 1 von 12: Wie stellst du dir unser Sonnensystem vor? Zeichne es mit verschiedenen Stiften.

Frage 2 von 12: Beschrifte deine Zeichnung so weit wie möglich.


GOE24_kl09_A_ 07

Frage 3 von 12: Wie denkst du würde das Sonnensystem ein Erd-Jahr später aussehen? Zeichne erneut auf dieser Seite. Ändere aber bitte nichts an deiner vorherigen Zeichnung.

Frage 4 von 12: Beschrifte deine Zeichnung so weit wie möglich.

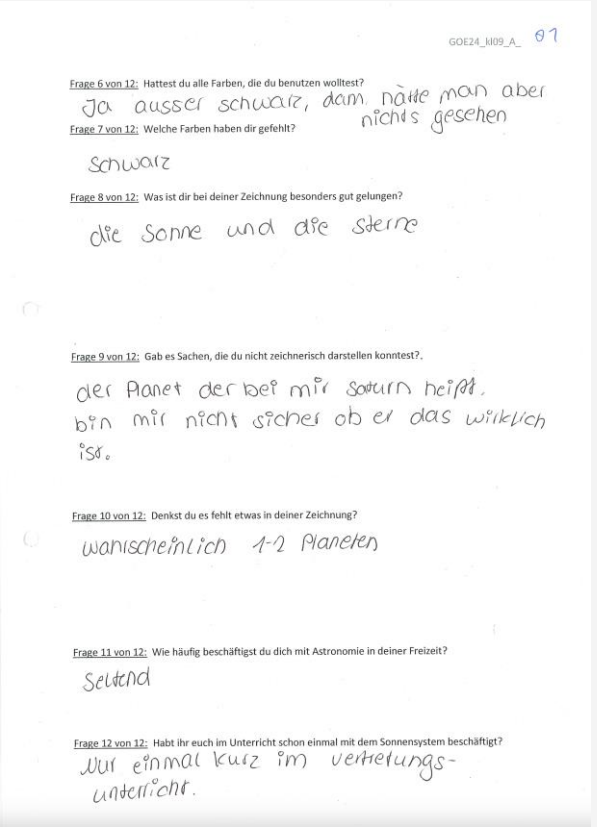

GOE24_kl09_A_ 07

Ändere ab jetzt nicht mehr deine Zeichnungen!

Frage 5 von 12: **Begründe** Gemeinsamkeiten und Unterschiede der beiden Zeichnungen.

Gemeinsamkeiten: - die Planeten drehen sich innerhalb eines Jahres 1 mal also bleiben sie so wie sie sind

Unterschiede: - Die Sterne haben sich verschoben


GOE24_kl09_A_ 07

Frage 6 von 12: Hattest du alle Farben, die du benutzen wolltest?
Ja ausser schwarz, dann hätte man aber nichts gesehen

Frage 7 von 12: Welche Farben haben dir gefehlt?
Schwarz

Frage 8 von 12: Was ist dir bei deiner Zeichnung besonders gut gelungen?
die Sonne und die Sterne

Frage 9 von 12: Gab es Sachen, die du nicht zeichnerisch darstellen konntest?.
der Planet der bei mir Saturn heißt. bin mir nicht sicher ob er das wirklich ist.

Frage 10 von 12: Denkst du es fehlt etwas in deiner Zeichnung?
wahrscheinlich 1-2 Planeten

Frage 11 von 12: Wie häufig beschäftigst du dich mit Astronomie in deiner Freizeit?
Selten

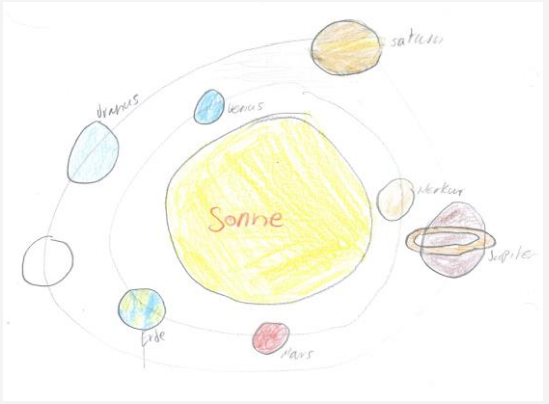
Frage 12 von 12: Habt ihr euch im Unterricht schon einmal mit dem Sonnensystem beschäftigt?
Nur einmal kurz im Vertretungs-unterricht.

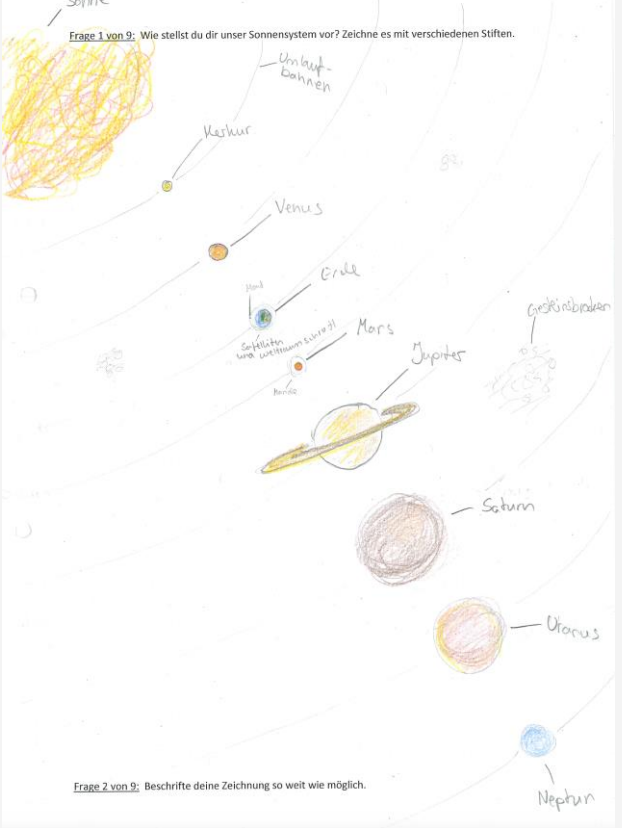
Results

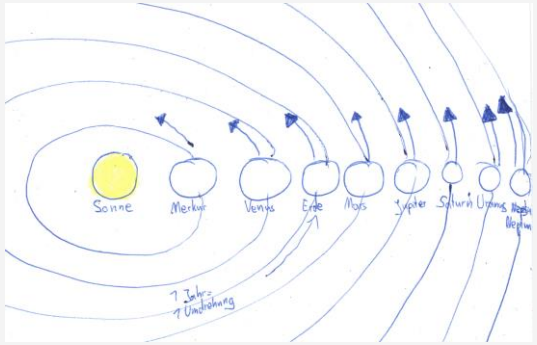
1. What mental models exist?

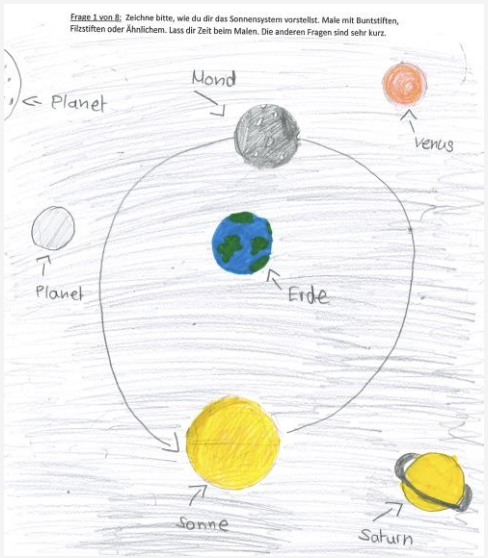
2. What are the influences of artifacts… – (in progress)

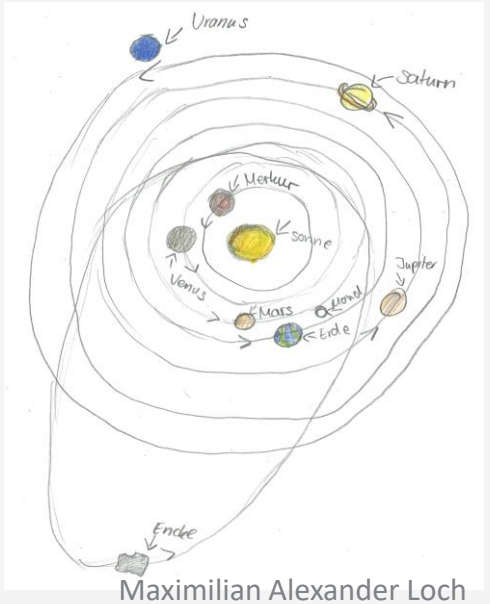
What mental models exist?



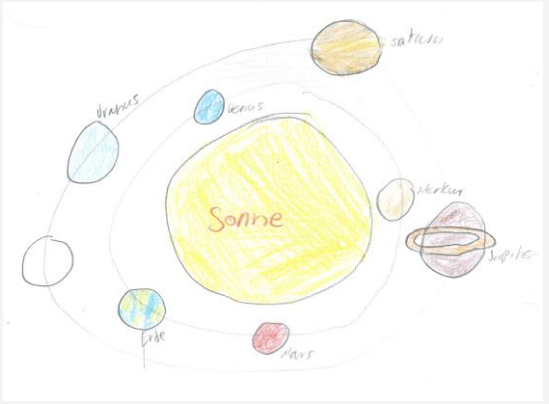


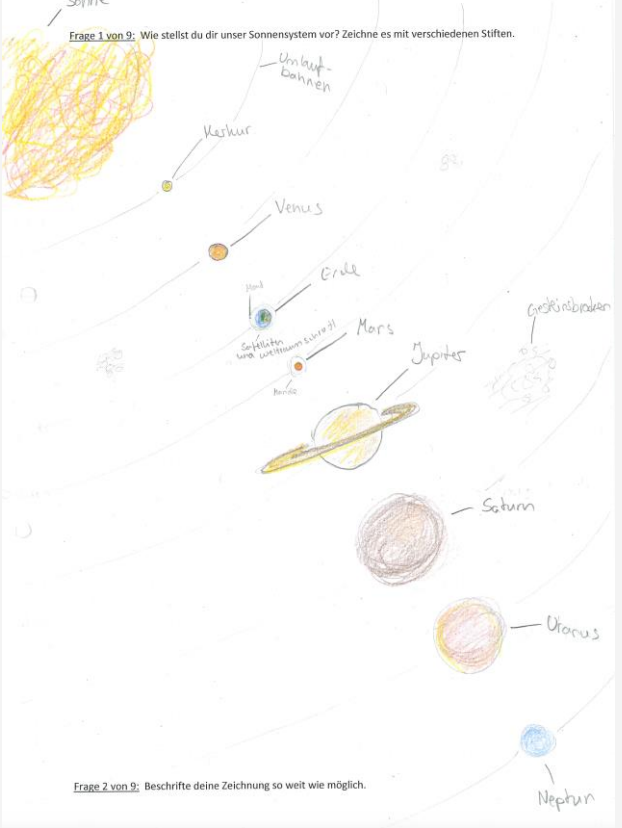


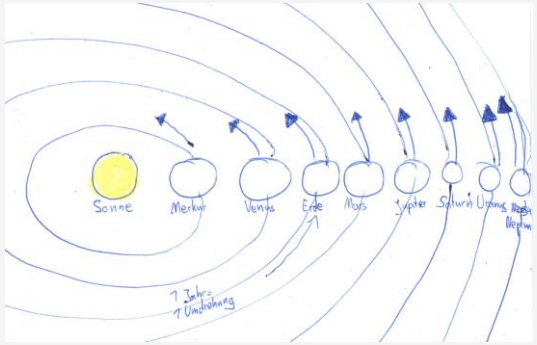


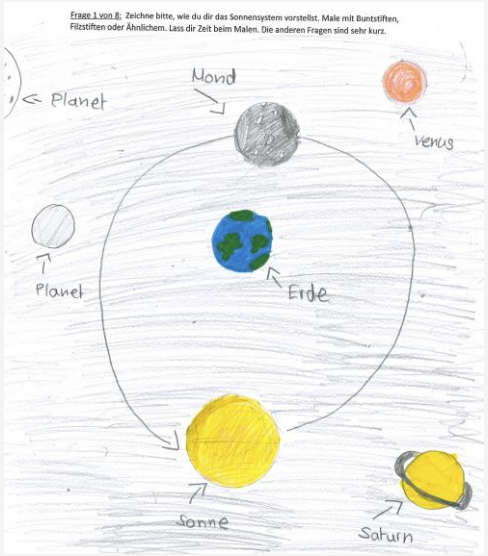


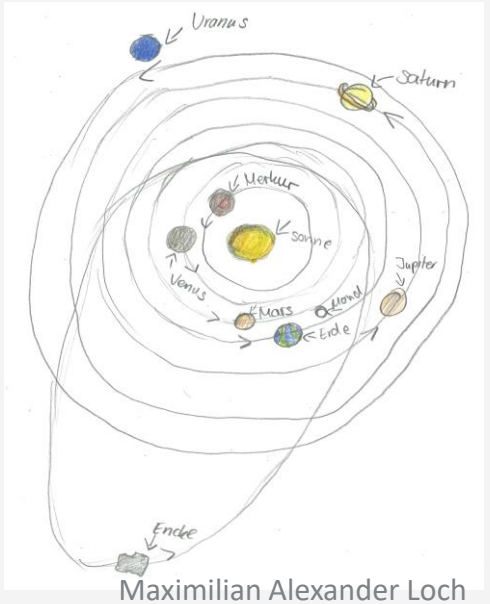
What mental models exist?







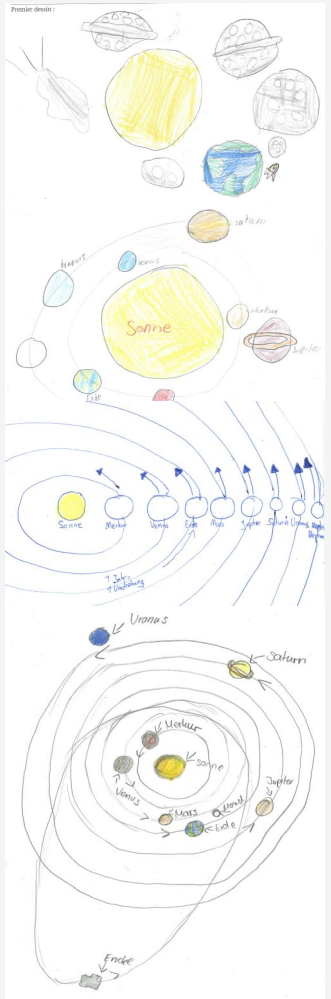




But how do we make this comparable?

What mental models exist?

It is not as easy as we thought!



1. Heap
2. Multiple
3. T1-Orrery
4. T2-Orrery

Categories won't work

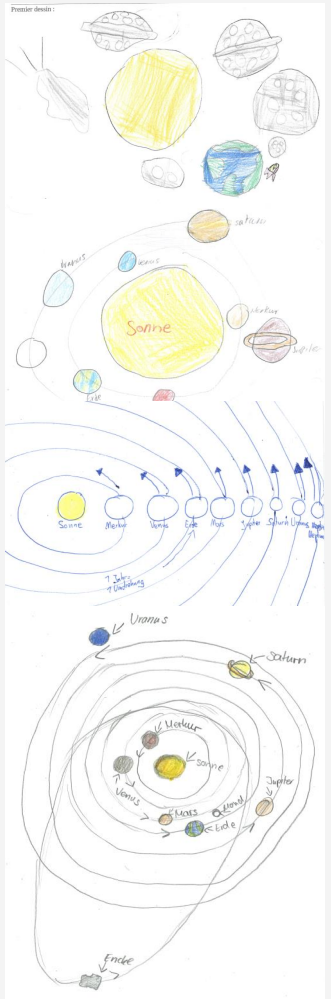
Too many edge cases

DHCPF

Distribution
Hierarchy
Complexity
Prettiness
Functionality

What mental models exist?

It is not as easy as we thought!



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2. Multiple
3. T1-Orrery
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Categories won't work

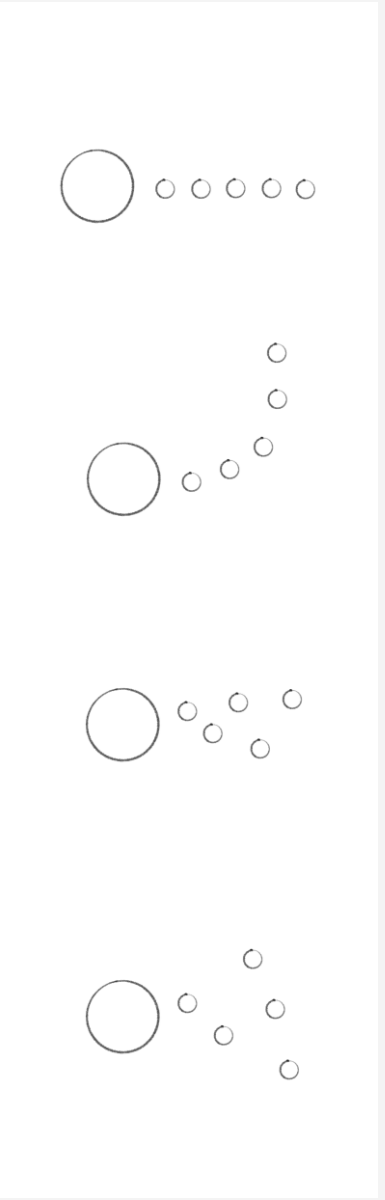
Too many edge cases

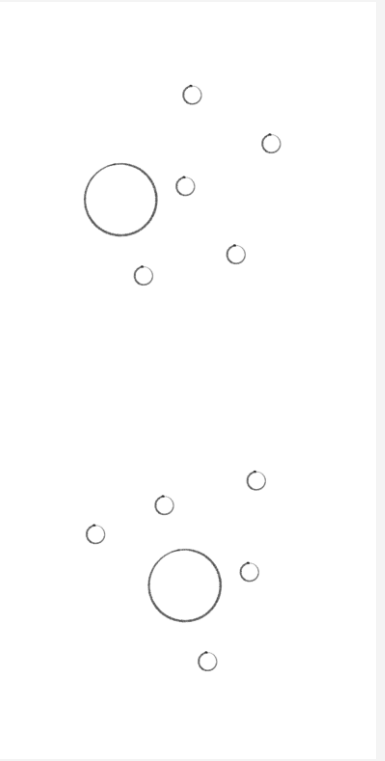
DHCPF

Distribution
Hierarchy
Complexity
Prettiness
Functionality

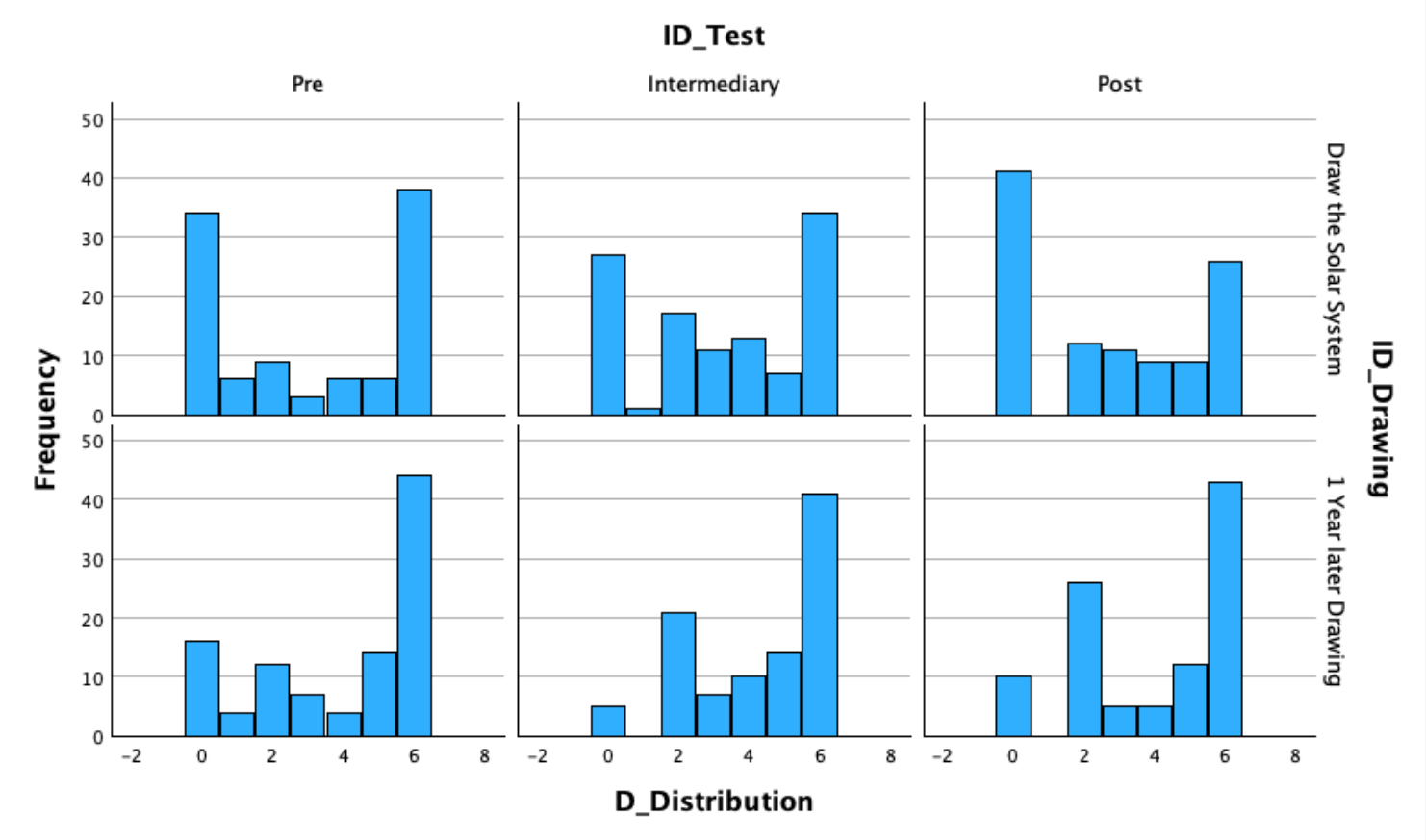
Distribution

- 0: Straight Line
- 1: “Pearl string”
- 2: < 45°
- 3: < 90°
- 4: < 180°
- 5: 360°



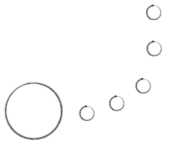


Distribution



0

1



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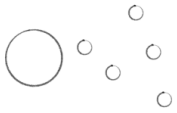

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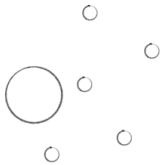

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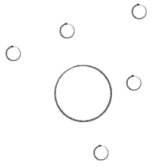
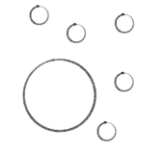


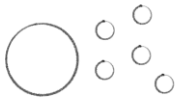
Hierarchy

- 0: No Order
- 1: Sun assumes a role of importance
- 2: All planets are on one Orbit
- 3: Multiple planets per Orbit
- 4: Differentiation between inner and outer planets
- 5: One planet per Orbit

0



1



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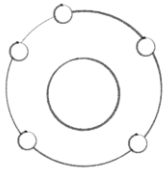

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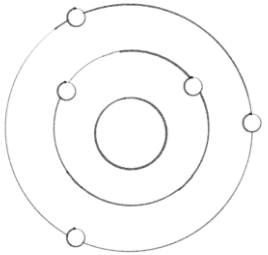

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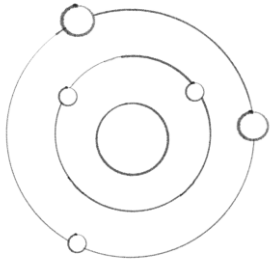

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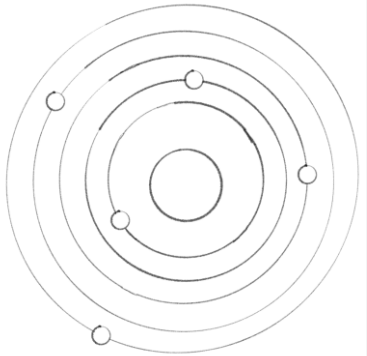
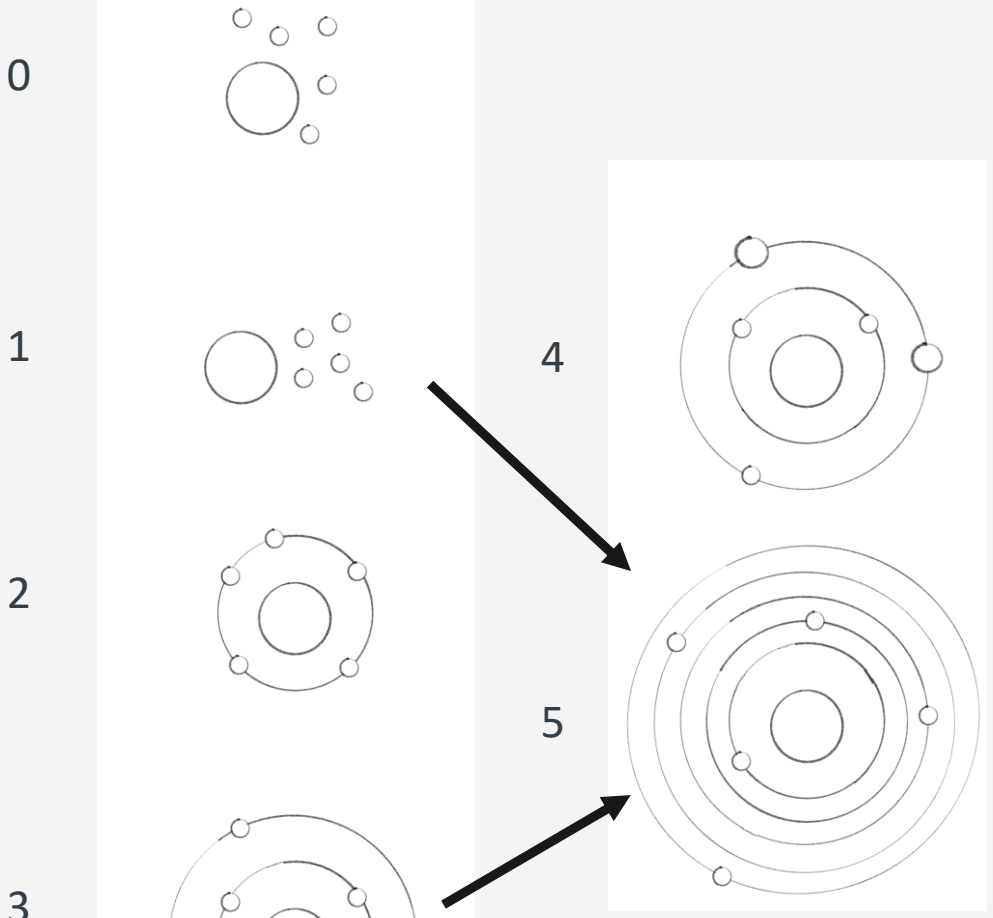


Hierarchy

N = 172

Pre \ Post	0	1	2	3	4	5
0	1	3	1	0	1	5
1	0	16	0	0	0	**29**
2	0	0	8	1	2	3
3	1	2	0	0	0	**18**
4	0	0	0	0	1	0
5	0	4	0	1	0	75

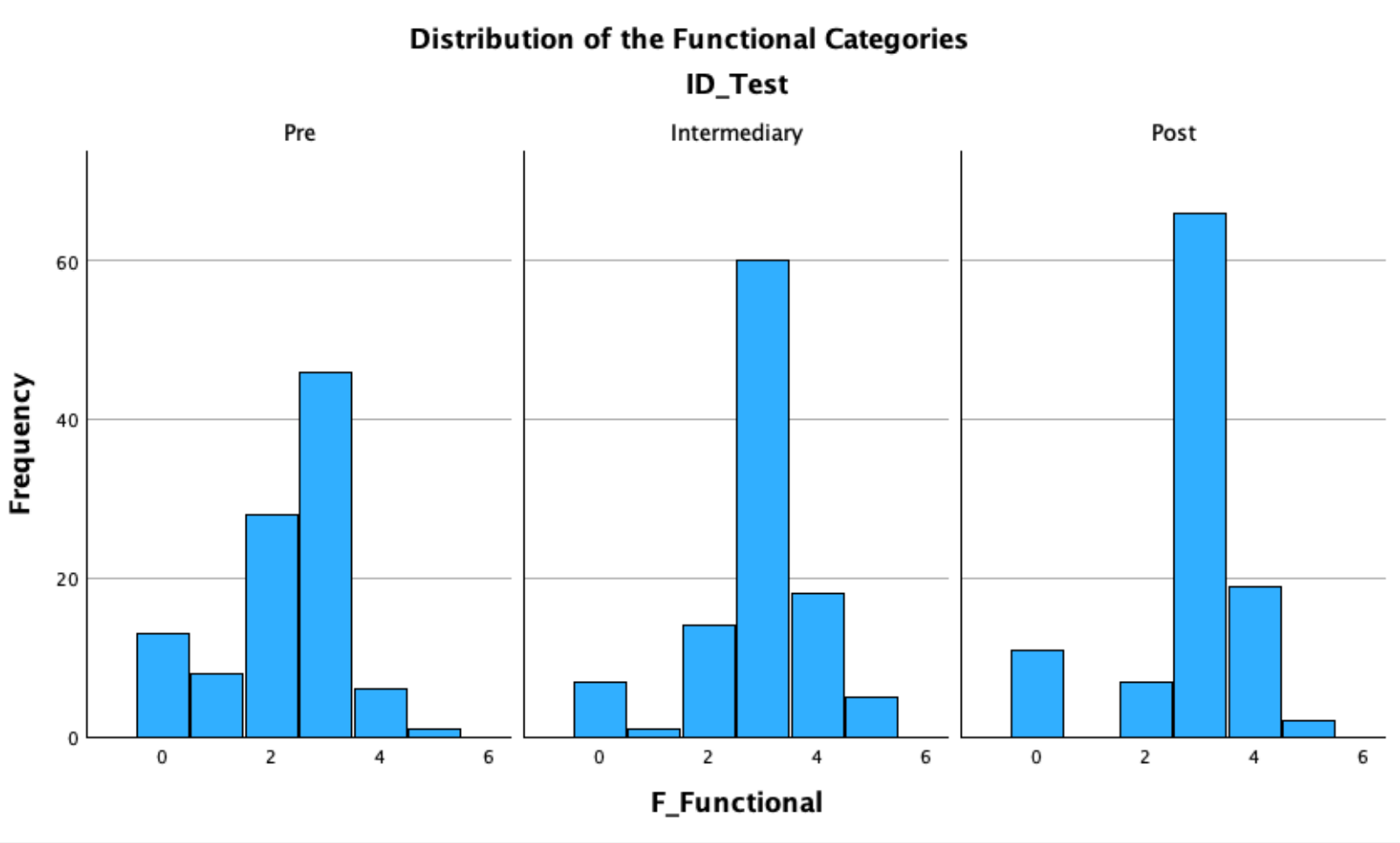


Functionality

- F0: No movement drawn or written
- F1: Only earth moves
- F2: All planets possess the same angular speed >0
- F3: The planets move at different speeds
- F4: The planets move “slower” the further away
- F5: There are specific ratios to the planet’s angular speeds

Functionality

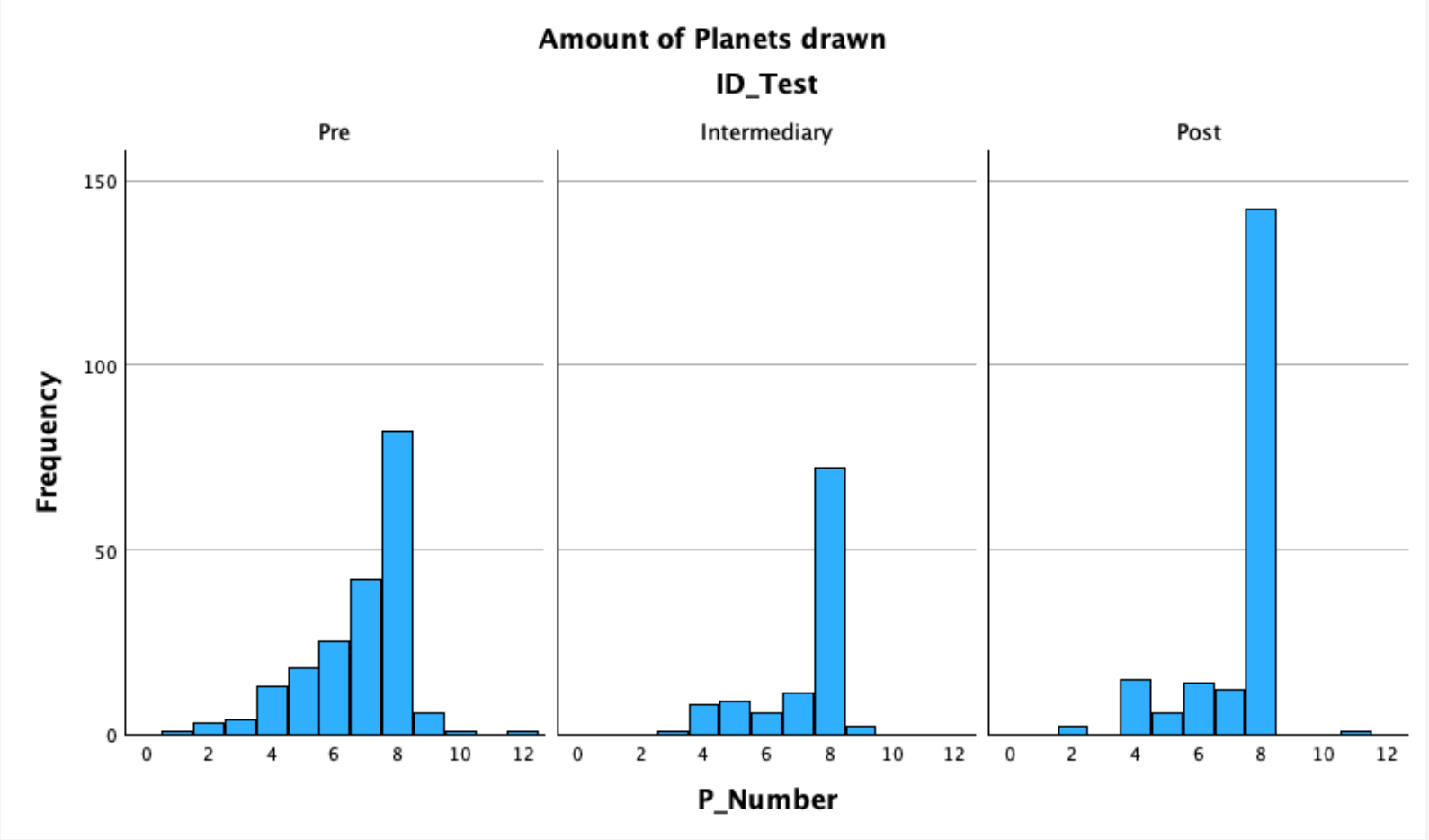
N = 100



- 0: No movement
- 1: Only Earth
- 2: All same angular speed
- 3: Different angular speed
- 4: Slower the further
- 5: Specific ratios

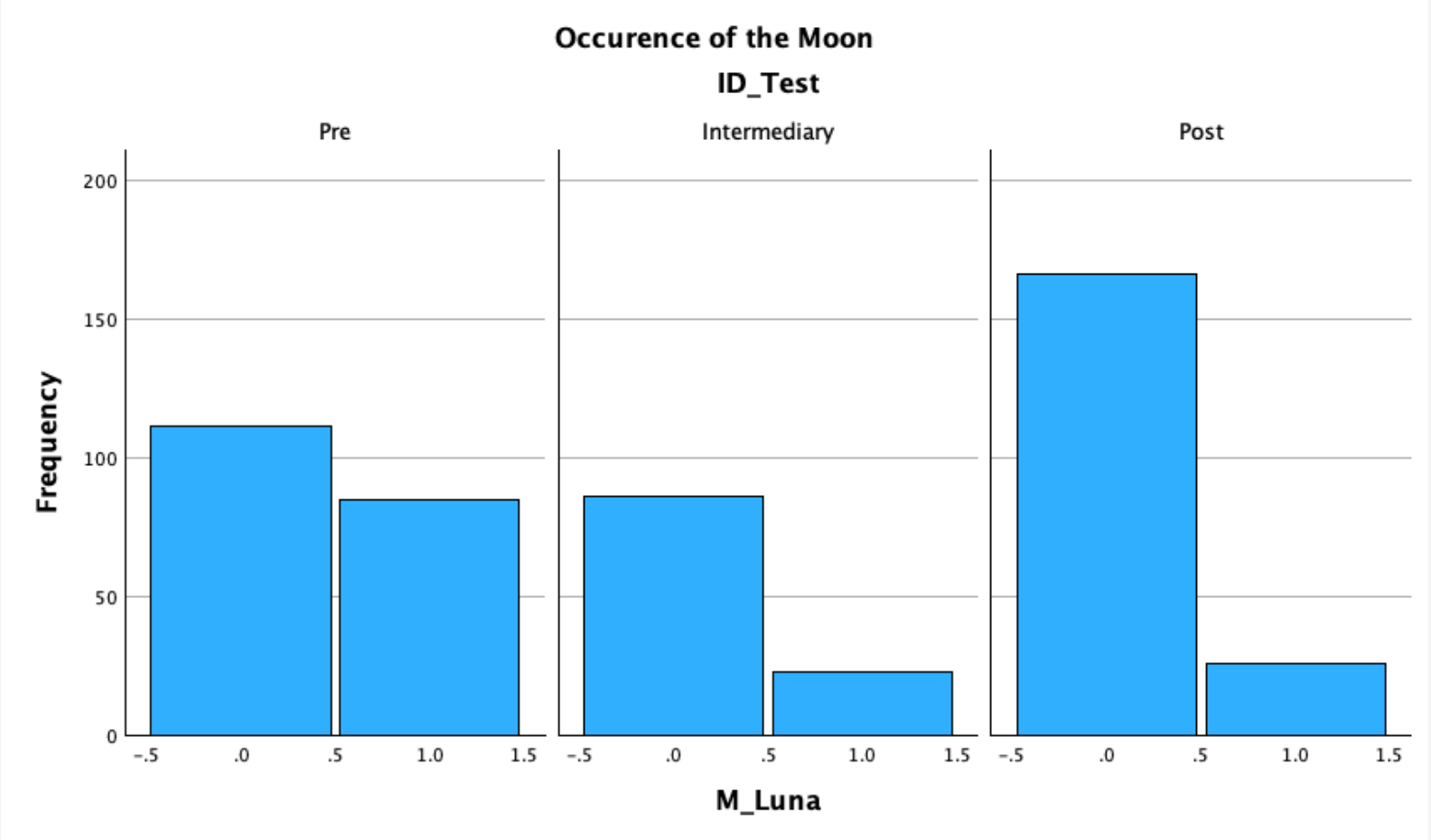
- 0 in the Post test likely attributing to “laziness”

Amount of Planets



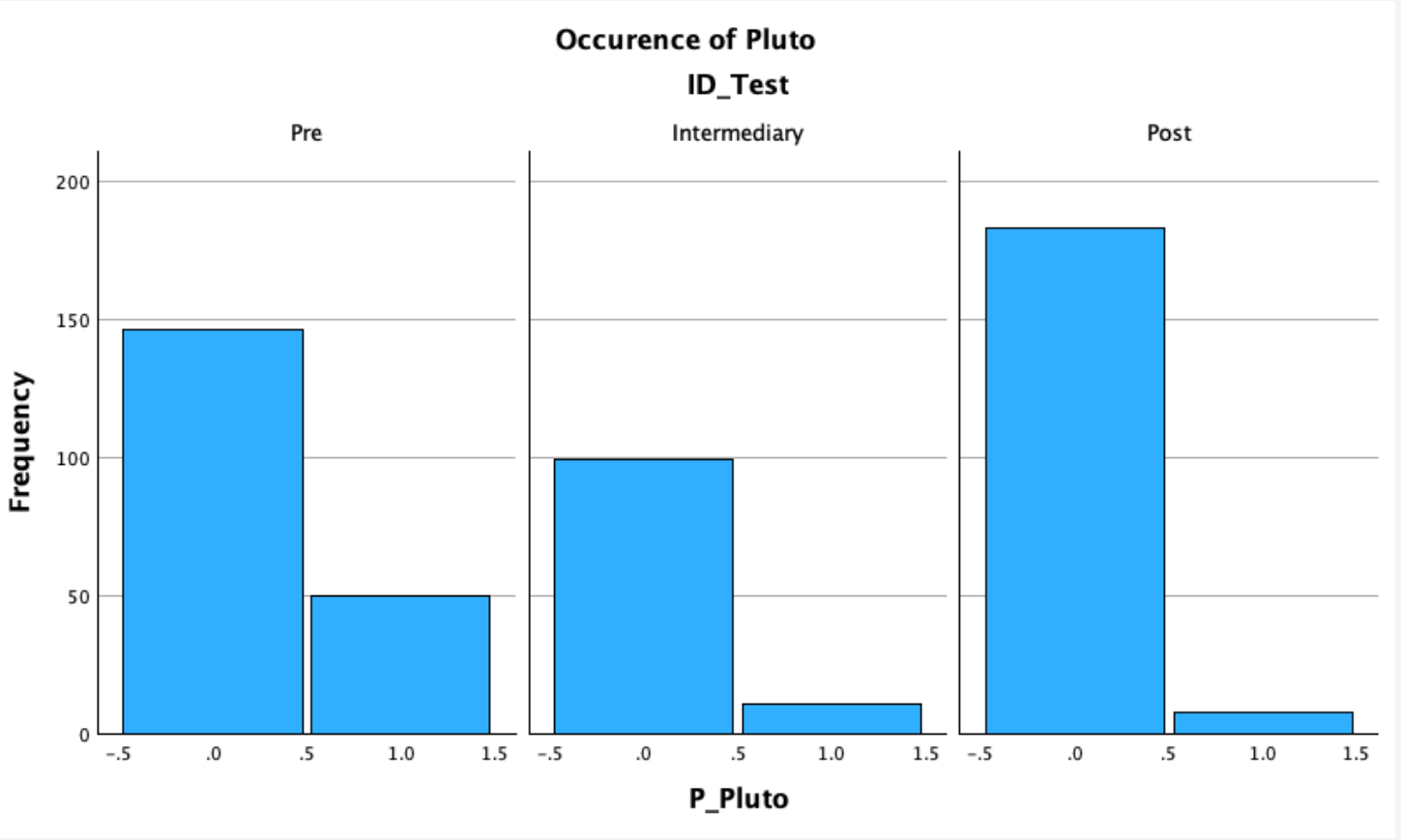
- Own research or influence of the teacher?
- “Negative” Influence on students resulting in a “peak” at 4 planets.

The Moon



- Moon taught to be not visible on the orrery
- Goes hand in hand with other details also vanishing from the drawing towards the post test

Pluto



- Unusually high occurrence of Pluto.
- More likely to be mentioned than all 8 planets.

Lookout and Questions

How do the models progress?

- **with age**
- **with intervention**

Is there a correlation between functionality and gestalt (in the development)?

Universität Münster

CERGY PARIS UNIVERSITÉ

Thank you for your attention!

Maximilian Alexander Loch WCPE 2024 Krakow
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Universität Münster

Sources

- UBBEN, M. S. (2020). Typisierung des Verständnisses mentaler Modelle mittels empirischer Datenerhebung am Beispiel der Quantenphysik. *Berlin: Logos.*
- J. Nussbaum and J.D. Novak, *An assessment of children's concepts of the earth utilizing structured interviews.*, Sci. Ed. ,(1976)
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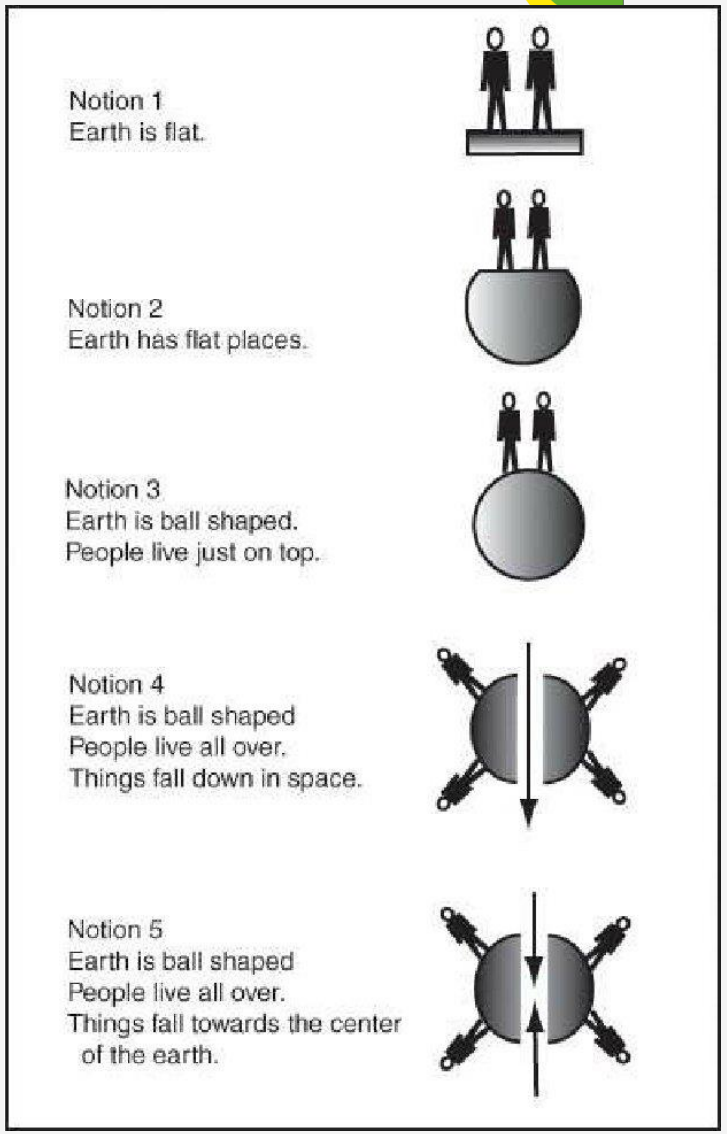
State of the art

- J. Nussbaum and J.D. Novak, *An assessment of children's concepts of the earth utilizing structured interviews.*, Sci. Ed. ,(1976)



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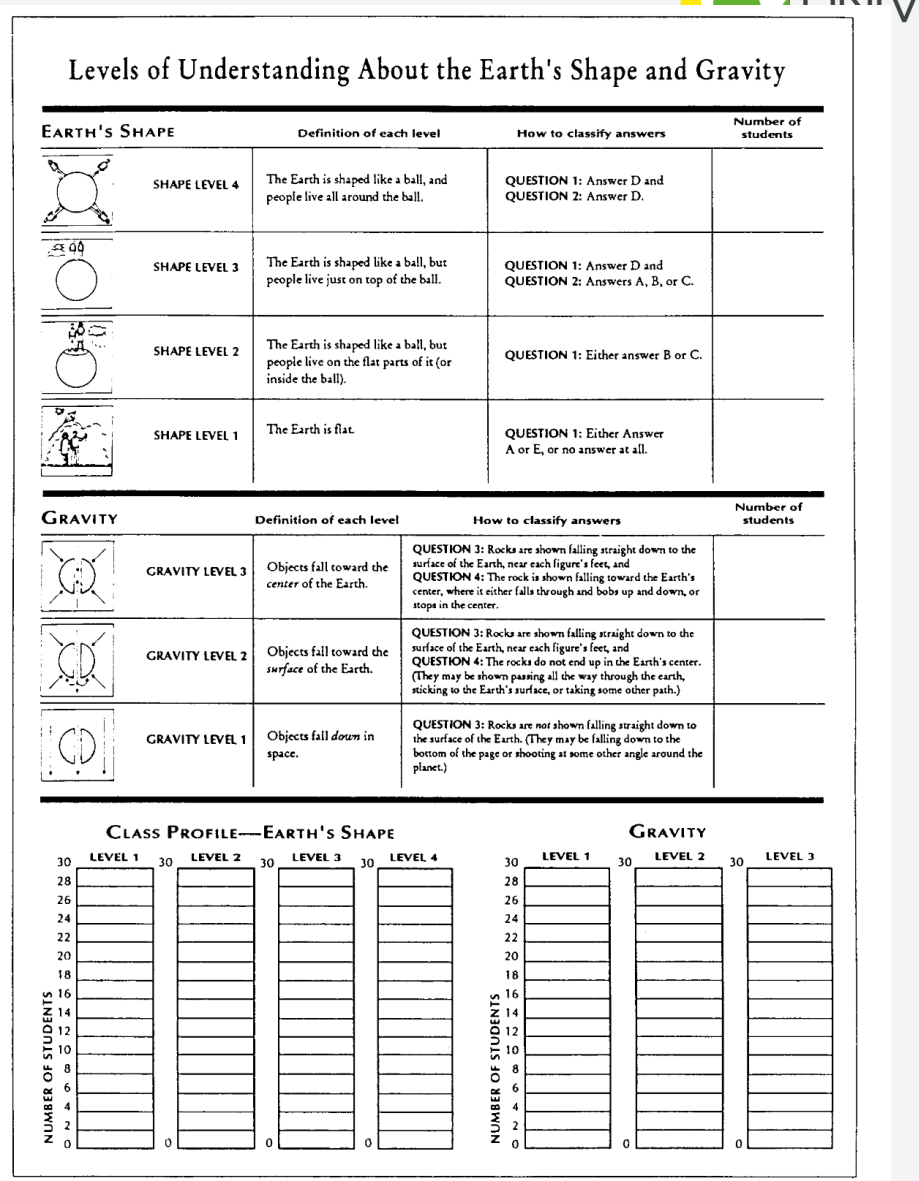
- Sneider, C.I. and Ohadi, M.M. (1998), Unraveling students' misconceptions about the earth's shape and gravity. Sci. Ed., 82: 265-284.



Levels of Understanding About the Earth's Shape and Gravity

EARTH'S SHAPE		Definition of each level	How to classify answers	Number of students
	SHAPE LEVEL 4	The Earth is shaped like a ball, and people live all around the ball.	QUESTION 1: Answer D and QUESTION 2: Answer D.	
	SHAPE LEVEL 3	The Earth is shaped like a ball, but people live just on top of the ball.	QUESTION 1: Answer D and QUESTION 2: Answers A, B, or C.	
	SHAPE LEVEL 2	The Earth is shaped like a ball, but people live on the flat parts of it (or inside the ball).	QUESTION 1: Either answer B or C.	
	SHAPE LEVEL 1	The Earth is flat.	QUESTION 1: Either Answer A or E, or no answer at all.	

GRAVITY		Definition of each level	How to classify answers	Number of students
	GRAVITY LEVEL 3	Objects fall toward the *center* of the Earth.	QUESTION 3: Rocks are shown falling straight down to the surface of the Earth, near each figure's feet, and QUESTION 4: The rock is shown falling toward the Earth's center, where it either falls through and bobs up and down, or stops in the center.	
	GRAVITY LEVEL 2	Objects fall toward the *surface* of the Earth.	QUESTION 3: Rocks are shown falling straight down to the surface of the Earth, near each figure's feet, and QUESTION 4: The rocks do not end up in the Earth's center. (They may be shown passing all the way through the earth, sticking to the Earth's surface, or taking some other path.)	
	GRAVITY LEVEL 1	Objects fall *down* in space.	QUESTION 3: Rocks are *not* shown falling straight down to the surface of the Earth. (They may be falling down to the bottom of the page or shooting at some other angle around the planet.)	

Figure 2. Assessment rubric. Adapted from Sneider, Pulos, Freenor, Porter, and Templeton (1986).

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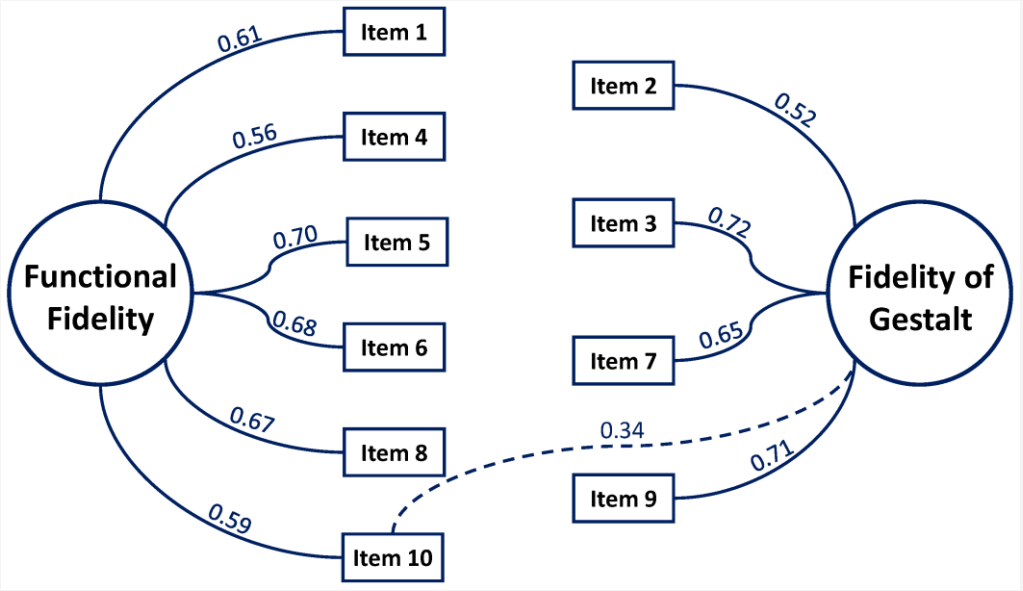
- M.S. Ubben and P. Bitzenbauer, *Two Cognitive Dimensions of Students' Mental Models in Science: Fidelity of Gestalt and Functional Fidelity.*, *Educ. Sci.*, 2022,



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