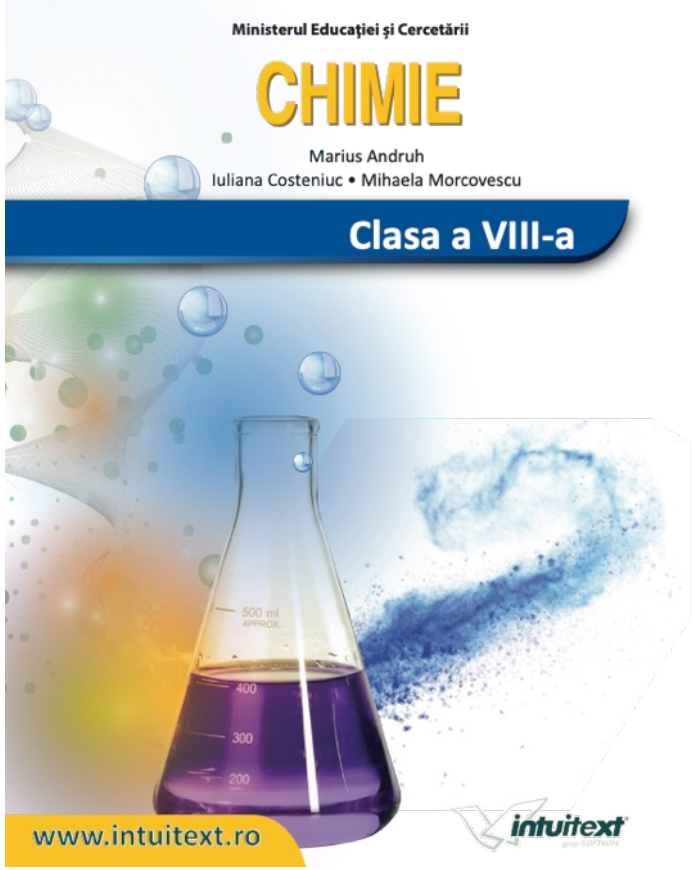
ComMetSci



Communicating Science to Young Generations: Metaphors Our Children Learn by

Școala Națională de Studii Politice și Administrative

ComMetSci Project
Funded by the Romanian Ministry of Education and Research
CNCS - UEFISCDI, project no. PN-III-P1-1.1-TE-2019-1300, within PNCDI III

Project technical fiche

Funding institution: Romanian Ministry of Education and Research, CNCS - UEFISCDI

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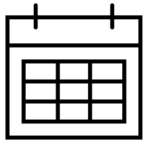
Duration: 20 months (November 2020- June 2022)



Project workplan:

Phase I: Identification and classification of metaphors

November 2020 – March 2021

Phase II: Carrying out of classroom observation & dyad interaction

March 2021 – December 2021

Phase III: Data analysis and dissemination of findings

January 2022 – June 2022

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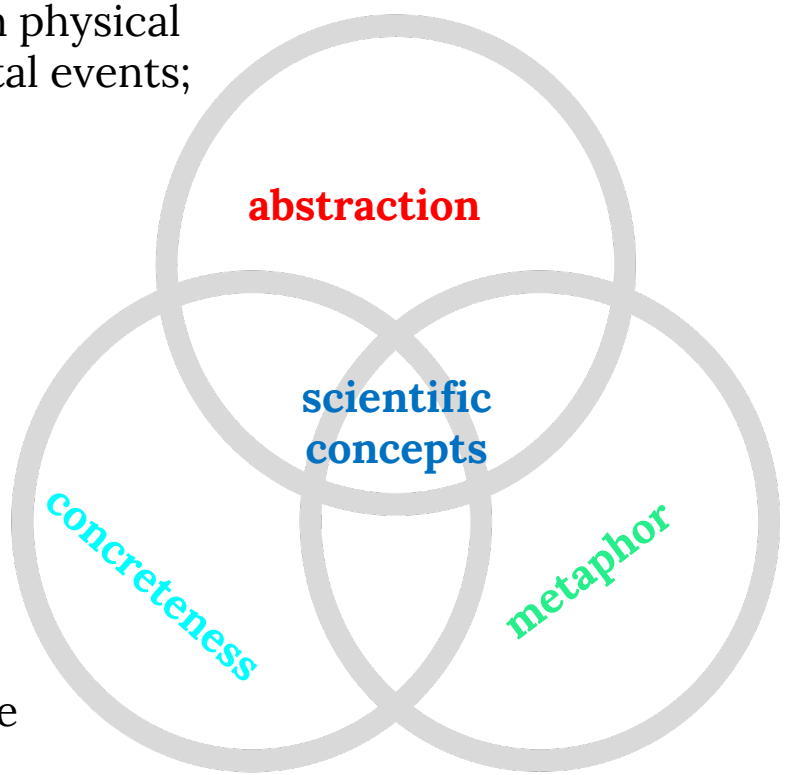
Goal & Objectives

To examine the metaphors and analogies used in Romanian science textbooks for lower secondary education (5 to 8 grade) to explain abstract scientific ideas and to communicate them to young learners

- To identify and classify linguistic and visual metaphors in physics, chemistry and biology textbooks
- To investigate how young students aged 11-14 understand metaphors for abstract concepts used in textbooks and in educational videos, and to examine how they use these metaphors to explain scientific phenomena
- To examine the alternative metaphors that students create during conversation to make sense of scientific abstract concepts
- To explore how metaphors and analogies can be used in science education to help young learners develop a scientific reasoning and to shape their understanding of the complexity of the physical world

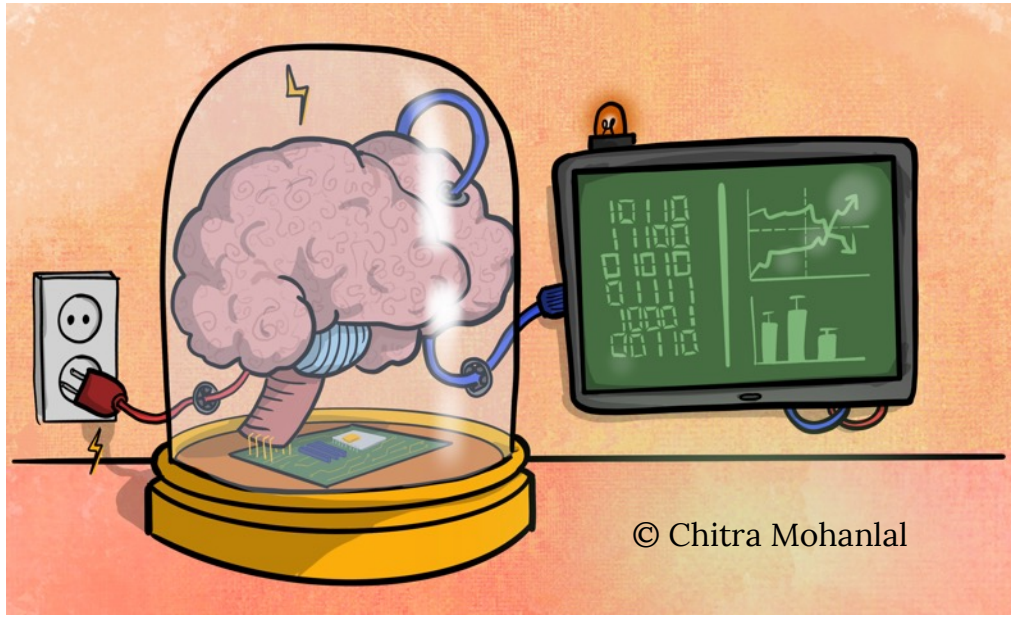
Metaphors & abstract knowledge

Abstraction > abstract concepts (Barsalou, 2003): concepts detached from physical entities; associated with mental events; properties and relations

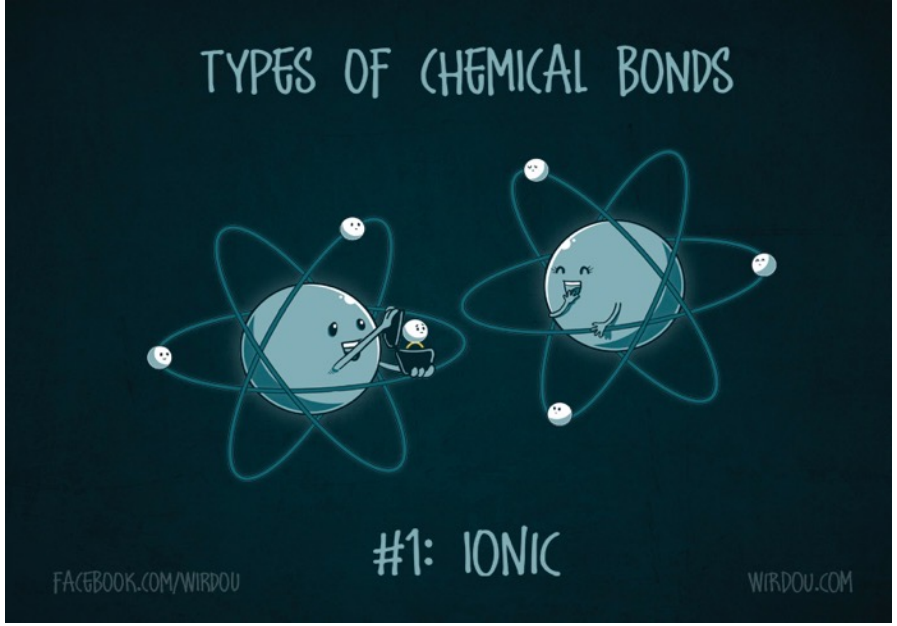


Concretness: the degree to which a referent in the real world is associated with a concept that can be accessed via sensory experience (Bolognesi et al., 2020); perceptibility; image-arousing value of items (Paivio, 1986); visualization

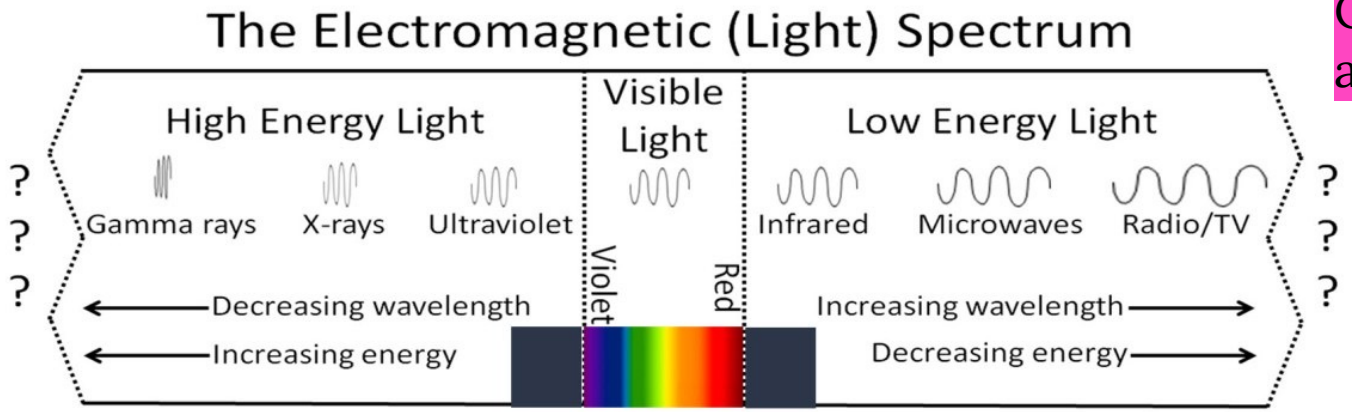
Metaphor: allows us to map concrete knowledge onto abstract concepts (Lakoff & Johnson, 1980; Gibbs, 1994); embodiment; metaphor comprehension relies on sensorimotor simulation (Jamrozik et al., 2016)



Brain as a computer

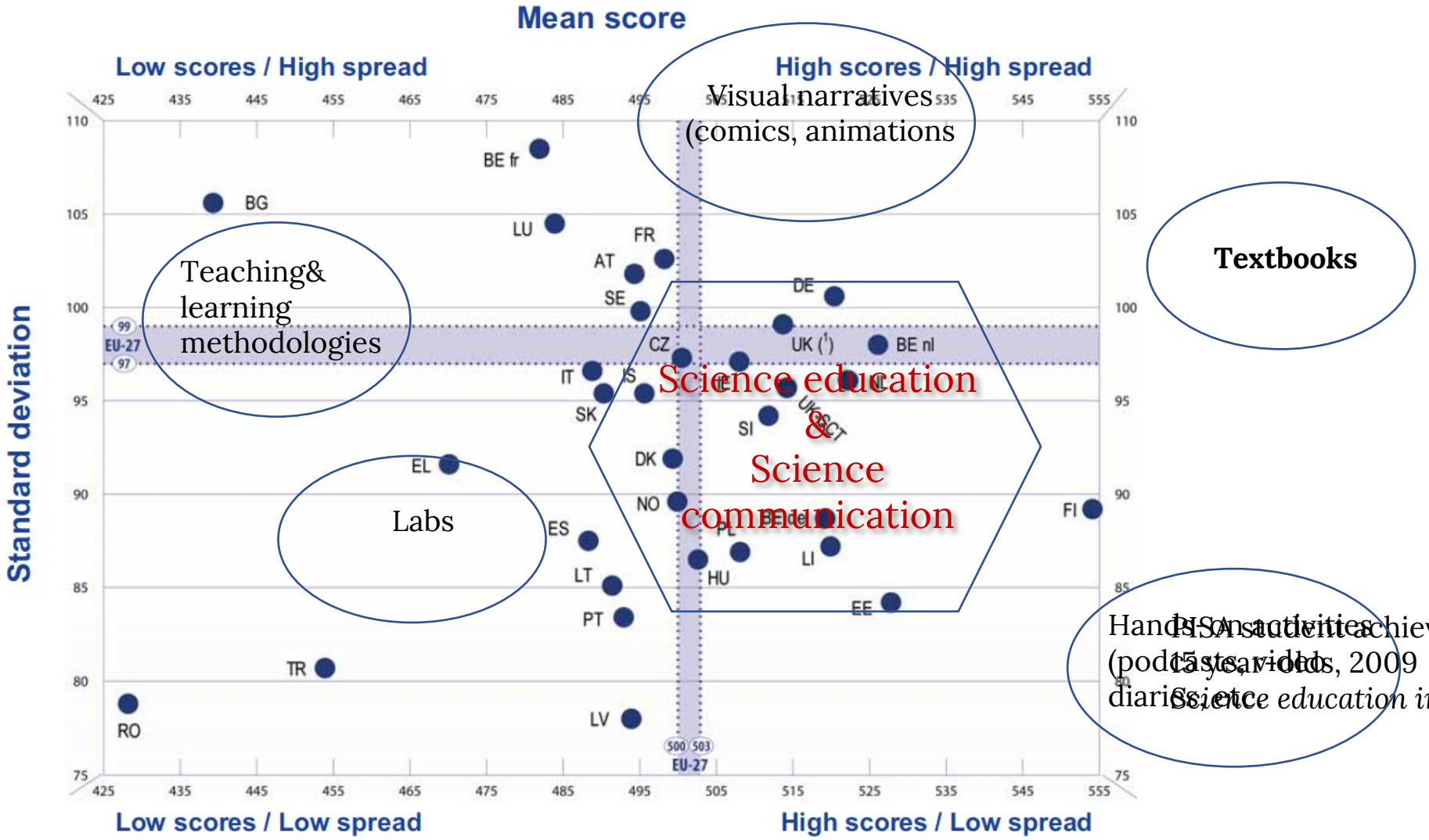


Connections between atoms as bonding



Light as a wave

Science education&comm



Methodology

Content analysis

- MIP(VU)
- 16 textbooks: physics (6), chemistry (5), biology (5); lower secondary education
- pre-defined target domains ~ scientific topics taught
- visual metaphors

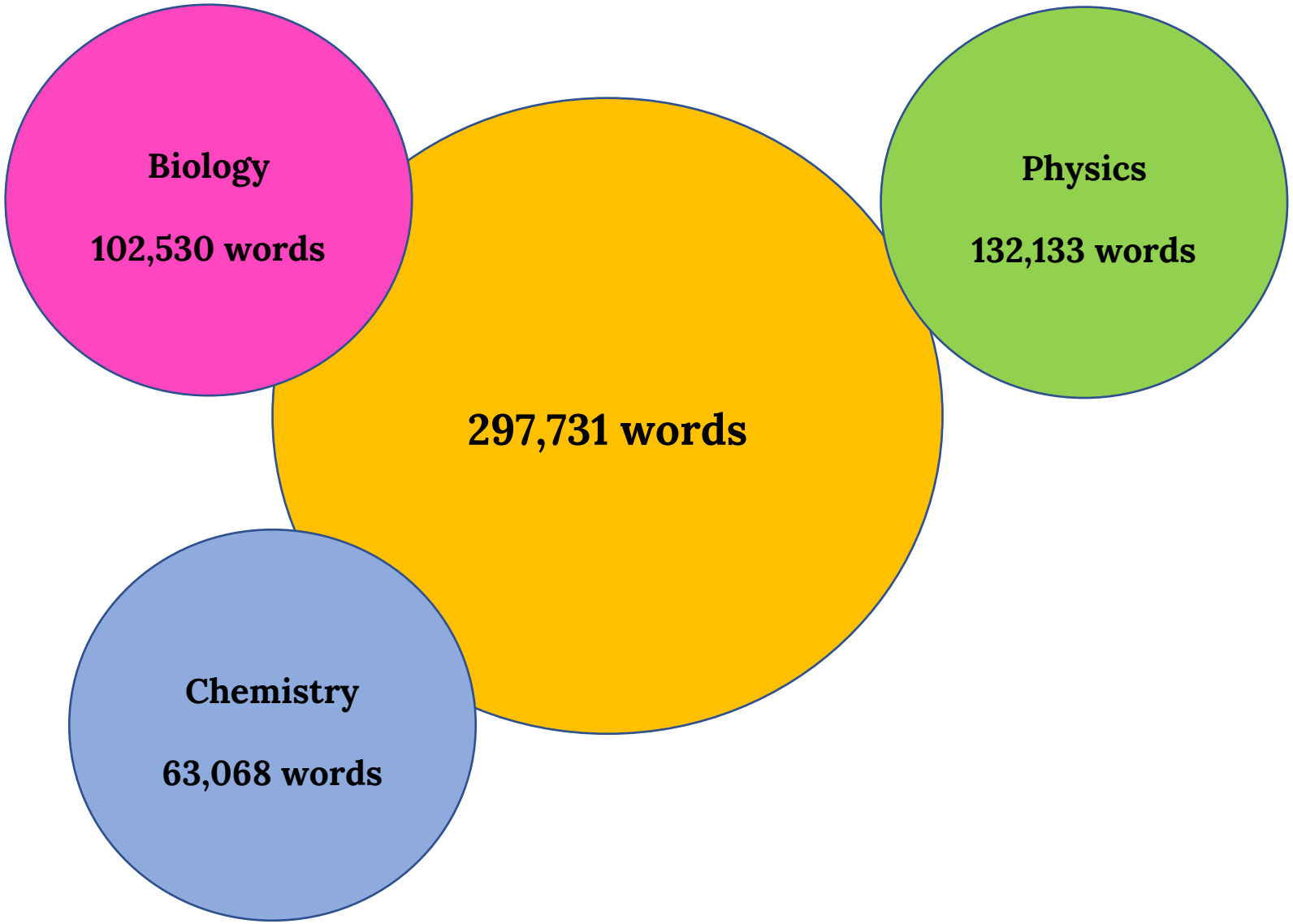
Classroom observation

- observation protocol
- 4 observations; biology (3) and chemistry (1); hybrid, online
- 1 school from Bucharest, 1 school from Vaslui (Vaslui county) and 2 schools from Slobozia (Ialomita county)

Dyads

- GITA (Goal-Directed Interactive Think Aloud) protocol
- text & video-based thinking-and-talking
- fragments from textbooks; heart (biology), electricity (physics) and electron configuration (chemistry)
- 14 dyads + 1 triad; biology (9), chemistry (2), physics (4); online
- students enrolled in secondary education; grade 6 (10); grade 7 (12), grade 8 (5)
- 14 male & 15 female students
- residence: Bucharest, Vaslui (VS county), Slobozia (IL county), Caracal (OT county), Fierbinti (IL county)

Corpora


Biology
102,530 words
297,731 words
Physics
132,133 words
Chemistry
63,068 words

Metaphor frequency & density

	Frequency of metaphors	Percentage	Metaphor density scores (%)*
Physics	997	77.3	7.54
Chemistry	101	7.8	1.60
Biology	191	14.8	1.86
Total	**1289**	**100.0**	**4.32**

*Metaphor density is calculated as the number of metaphoric expressions per 1000 words.

Target domains

	Grade 6		Grade 7		Grade 8	
	Target domains	**#M**	**Target domains**	**#M**	**Target domains**	**#M**
Physics	physical body	37	force	33	electricity	110
	light	28	energy	26	light	76
	electricity	18	pressure	10	heat	67
Chemistry			atom	20	atom	4
			air	5	energy	3
			water	5	substance	3
Biology	energy	22	nervous system	10		
	heart	20	neuron	8		
	cell	5	energy	7		

Conventional metaphors

Physics
Electric circuit as the road traveled by electric charges
Flowing of electrons in the circuit
Conductors allow electricity to flow

Chemistry
Atoms as objects
Connections between atoms as bonding
Atmosphere as a greenhouse

Biology
Synaptic receptor as key-lock mechanism
Heart as a pump
Central nervous system as a computer

Novel metaphors

Physics
Atoms as chopped pieces of wood

Chemistry
Chemical substances as transportation vehicles
Electron shells as field track lanes

Biology
Genital organs as entry gates
Plants as living chemical plants

To describe the electron configuration in an atom, we could draw an analogy with a track and field event (running) which takes place on a circular track. Athletes have the tendency to occupy the inside lane of the track because the distance they must run is shorter and therefore the amount of energy they consume is smaller. As the inside lane is occupied, the other athletes must occupy lanes that are more far away from the centre and, therefore, a higher amount of energy is required to run the distance. Only a certain number of athletes are allowed on each lane. Atomic structure contains electron shells similar to lanes on a field track. In an atom, there can be n shells numbered with digits 1, 2, 3, 4, 5, 6, 7, or with letters K, L, M, N, O, P, Q.

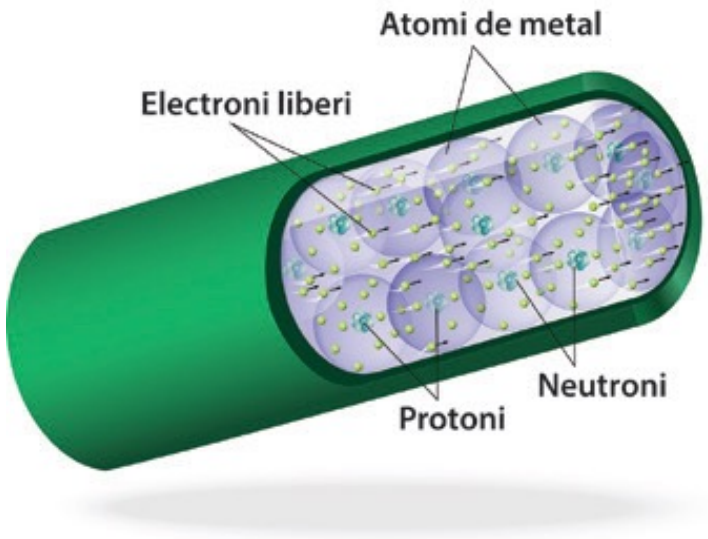
(Chemistry, grade 7, Intuitext, pag. 57)

TARGET	SOURCE
Electrons	Athletes
Electron configuration	Track field
Electron shells	Lanes
Orbiting	Running

The generator is like a pump that raises the water into a high tank from where it will flow freely – like the "flowing" of electrons in the circuit.

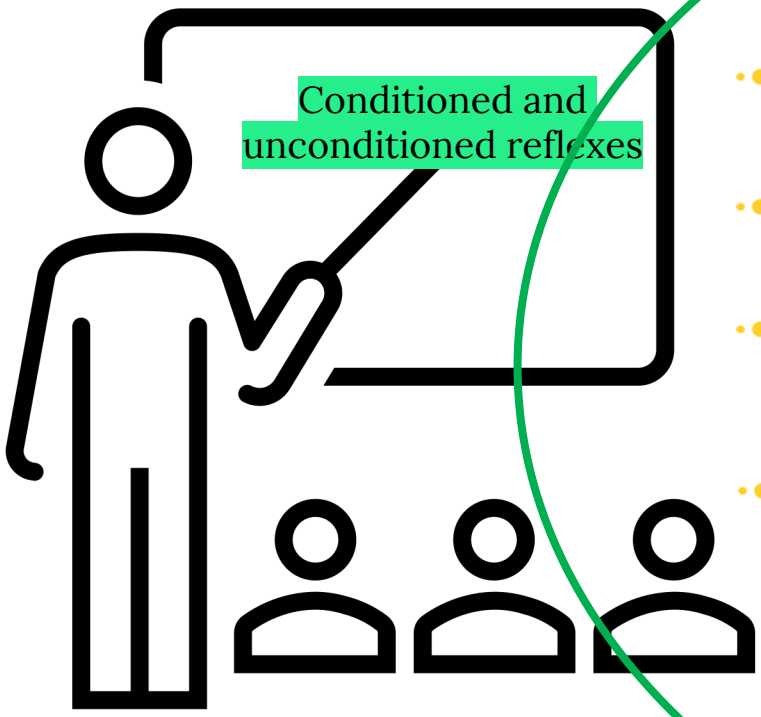
(Physics, grade 8, Litera, p. 57)

TARGET	SOURCE
Generator	Pump
Electricity	Water flowing
Electrons	Water molecules?
Voltage	Water debit



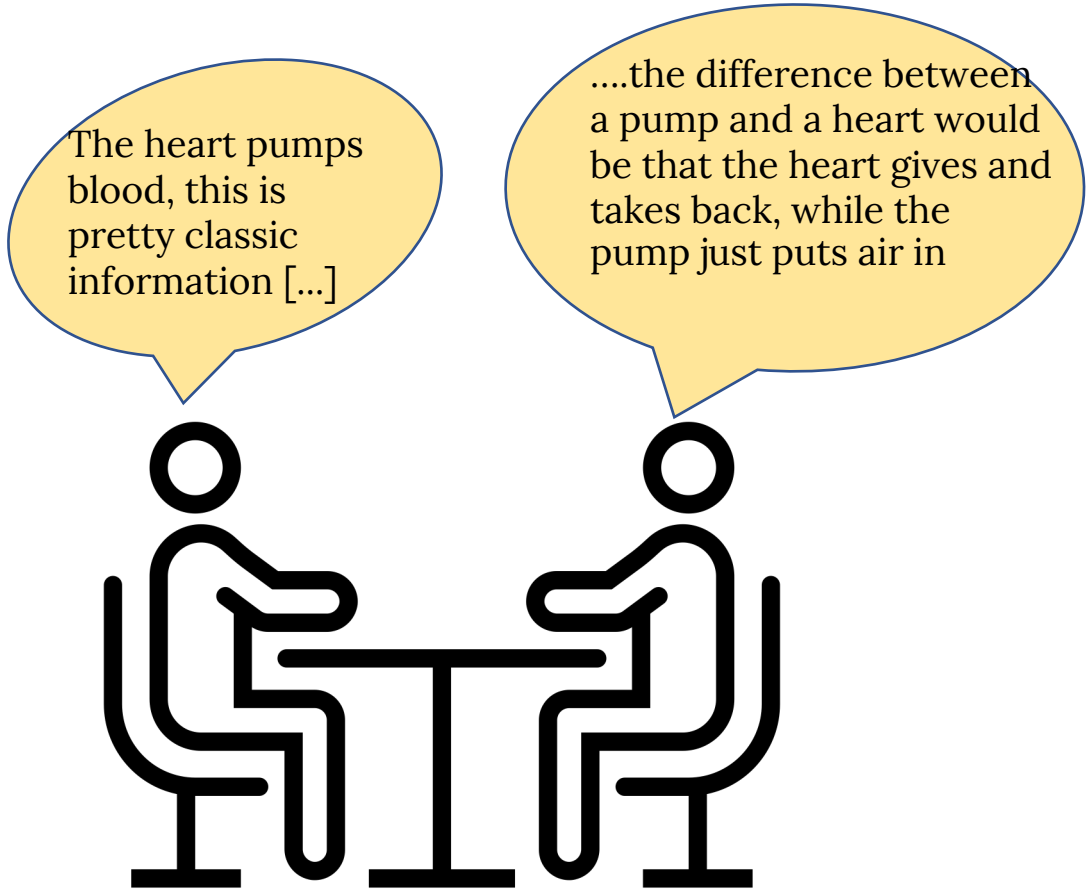
TARGET	SOURCE
Electric circuit	Water pipe
Electricity	Water flowing
Atoms	Air bubbles?

Classroom interaction



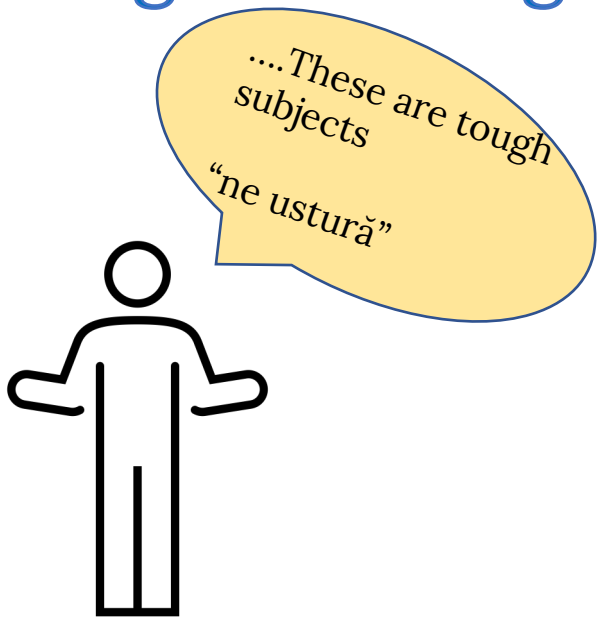
- Visualization
- Video materials
- Tactile stimuli (e.g., using play clay to module the brain in a biology class)
- Recalling personal experiences and behaviors and classifying them as unconditioned or conditioned reflexes

Dyads



GITA protocol (Cameron, 2003)
Collaborative thinking-and-talking experience; participants were encouraged to read a text and then talk freely about their understanding of the abstract idea (e.g., electricity, heart, election configuration) as presented in the text
Adaptation of GITA: after discussing the text, participants were shown a short video explaining the same scientific concept they had read about in the text

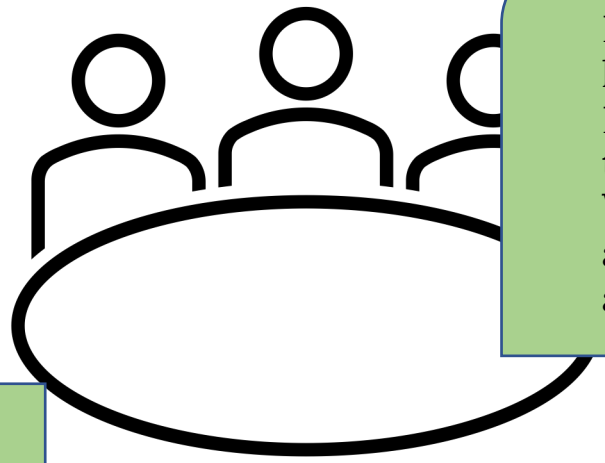
Dyads: young stydents' perception of teaching & learning science



- Lack of interest & confusion about the discipline and the role of science in knowledge acquisition , education, society…
  Decontextualization of knowledge/ science
- Fear of failure
- Preference for alternative methods of teaching & learning (video, games, modelling, experiments, hands-on activities, etc.)

Dyads: alternative metaphors for scientific conceps

the heart is like a doll's house, it has four rooms such as the bathroom, the kitchen, the bedroom and the living room



P2. Blood vessels are like lollipop straws.
P3. The cells are the sugar and the straw is the blood vessel. We say *blood vessels* and *cells* and we understand[...] straw and sugar.

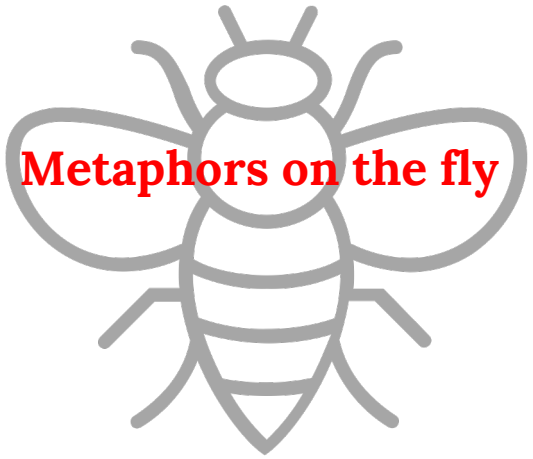
P1: To be honest, I would draw a car that has the doors and trunk open, and they close when needed. And around the car there are grooves that somehow bring the air in. This car, when it has too much air, automatically closes its doors and trunk.
P2: I think the car is a good resemblance, I don't know if I'd think of anything else, because it (i.e., the heart) looks simple on the outside but is more complicated on the inside. With the car is the same, underneath it has a lot of mechanisms.

The atom is a dwarf, there are more dwarves. [...] I don't know, they are all part of a team, just like in a story.

When I read this sentence, I thought of a fire hydrant to which one attaches a hose and uses it to fill up a swimming pool. When that faucet is closed, water stops flowing, just like an electric light is on or off.

Discourse-emerging metaphors

- Metaphors that students come up with to explain the scientific concepts; soon replace the metaphors in the text
- Draw on immediate experience/ embodiment



- Students struggle to make sense of the metaphors in the text; lack of knowledge of the source domain undermine their understanding
- Could alternative metaphors be more efficient in science education?
  - Creativity ✓
  - Perceptibility ✓
  - Concretness ✓
  - Accuracy ?
  - Semantic distance ?

Future avenues for research

- Metaphors & embodiment in science education and science communication
- Metaphors & visualization of abstract information
- Metaphors & its role in increasing students' engagement with science