Understanding abstract concepts in science education: Metaphors and grammar in Romanian Physics textbooks

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CommetSci Project

Communicating science to young generations: Metaphors our children learn by

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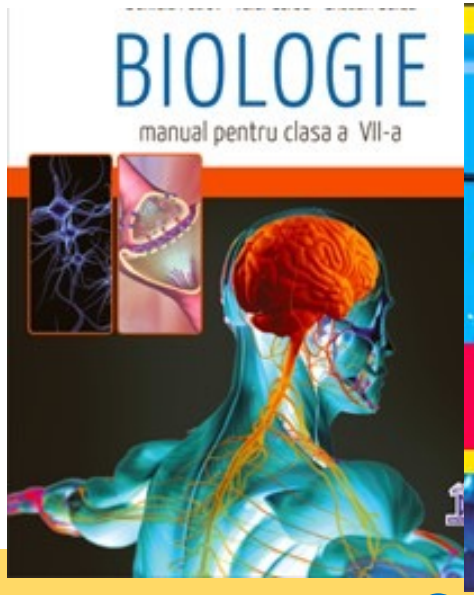
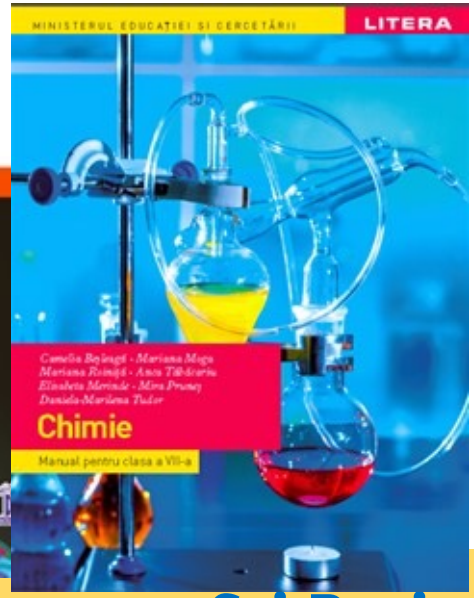
Goal: to examine the **metaphors and analogies used in Romanian science textbooks for lower secondary education** (5th to 8th grade) to explain abstract scientific ideas and to communicate them to students





Methodology

→ **Content analysis** (we used the MIPVU (Steen et al., 2010) to identify metaphors)

→ **Classroom observations**

→ **Focus groups** (we used the Goal-directed Think Aloud technique (Cameron, 2003))

Scientific concepts & metaphors

Scientific literacy is crucial to informed citizenship (Davies, 2014) and school textbooks are instrumental for transmitting knowledge and values to the young generation (Kalmus, 2004).

Scientific concepts are abstract and cannot be perceived through our senses, but we learn about them, talk about them, make inferences based on them, solve problems, etc.

Metaphors and analogies help grounding abstract concepts by mapping attributes of (more) concrete domains (source domains) onto abstract concepts (target domains)

Metaphors and analogies in science education

→ Generate **new meanings**
→ Play and important role in **knowldege acquisition** (Cameron, 2003; Littlemore & Low, 2006; Nacey, 2013)
→ **Simplify** complex ideas and communicate them to students (Low, 2005; Cameron, 2003)
→ Help us 'see' things from a **different perspective**

Simplification and communication of abstract concepts in science education

Simplification → metaphors simplify abstract concept by making them easier to understand via correspondence with other concepts which are conceptually simpler

- more easily processed
- ease to evoke a mental image

e.g., light as *waves*
links between molecules as chemical *bonding*
electron configuration as *running track* and electrons as *runners*
synaptic receptors as *key-lock mechanism*
heart as *pumping* blood into the organism

Communication → metaphors facilitate communication by enabling overt comparisons between abstract concepts and simpler, more familiar ideas, which are conveyed multimodally

Electricity explained in textbooks

Electricity is key to physics curricula for secondary education; concepts related to electricity are particularly complex and abstract, therefore they are often explained via metaphors

Physics textbooks for 6th and 8th grade, lower secondary education

Two widespread metaphors/ analogies (Gentner & Gentner, 1983)

- → the water-flow
- → the moving crowd

When they think of electricity as water flowing or as a moving crowd, people import elements of the source domains to make inference within the target domain (electricity)

Electricity is movement of free electrons

→electrons as objects/ particles, identifiable points

→ SOURCE-PATH-GOAL image schema is activated

→ attention drawn to the PATH element of the schema that is taken by an object (electron) to travel from one place to another

→ e.g., electrons *move, pass from* an atom to another, are *transported,* they *travel a road*

Electricity is electrons flowing

→electrons as waves (flow), smeared paste, not (easy) identifiable borders

→ analogy with water pumps; the volume of the water flowing is metaphorically mapped onto the strength of an electric current (amperage); the pressure of water is mapped onto the tension of the current (voltage)

→ e.g., electrons *flow* though the circuit

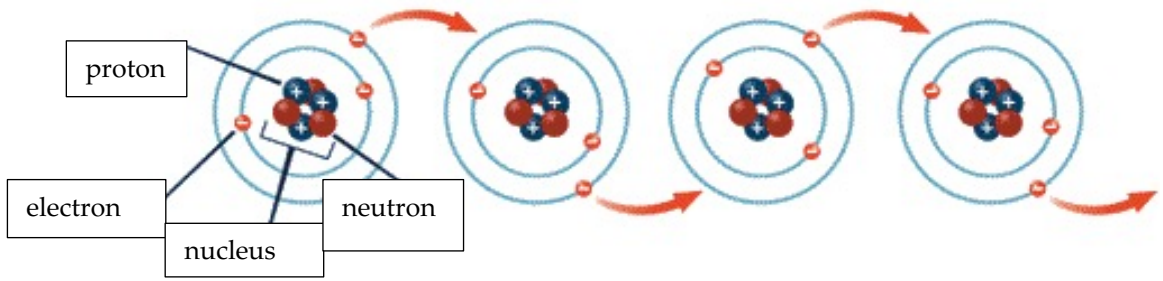
Understanding electricity as movement of electrons

Does it simplify children's understanding of the concept?

→ focus is on the agents of the action described by the verbs (electrons, electric current, electric circuit)

→ electrons are objects and objects are usually perceivable and conceptually simpler

→ the image schema SOURCE-PATH-GOAL helps the children create a mental representation of the abstract concept of electricity via visualizations of electrons, atoms and the movement of electrons



- Electrons can *pass from an atom to another*, by *moving* freely inside the physical body.
- The *movement* of electrons is called the electric current.
- The electric circuit is the *road traveled* by the electric charges that form an electric current.

Understanding electricity as electrons flowing

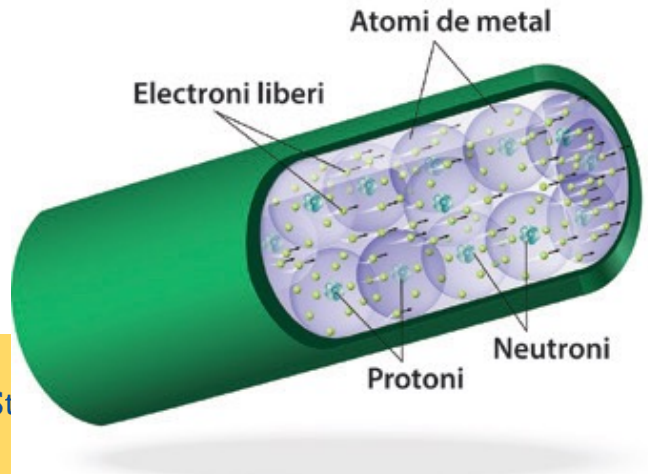
Does it simplify children's understanding of electricity?

→ focus is on the process described by the verb (flowing)

→ verbs label relational concepts, more difficult to perceive and, therefore, more difficult to represent than nouns that define objects

→ water pump analogy requires specific knowledge that allows children to map elements of the source – water pump (e.g., water debit) onto the target – electricity

→ the image draws attention to attributes that electricity does not share with water (e.g., transparency)



- 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.
- There are materials that allow electricity "to flow" through them (because of the movement of free electrons) and they are called electrical conductors.

Conclusions

The two metaphors of electricity may impact differently on the understanding of this abstract concept by pupils

→ electricity as movement of electrons: + simplification (i.e., easy processing, evoke a mental image),

→ electricity as electrons flowing: -? simplification, - communication (the image used highlights attributes that electricity does not share with the source domain, the mapping pipe --> wire is visual only, but no linguistic expression is used to describe it)

The 'electricity as electron flowing' metaphor might inhibit learning

→ e.g., the generator as a pump raising the water is supposed to enable children make connection between what they already know (existing knowledge) about water pumps and the unfamiliar concept of electricity (new knowledge); however, children aged 11-14 may be less (or equally) unfamiliar with the source domain as they are with the target domain