

# The many roles of metaphors in learning and doing physics

*Thursday, December 16, 2021 11:00 AM (20 minutes)*

## Abstract.

In recent years, the physics education community has explored the role of conceptual metaphors in the teaching and learning of physics. While researchers seem to agree on the crucial cognitive value of metaphors that can aid scientific inquiry, their instructional potential in physics education is not yet fully realised. In this paper, we first review the many roles of metaphors in learning and doing physics. Synthesising insights from the history and philosophy of science and physics education research, we then show how the explicit use of metaphors can improve instructional practices in physics education.

## 1 Introduction

Metaphors play a crucial role in science by providing aids to reasoning and imagination (1). Metaphors can also provide the basis of scientific knowledge that is too abstract to be understood through our senses alone (2). Although the extent to which metaphors constitute an essential part of scientific knowledge is still a debated topic among scholars, there is no doubt that metaphors have excellent potential to improve instructional practices in physics (3). However, there remains a gap between research and practice. While physics education researchers have argued for the importance of conceptual metaphors (4,5), few instructional practices make explicit use of such metaphors (6). We address this gap and suggest ways of bridging it. First, we review the roles of metaphors in learning and doing physics. Second, we synthesise findings from the history and philosophy of science (HPS) and physics education research (PER) to suggest how physics teachers can take advantage of these different roles. Two research questions guide our inquiries: 1) Which role do metaphors play in learning and doing physics? 2) How can metaphors be put to good use in physics education?

## 2 The role of metaphors in learning and doing physics: insights from HPS

Metaphors play a crucial role in scientific knowledge construction: metaphors can serve as aids to reasoning, and specifically, as aids to imagination (1). By suggesting directions of inquiry, metaphors guide scientific thought. Many historical accounts describe how physicists drew on metaphors to develop their scientific imagination and develop and refine physical theories. Prominent examples include

1. Newton's efforts to understand the nature of light by comparing refracted light rays through a prism as "tennis balls" describing curved lines (7).
2. Faraday's metaphorization of his early intuitive conception of lines of force as vehicles moving, shaking and undulating when transmitting magnetic and electric forces (8).
3. Einstein's thought experiments gather many conceptual metaphors to grasp essential features of the general theory of relativity (3).

## 3 The role of metaphors in learning and doing physics: insights from PER

To understand the role of metaphors in learning and doing physics, physics education researchers have drawn on conceptual metaphor theory (3,5). According to these perspectives, our understanding of physics concepts is grounded in our bodies, and we extend embodied experiences to more abstract domains through conceptual metaphors. Here, the role of metaphors in learning physics is constitutive: metaphors are conceptual mechanisms that evoke lived experiences as an experiential basis for the construction of abstract concepts. There is another role of metaphors that extends the cognitive linguistic view of conceptual metaphors: enactive metaphors build on the idea that metaphorical meaning emerges from human actions and is closely embedded in the environment. While conceptual metaphors transfer embodied experiences to more sophisticated cognitive structures, enactive metaphors demonstrate the relevance of action-based metaphors for learning (6).

## 4 How can metaphors be put to good use in physics education?

We have gathered insights from HPS and PER to identify three roles of metaphors in learning physics:

- 1) imaginative role: metaphors as aids to imagination
- 2) embodied role: metaphors as conceptual mechanisms of knowledge transfer
- 3) enactive role: metaphors as figures of action.

We now turn to instructional implications and briefly sketch how addressing the embodied role of metaphors can improve instructional practices in physics education. In our talk, we will also elaborate on instructional opportunities for the other two roles of metaphors.

Conceptual metaphors: If our understanding of physics concepts is grounded in our bodies, teachers can ground instructional activities in embodied sources (6). Such grounding can mean choosing instructional metaphors with embodied sources (3) or letting students perform concrete kinaesthetic activities that link to scientific concepts. One exciting implication of combining the imaginative and embodied roles of metaphors is that metaphors could be considered as imaginary laboratories for conceptual change.

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