# LEARNING SCIENCE WITH THE BODY IN MIND

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**This article explores embodied learning in the science classroom. The authors use research in science education to illustrate, practically, how teachers can create immersive, full-body thinking and knowing experiences for their students.**

*"[A]s embodied, imaginative creatures, we never were separated or divorced from reality in the first place. What has always made science possible is our embodiment, not our transcendence of it, and our imagination, not our avoidance of it."* — George Lakoff.

*"... don't underestimate the importance of body language"* — Ursula the witch in Disney's Little Mermaid.

Consider explaining to someone the earth's orbit around the sun with your hands tied behind your back. Many people might find it challenging to talk about planetary motion without moving their hands or arms in an elliptical gesture. Many may even feel inadequate in explaining day-to-day experiences without using their bodies to express. This is because our understanding of the world is not exclusively encoded through language; our gestures and movements are also connected to the ways we think and learn.

We often think and understand the world using our bodies. Our senses and movement shape how we form and process knowledge. In understanding the world, it is quite common to combine language and gestures to communicate meaningful concepts. Particularly when dealing with abstract concepts, we tend to base them in some concrete physical sensation. This is called **embodied learning.**

Scientists who study embodied learning are interested in the ways our bodies help us to learn and understand. They consider our body's sensory and motor activity as an essential part of learning, knowing, and meaning-making. They also encourage educators to reconsider the role of senses and physical movement in learning, and design pedagogy that embraces embodiment.

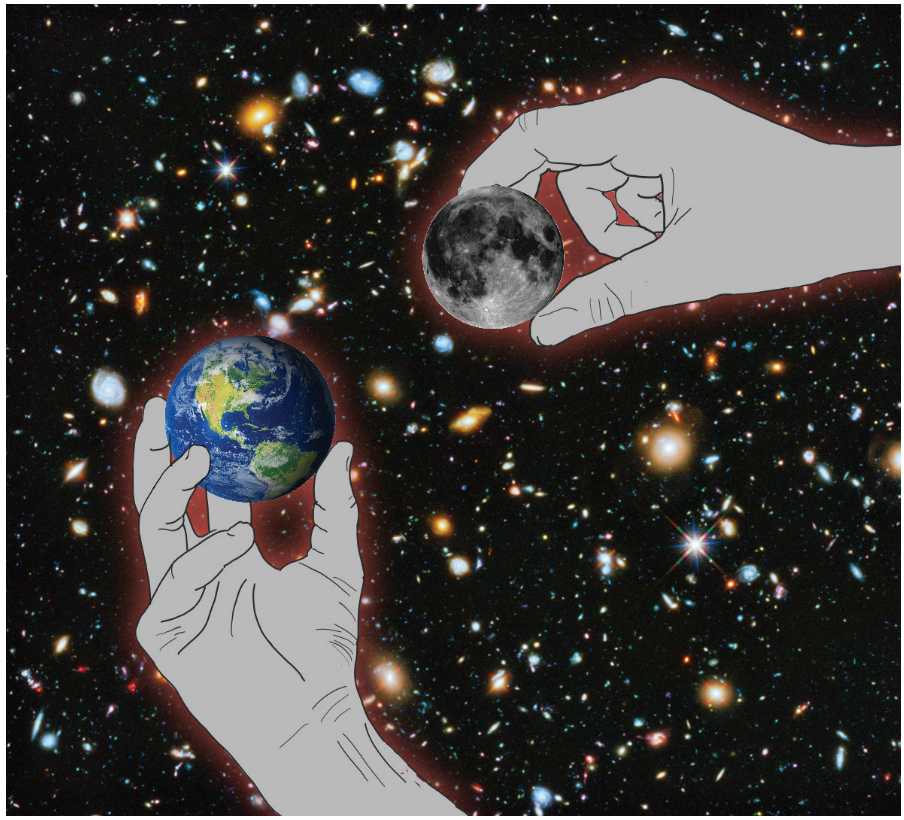

**Fig. 1.** **Our understanding of the world is not exclusively encoded through language; our gestures and movements are also connected to the ways we think and learn.**

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## What is embodied design for learning?

**Embodied design for learning** considers how students can develop meaningful ideas using natural and intuitive movements. Students might engage in gestures or motion using their own natural movements and environments as learning resources. Then, combining physical movement with reflective language, students could explore and communicate their understanding of fundamental but abstract scientific concepts such as force, inertia, or motion. Thus, the physical actions they engage in become the pathway toward a deeper understanding of abstract concepts.

Embodied learning is not a stylistic preference like visual or kinesthetic learning styles. Embodied design principles are concerned with immersive, full-body thinking and knowing, where physical movement is a natural part of

**Fig. 2.** **The physical actions we engage in become the pathway toward a deeper understanding of abstract concepts.**

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learning. Additionally, embodied design for learning challenges traditional and common practices that privilege certain ways of knowing over others. In fact, scientific knowledge that resides in the head may not be superior to that which is embodied through action, and often represented through muscle memory, instinct, visual mapping, or ways of moving. Through embodied design, science learning can become a more inclusive, participatory, and humanizing process, both in what is learned and how it is learned.

## What does the research say?

Roni Zohar and colleagues utilized an embodied design approach to support students' understanding of high-school concepts in physics. Their pedagogical design engaged students in physical experiences in which they coordinated movements to enact concepts. Then, they reflected on their experiences through the lens of the relevant physics ideas. We share examples of embodied design through two of their case studies:

**Case Study #1:** In a dance studio, Zohar facilitated students as they learned about two concepts related to balance: **area of support** and **center of mass**. In four 90-minute lessons, students worked collaboratively to explore different bodily positions that were either steady or unsteady. Students learned that positions with larger areas of support were more stable. Students also explored the concept of center of mass by considering where their center of mass was located when assuming different bodily positions, such as when raising their arms or leaning forward.

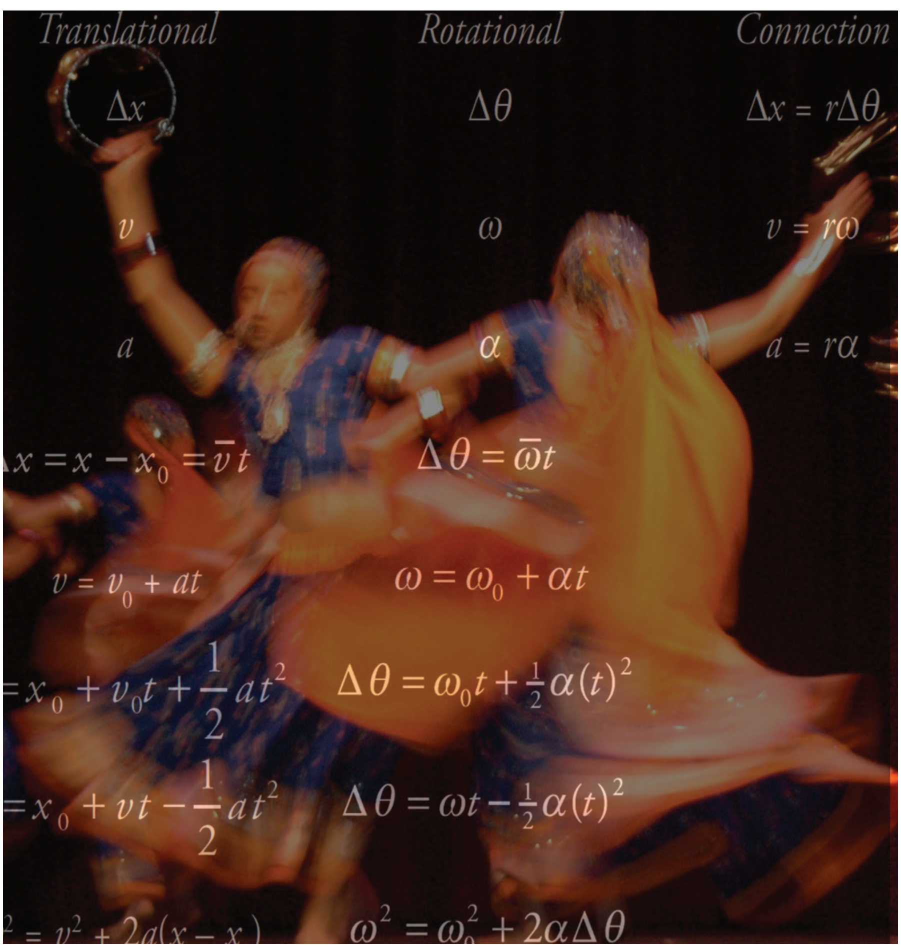


**Fig. 3. Relating linear and angular motion.** Photo of dancers overlaid with equations comparing linear and angular motion.



In the last of these lessons, students worked in pairs, with one student demonstrating a position while the other determined the area of support and the center of mass. The final project required pairs of students to demonstrate a sequence of three balanced positions, while explaining their conceptual understanding using the terminology from the lessons as well as physical movements and gestures.

**Case Study #2:** A series of lessons focused on the difference between linear and angular velocity. Linear velocity was taught in a typical classroom setting, and angular velocity was taught in the dance studio. Students began by exploring circular movements with one body part at a time, such as their heads, hands, hips or feet. Each student explored circular movement at their own speed and direction.

The next activity required them to stand alongside each other, holding hands, and move around a bottle placed on the ground next to the person at the end of the line. Their movement as a row around the bottle at the center formed a circle of which they were the radius. To keep the angular velocity constant, the students had to negotiate their movements several times before reaching a consensus. To help the students understand the circular movement, the instructor also mimicked their movement using her arm, anchoring her elbow to the ground as a center and rotating her arm in a counter-clockwise direction. This movement represented the larger physical activity, and further developed the concept of angular velocity.

In their analysis of both the case studies, Zohar and colleagues found that students' final projects demonstrated a deep understanding of the physics concepts taught. These understandings also reiterate what other embodied cognition scholars and educators have found in their work in linguistics (e.g., George Lakoff) or arts and humanities (e.g., Kerry Chappell), among others. Students enacted their conceptual understanding of balance and velocity by using gestures and physical representations of the movement activities involved in the lessons. Making use of a variety of forms, such as music, art, dance, and video, their projects reflected their embodied experiences of the pedagogical design.

## How can teachers use embodied design to support science learning?

### Guide 1: Begin with Physical Experiences

Physical experiences have the potential to engage students and are, often, the hallmarks of good teaching practice. Through the embodied design lens, physical experiences can take on new significance. These experiences serve as a starting point for the development of sophisticated conceptual understanding.

As Zohar and colleagues suggested, these bodily experiences *"act as a resource enabling [learners] to relate complex (often abstract) ideas in physics to [their] everyday experiences"*.[1] Additionally, physical interactions bring value to various ways of thinking and knowing, and can engage learners who may lack prior formalized knowledge. This important shift in the science classroom gives students access to concepts that might otherwise seem 'out there'.

One way teachers can put these ideas into practice is through the use of gestures. Studies have shown that when students gesture with their hands while they communicate, these movements help to form ideas for which they may not yet have language. As they learn, students seek to reconcile differences between their physical movements and oral expression.

Teachers can help to shape students' learning experiences through the use of their own gestures as well. For instance, Zohar and colleagues also found that students imitated the instructor's gesture when asked to answer an oral question about the velocity lesson. Attending to gestures can be a first step toward embodied design that does not require major revisions to existing pedagogies.

**How to Implement:** Take some time in instructional planning to explore possible physical actions that can lead to conceptual understanding in science. You can start by analyzing your own physical movements and gestures as you explain the concepts. This also presents an opportunity to collaborate with your colleagues to observe each other's movements while discussing lesson plans, thus supporting collaborative preparation and reflection. While planning, consider the concepts that students can enact through movement. For e.g., imagine ways students might position their arms to simulate aircraft wings when studying flight mechanics.

**Fig. 4. Understanding Newton's Laws through physical activity.** Silhouette of children playing tug-of-war superimposed on text of Newton's notes on the Laws of Motion.

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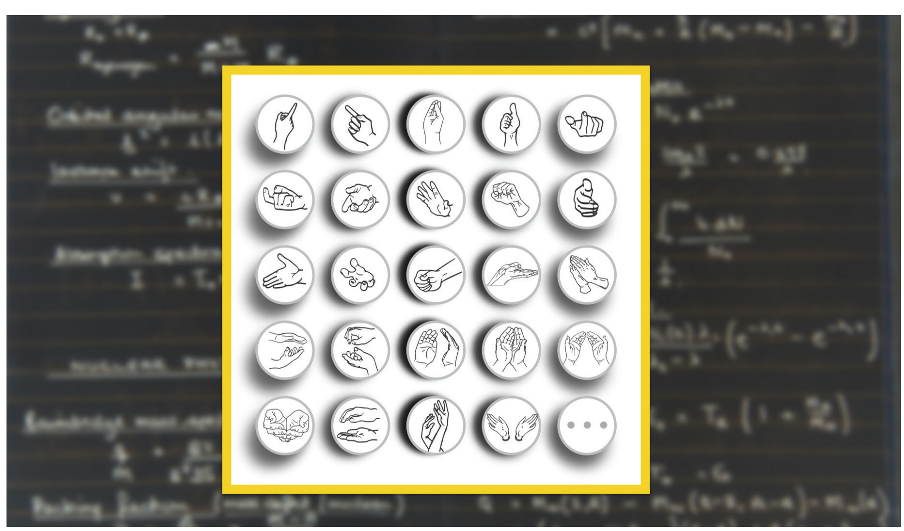

**Fig. 5. Take some time in instructional planning to explore possible physical actions that can lead to science conceptual understanding.**

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**Fig. 6. Provide opportunities for students to engage in reflective conversation about their physical experiences.**

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In classroom lessons, take advantage of students' natural movements to explore the dynamics of ecosystems. When introducing abstract or counter-intuitive ideas or concepts, be prepared to invite students to explore and move in new ways through scaffolded support.

### Guide 2: Engage Learners in Reflection

A key component of embodied design for learning is to "*guide learners from immersive action to structured reflection*".[2] Reflective conversations can help students use language to explain their movements and, in the process, make sense of associated concepts. Through classroom dialogue, teachers can anchor new learning in students' lived experiences as well as encourage the development of meaning and collective understanding. Creative reflective tools such as journals, video blogs, and interviews can also bring value and empathy to classroom interactions.

**How to Implement:** Provide opportunities for students to engage in reflective conversations about their physical experiences. Ask yourself: how did the experience challenge their assumptions and prior thinking? How did physical movement disrupt their existing patterns of thinking about scientific concepts? What new ideas or questions do they have now? Teachers develop a humanizing learning environment when classroom conversations focus on highlighting students' strategies and insights.

### Guide 3: Encourage Multimodal Student Projects

Drawing on the strengths of project-based learning, multimodal projects provide students with opportunities to draw on a variety of resources to develop understanding and communicate meaning. Collaborative student projects move beyond written word responses and can take the form of art, video, dance, oral presentation, or short film.[3] These projects give students the opportunity for increased participation, and allow for the inclusion of bodily movement in creating and sharing meaning. Projects that leverage more tools — such as brain, body, and environment — have the added benefit of enhancing creativity and expression.

**How to Implement:** Give students opportunities to incorporate social, cultural, and personal elements into science projects. While poster boards and three-dimensional models are well-suited to scientific displays, physical movement is less common. Consistent with embodied design, teachers might encourage a movement routine to demonstrate how organisms interact within their environment. Students could be encouraged to use their hands to illustrate the push and pull of magnetic forces, how electricity travels along a circuit, or ideas related to the transfer of energy.

## Conclusion

Embodied design for learning presents several unique challenges to the ways we conceptualize thinking and learning. For science teachers, embodied design highlights the role of physical movement in how our students interact with important scientific ideas and processes. Embodied design presents opportunities for us to rethink our science teaching practices. In many ways, it offers us a pedagogy that recasts learning as a more complete, complex and human activity.

**Fig. 7. Collaborative student projects move beyond written word responses and can take the form of art, video, dance, oral presentation, or short film.**

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## Key takeaways


- It is common to combine language and gestures to communicate meaningfully.
- Embodied design for learning incorporates physical aspects such as dance, music, art for better understanding of scientific concepts.
- For e.g., dance movements could be used to learn physics concepts of area of support and centre of mass.
- Students imitate gestures used by their teacher to explain concepts, so teachers can pay attention to their own movements and modify them as necessary.
- Discussion and reflection can help students relate language to their physical movements.
- Multi-modal projects encourage students to use their bodies, mind and the environment.



**References:**


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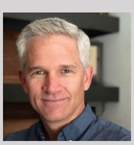

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