

Dance the Doctorate and the Laws of Physics

"Movements as a Door for Learning Physics Concepts, Integrating Embodied Pedagogy in Teaching"

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Dance Your Ph.D

Dance Your Ph.D. is an annual contest which challenges scientists from all around the world to interpret their doctoral dissertations through interpretive dance. The contest requires each of the scientists to take part in a video dance performance which is uploaded to YouTube (<https://www.sciencemag.org/projects/dance-your-phd>). There are four categories of winning based on the scientific field of the scientists' thesis: Physics, Chemistry, Biology, and Social Sciences. Our dance video was the winner of the social science category in the Dance Your PhD/2018 Competition <https://www.youtube.com/watch?v=oLCTJQ-GCLQ&t=306s>.

The Link Between Science Learning and Movement

My deep belief is that, *"Movement is the door to learning"* (Paul Denison) and my Ph.D. dissertation title is: *"Movement as a Door for Learning Physics Concepts, Integrating Embodied Pedagogy in Teaching."* The research was conducted under the guidance of Prof. Bat Sheva Eylon of the Science Teaching Department at the Weizmann Institute of Science, and Prof. Dor Abrahamson of the University of California at Berkeley. Our research is based on a cognitive paradigm, embodiment that regards the brain and the body as one unit. The underlying assumption of the research is that physical experience can be used as a unique resource for learning complex concepts in physics by associating them with daily bodily activities.

The research goals were: 1. Development of the approach 'Embodied Pedagogy,' which combines movement and physical activities in learning concepts and principles in physics. Some of the components of the approach include improvisation in movement, selected aspects of the Feldenkrais method, techniques combining learning with walking, and relaxation. The main principle of the embodied pedagogy is *"experience first, signify later."*

2. Research on learning and teaching processes by enacting 'Embodied Pedagogy' and its contribution to perceiving and using physics concepts. The research contributes both to the research and practice of science teaching. We explored, through two case studies, the potential of 'Embodied Pedagogy' for learning two complex physics concepts by high-school students: 'Balance' and 'Angular

Velocity.' Throughout the entire learning process, the contribution of the instructional approach to the students' learning and understanding of the concepts was evident. Moreover, in their summative projects, the students not only expressed a deep conceptual understanding, but also creativity and a philosophical and effective depth. Related publication: (Zohar, R., Bagno, E., Eylon, B., & Abrahamson, D. (2018). Motor skills, creativity, and cognition in learning physics concepts. *Functional Neurology, Rehabilitation, and Ergonomics*, 7(3), 67-76 or in Hebrew in *Mahol Akhshave - Dance Today* 32, 2017). Similar to my students who summarize their learning in creative ways, our video summarizes my research via dance. It is consistent with my belief that we can learn and explain science through movement.

The Video Dance Analysis

The video takes place in various locations including dance studios where most of my research was conducted. I will analyze the video dance according to four scenes: Opening Scene (dance), Documentary Scene ('Balance Scene'), Illustration Scene ('Angular Velocity') and Closing Scene (dance).

Opening Scene

Location: Dance Studio-Accelerator Auditorium in Weizmann Institute of Science.

Setting: I dance with formulas on my black clothes and the other dancers with black clothes and the curtains are closed.



Figure 1: Dance from the 'Opening scene'

In this scene I awaken my students and inform them of a new pedagogy for learning physics, 'Embodied Pedagogy.' Once they awaken, we demonstrate a number of mechanical concepts in physics

through dance. The concepts presented in this scene include some of the concepts I taught in a mechanics courses for high-school students, for example: Newton's first and third law of physics, friction and gravity.

The Documentary 'Balance Scene'

Location: Dance studio – high-school dance studio. A documentary scene from a mechanics course that I taught to 10th grade dance students. Students experimented via movement concepts related to balance and differentiated between steady/unsteady balance. We are exposed to the main principle of the embodied pedagogy "Experience first, Signify later". At the end of the scene, we are briefly exposed to the students' summative dances in which they explain the concepts learnt.



Figure 2: The documentary 'Balance Scene' in a 10th grade dance class

The 'Angular Velocity' Scene:

Location: Outdoors at the Weizmann Institute of Science. The scene illustrates how I teach the 'angular velocity' concept to 10th grade physics students in a circular group assignment. After the group assignment we see how I use my arm to explain the concept to them. The 'arm model' was used by my students during the research when they were asked to explain the concept to younger students, a finding that indicated the importance of body gestures in learning. The scene was photographed using a drone. At the end of the scene some of the creative summative projects of my physics students are presented in the background. (For example: video art with colors & mandala on a log).



Figure 3: Top view of the synchronized group- from the 'Angular Velocity Scene'

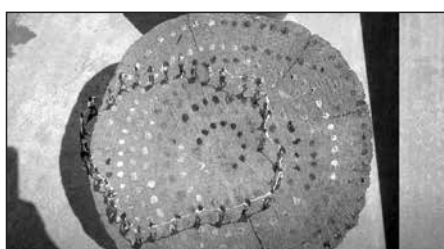


Figure 4: Dancing in a circle, with the creative work of one of the students in the background - from the 'Angular Velocity Scene'

End Scene:

Location: Dance studio-Accelerator Auditorium in Weizmann Institute of Science.

Setting: I am with formulas on my white clothes and the other dancers with colorful clothes and the curtains open and we see the beautiful scenery. (The colorful earrings were borrowed from the choreographer Sharona Florsheim whose dancers appeared in these clothes in the show Noa's Infinity Secret).

In the summative dance, we dance ideas related to circular movement and balance (dancing with exercise balls). We, the dancers, expressed through dance the students' deep understanding via the transfer of knowledge to other mediums. This summative dance celebrates the pleasure and creativity in the learning process; the colorful clothes, the open curtains and the beautiful scenery.



Figure 5: Dancing with exercise balls at the Accelerator Auditorium in Weizmann Institute of Science - from the 'Closing Scene'

"When the learning material is not just on the board, it helps us to understand that these rules were not useless discoveries but are a part of the world around us. Experiencing them reduces the fear of learning," explains one of the 10th grade students at the end of the video.

Details about the filmmakers and the film participants

Movie creators: Roni Zohar & Yael Leibovitz | Video photographer: Roy Bercovich | Choreography: Roni Zohar & Rotem Lev | Dancers: Ortal Mageny, Sarit Livnat-Ivry, Yael Nidam, Tal Keret, Maayan Allen, Sigal Waldman, Karen Cooper Shimshi, Rotem Lev and Roni Zohar | Music: Mark Eliyahu "Coming Back" & "Journey"

Dr. Roni Zohar is a postdoctoral fellow in the Department of Neurobiology at the Weizmann Institute under the supervision of Prof. Ehud Ahishar and Prof. Eitan Gross. Her current research expands upon her doctoral studies in which she has developed and researched an approach to combining physics studies and movement. The doctoral studies were on behalf of the Department of Science Teaching at the Weizmann Institute under the supervision of Prof. Bat-sheva Eylon, in collaboration with the Department of Education at the University of Berkeley, USA under the supervision of Prof. Dor Abrahamson. Roni holds a master's degree in neuroscience from the Hebrew University of Jerusalem in the field of motor control and a bachelor's degree in physics from the Hebrew University, in collaboration with studies at the Movement Department at the Rubin Academy of Dance in Jerusalem. Roni works to promote the integration of movement in teaching in Israel and the link between science and dance, facilitates academic courses in movement, science and learning at the Weizmann Institute and Orot College. She is a teacher training instructor under the supervision of the Ministry of Education and an improvisation and movement instructor for women at the Dance and Movement School in Ness Ziona. Email: roni.zohar@weizmann.ac.il