Questions and answers with Peter Lindenfeld and Suzanne White Brahmia

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Colleagues for more than 19 years at Rutgers University in Piscataway, New Jersey, Peter Lindenfeld and Suzanne White Brahmia long knew that they had compatible outlooks on teaching. Their introductory textbook, *Physics: The First Science* (Rutgers University Press, 2011), is a product of their unique pedagogical philosophy and distinct yet complementary career backgrounds.

Lindenfeld was born in Vienna, Austria. After completing his PhD in physics at Columbia University in New York, he started his teaching and research career in 1953 at Rutgers. He has amassed several teaching honors, including the 1989 Robert A. Millikan Lecture Award and Medal from the American Association of Physics Teachers.

Since his retirement in 1999, Lindenfeld has continued as professor emeritus in the physics department at Rutgers, writing, and occasionally giving talks on physics education. He is coauthor, with George Pallrand, of the *Physics Today* article "The Physics Classroom Revisited: Have We Learned Our Lesson?" (November 1985, page 46).

Before attending graduate school from 1990 to 1993 at Cornell University, where she conducted research in solid-state physics, Brahmia was a Peace Corps volunteer teaching physical science at a rural French-speaking secondary school in Gabon, Africa. Since 1993 she has been director of the Rutgers extended physics program, designed for engineering students entering college at the precalculus level; many of those students are from groups underrepresented in physics and engineering. Based on her work with the extended physics program, she has published several papers on bridging the ethnicity and gender gaps in engineering.

Brahmia is also the associate director for physics at the Rutgers math and science learning center, which provides academic support for undergraduates in math, physics, chemistry, and biology through coordination of student support services and provides outreach to regional K–12 students and teachers. She is currently participating in an NSF-funded project to develop materials and assessments for mathematical reasoning in introductory college physics courses.

Physics Today recently caught up with Lindenfeld and Brahmia to discuss *Physics: The First Science*.

PT: Why did you decide to collaborate on this textbook?

Lindenfeld: We come with quite different backgrounds and experiences: mine in solid-state experimental work and some adventurous teaching with students and with high school teachers; hers in the Peace Corps and then in physics education research with innovative teaching of physics courses, primarily for engineering students. I had started writing but felt very isolated. We saw that we had complementary strengths and decided to work together.

PT: Why did you choose that title for the book, and does it relate to the "physics-first" model?

Lindenfeld: It was our working title, and by the time we wanted one that was more descriptive—something like, *The Physics in Our Lives*—the current title had been registered by the publisher and we could no longer change it. There is no relation to the movement that is concerned with the sequence of teaching the sciences in high schools.

PT: In the preface, you write, "We want to change the way physics is taught and the way it is perceived." Why? And how did you go about accomplishing that?

Brahmia: Physics is a thrilling way to think about nature and the universe; students rarely leave an introductory physics course with an appreciation of the importance and the excitement that is our discipline. At a time when young people have fairly short attention spans, traditional physics courses spend excessive curricular energy on teaching students procedural problem-solving techniques and seemingly dogmatic, immutable laws. Tests are mostly comprised of multiple-choice standard textbook problems. Yet, in practice, physics is nothing like that at all.

That misplaced emphasis does a huge disservice to introductory physics students, for over 90% of whom this is their only physics course. In our book, we treat physics as one of the liberal arts and expect the students to use both critical reading and reasoning skills to learn. We introduce mathematics as needed, and do not rely on contrived and puzzling problems to find applications for more mathematics.

Lindenfeld: Physics is having a hard time shedding its image as remote, irrelevant, and buried in mathematics. We thought we could write a book that students would find interesting and perhaps even enjoyable. This is not a watered-down survey. It is much shorter than the usual texts but contains material that goes further in many ways. We have a more detailed and accessible introduction to quantum mechanics, for example, and sections on modern and lively topics such as energy use, the greenhouse effect, and the basis of solar cells and transistors.

We try to make physics human. We do that with historical notes, applications, and many references to the relevance of physics in our lives. We look at it as the basis for all scientific inquiry. There is even a chapter where we look at what could ambitiously be called the philosophical basis of all of science.

PT: What do you see as the pros and cons of the algebra-based approach?

Lindenfeld: Students often see physics as "all math." It isn't, and shouldn't be made to look that way. The math is part of the language that we use. Studying physics becomes a little like reading a poem in a language that you don't know. You tend to spend so much time on grammar, syntax, and vocabulary that you barely get to an appreciation of the poem. We want to get to the poetry. We make mathematics part of the language of the book. We do, in fact, introduce the elements of calculus, but we see no need to make it a prerequisite.

Brahmia: Much of the reasoning in physics is contextualized algebraic reasoning. Calculus extends those ideas and refines tools that allow us to explore more complex systems, but the absence of calculus does not limit students from learning to reason mathematically in physics. An algebra-based course can be seen as an opportunity because it challenges the instructor to think about the essence of the mathematical concepts we use in physics. Even in the calculus-based introductory course, [calculus is] mostly used to facilitate derivations for the instructor. But the concepts of rates of change and summations are accessible to pre-calculus students and can be part of an algebra-based course.

PT: What books are you reading at the moment?

Brahmia: I am usually in the middle of two or three books at any given moment. Currently sitting on my bedstand—Michio Kaku's *Physics of the Future* (Doubleday, 2011; reviewed by Neil Gershenfeld in *PHYSICS TODAY*, October 2011, page 56), recommended to me by my college-age nephew who is a huge Kaku admirer. The book's effect on him was to enlighten a bright student turned off from physics in high school to now consider majoring in physics. Kaku is a master at capturing the thrill of physics that usually gets lost in the only physics course most people take. I plan to use excerpts and ideas from *Physics of the Future* to spice up the discussion in my introductory physics lectures. I am also rereading Ramamurti Shankar's *Principles of Quantum Mechanics* (2nd edition, Springer, 1994). Although I don't use quantum mechanics in my work, it is an interesting and well-written book and refreshes knowledge that I love. For pure literary pleasure I am reading *Truth Like the Sun* (Knopf, 2012), which is a clever, well-written treat of historical fiction set in Seattle by acclaimed novelist Jim Lynch.

Lindenfeld: I am the convener of a political book group and get to read a lot of books outside science. The present one is *Power, Inc.* (Farrar, Straus and Giroux, 2012) by David Rothkopf. It was suggested by Tom Friedman in a recent column in *The New York Times*.