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Physics in Perspective

Editorial

Physicists at Play

A much-circulated photograph (figure 1) shows Wolfgang Pauli and Niels Bohr crouching side-by-side, fixated on a small spinning top. It is a tippe top, a simple toy that raises some not-so-simple physical questions. When spun with sufficient angular momentum, it will invert itself and start spinning on its stem, raising its center of mass (and so its potential energy) in the process. But where does that extra energy come from? Has one of our most sacred conservation laws been defeated by a mere toy? Few physicists can resist such a stumper, as indicated by the rapt and slightly bemused expressions of Pauli and Bohr.

In this issue, Jean-François Gauvin gives us another example of physicists at play. Gauvin describes a set of “quantum toys,” small boxes embedded with various optical polarizers that render tactile one of the most abstract aspects of physics—the matrix formalism of quantum mechanics. Harvard University physicist Costas Papaliolios developed these toys on the basis of Julian Schwinger’s quantum formalism, in the conviction that play can serve pedagogy. These devices represent an opportunity for hands-on experience of quantum enigmas using very simple means—no elaborate apparatus required.

Gauvin’s analysis raises timely questions about play and pedagogy. If numerous reports are to be believed, we are in the throes of a STEM crisis. Competitiveness depends on innovation, innovation comes from innovators, and innovators are apparently stifled by the strictures of formal scientific and technical education. Are not our most revered innovators, like Thomas Edison and Steve Jobs, autodidacts and college dropouts? Founded on this reasoning, efforts have proliferated to “disrupt” traditional modes of science education, to subordinate basic concepts to practical applications, and to promote skills through gamification.

Efforts to enthuse students, foster experiential learning, and connect abstract notions to concrete problems have much to recommend them, but we should consider play more deeply. It is common, in rhetoric bemoaning the Procrustean tendencies of science education, to hear stories of Albert Einstein musing aimlessly about trains and light on his way to dazzling new insights. Yet John Norton argued recently in this journal (“How Einstein Did Not Discover,” vol. 18, no. 3) that we abuse history when we propagate such myths, thereby misunderstanding deep and essential features of how science moves forward or even how people learn. Einstein had a playful streak, but its fecundity depended on his assiduous attention to the state of the field, his tireless work ethic, his strong command of

Fig. 1. Wolfgang Pauli (left) and Niels Bohr study a tippe top. Credit: Niels Bohr Archive, photograph by Erik Gustafson, courtesy AIP Emilio Segrè Visual Archives, Margrethe Bohr Collection

basic physical and mathematical concepts, and his obsession with their rigorous application.

Papaliolios's quantum toys may teach a similar historical lesson. At the time, they did not catch on, largely because the appropriate conceptual support was not in place. Familiarity with matrix formalism was not yet widespread and the toys were distributed without a manual that could have provided guidance. This gave playing with them little hope of educational value on its own. Yet these toys' potential comes from the fact that they permit a certain amount of freedom—but not too much. They illuminate quantum theory, whether expressed in Schwinger's less familiar formalism or in the ways that Paul Dirac and Richard Feynman made more popular.

Toys can draw their users into the world and make them want to know more about the deeper structures literally in play, but they do not necessarily teach those deeper structures just by themselves. Careful historical attention to the role of play in science, à la Gauvin, can indeed support a more robust understanding of the conditions under which it might be helpful, as a pedagogical tool and as a route to discovery. Papaliolios's quantum toys give us yet further historical evidence that play in pedagogical settings is at its most fruitful when combined with thoughtful attention to fundamental questions, including the sequence of activities and puzzles that would most effectively engage and assist students to make their own discoveries at the right time. Has the time for the quantum toys finally come? We are hoping to get some soon.

As for the tippe top, to rescue conservation of energy, simply add friction—in just the right places and amounts.

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