Passive learning in the electronic age

Among my recent reading, I found this, from Jeffrey Kluger's book *Simplexity:*

> Electronic devices . . . have gone mad. It's not just your TV or your camera or your twenty-seven-button cell phone with its twenty-one different screen menus and its 124-page instruction manual. . . .
>
> The act of buying nearly any electronic product has gone from the straightforward plug-and-play experience it used to be to a laborious, joy-killing exercise.[1]

Our electronic gadgets tend to become less transparent and more difficult to use as they evolve. Posting the above on Phys-L, an internet forum for physics teachers, I asked what effect such gadgets will have on the minds of our youngsters. Their push-button experience is very different from their parents' experience. Responding, one teacher wrote: "There are no radios . . . no grandfather clocks . . . no cars which anyone can take into their garage and work on. These things that we used to find fun and intriguing to put together and repair do not exist any longer in the world where everything is run by electronics and chips."

The disappearance of transparent gadgets such as radios and clocks is certainly a concern for physics teachers because we have come to see them as powerful reinforcers of curiosity and motivators for learning. The nontransparent smartphones, iPads, and similar gadgets don't promote curiosity and motivate learning, at least not in the ways and to the extent that more transparent tools have. If a decline in students' learning is observed, one must ask how much of it is due to the proliferation of touch-screen technology. One thing is obvious: Learning about how a toy truck works from an iPad or TV screen is quite different from taking apart a toy truck and putting it back together.

A decline in learning might also be due to other factors. But the proliferation of black-box technologies is likely to be one of them. Some consequences of using new technology might be very hard to repair if they are discovered too late. That is the great value of research in this area—and the sooner the better. Some teachers from the Phys-L forum have said they suspect that undesirable consequences might be due to an excess of passive learning.

Equally important are unknown effects that touch-screen toys have on toddlers, the middle school and high school students of tomorrow. Hanna Rosin, the author of an article entitled "The Touch-Screen Generation,"[2] reports that toddlers are spending more and more time watching what happens on the screens of iPads. She emphasizes that very little is known about cognitive effects of touch-screen technology on toddlers and about whether the overall effect will be positive or negative.

Any tool we are using without understanding—for example, a sophisticated commercial instrument or a new theory—can be said to be a nontransparent black box. We learn how to achieve certain results from it but not how the tool itself functions. Black boxes are frequently used as pedagogical constructs, they are used in scientific research, and they help us to be more effective, to benefit from the work and skills of others. But they also carry potential harm.

References

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Exotic nuclear physics with low-energy neutrons

Michael Snow's article "Exotic physics with slow neutrons" (PHYSICS TODAY, March 2013, page 50) was both enjoyable and informative. I especially appreciated reading about how neutrons can be used to probe fundamental physics. The author mentioned areas of physics in which meV and colder neutrons have played an important role. I wish he had also mentioned the very rich contributions made by the study of the interaction of low-energy neutrons with heavy nuclei. ("Low-energy" refers to neutron energies from roughly 1 eV to tens of keV, greater by factors of 40 to 10^{11} than those discussed by Snow.)

The absence of a net charge enables a low-energy neutron to interact with heavy nuclei and probe the resonant excited states near the binding energy of a neutron in the resulting compound nucleus. The study of those resonances over decades bore great fruit. I offer a few examples: the formulation of the low-energy optical model, a reaction theory designed in part to characterize those resonances, and level-density calculations based on thermodynamic models. In addition, the excited nuclear states are highly complicated, as implied by their high excitation energy (around 6 or 7 MeV), their huge numbers (many tens of thousands or more of a given spin and parity per MeV), and their seemingly random energy widths and spacings. Their nature could not be realistically described by the application of the shell or collective nuclear models and thus forced a statistical view of the behavior of their energy widths and spacing distributions.

The statistical view ultimately led to the Porter–Thomas distribution of reduced widths and to Wigner's and Dyson's theories of level-spacing distributions—that is, random matrix theory.[1] Remarkably, random matrix physics has found application as a signature of chaos in simple systems and is used in other areas of physics, even particle physics. Bravo to this strong neutral particle with a gentle decay.

Reference

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■ **Snow replies:** I also wish that I had been able to say more about the contribution of neutron measurements to the development of statistical treatments of excited nuclear states and the fruitful random matrix theory ideas that came out of them. They have broad applications in many areas of physics, and I thank Harry Camarda for his letter and references describing that physics.

Camarda's letter also provides the opportunity to highlight a fascinating subsequent development in the field—namely, the amplification of parity-odd effects in compound nuclear resonances. Experiments confirm that parity-odd amplitudes in nucleon–nucleon interactions are amplified by several orders of magnitude at certain *p*-wave resonances in heavy nuclei populated by eV to keV energy neutrons.[1] Random matrix theory has been used successfully to analyze the width of the distribution of those parity-odd asymmetries, since part of the amplification mechanism can be traced to the chaotic nature of the nuclear states involved.[2]

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Femtosecond currents via the dynamic Stark effect

The Search and Discovery report titled "An electrical insulator turns metallic within a femtosecond" (PHYSICS TODAY, February 2013, page 13) is a compelling account of the recent breakthrough experiments on dynamic Stark effects performed by Ferenc Krausz and collaborators. It describes how a strong nonresonant 4-fs laser pulse can be used to generate electric currents along a nanojunction on a femtosecond time scale. Phenomenologically, the current arises from the nonlinear interaction of the active material in the silica glass nanojunction with an incident laser pulse of low temporal symmetry. By varying the degree of time asymmetry of the laser, one can change the sign and magnitude of the photoinduced current. Microscopically, the underlying rectification mechanism of that rather spectacular effect is Stark shifts so large that they can dramatically modify the electronic structure of the silica glass and even bridge its large energy gap.

Significantly, and in a broader context, the groundbreaking experiment by Krausz and coworkers falls into a class of symmetry-breaking laser-control scenarios known to induce net currents in spatially symmetric systems through laser fields of low temporal symmetry.[1] The idea of using Stark effects as the main microscopic mechanism for the production of currents arose in an earlier theoretical proposal to use Stark effects to bridge the energy gap of a semiconducting material.[2] The experiments demonstrate how such ideas can be applied to induce currents in a material with an energy gap as large as 9 eV.

References

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