

friendly, if somewhat dry. I attended Dirac's course on quantum mechanics at Cambridge University in 1950. I was a neophyte physicist then, still weak on theory. I found the text hard to follow, but Dirac invoked some interesting sidelines—for example, that Maxwell's four equations reduce to one if you use spinor algebra. He appeared to me to be very old. Thin and stooped, he would lean over his narrow lectern until we were convinced that both he and it would fall over, though they never did.

Dirac was notoriously precise about his lectures. Victor Weisskopf used to tell the famous joke about Dirac's answering questions after he'd given a lecture. One student said, "I don't understand that second equation, Professor Dirac." Dirac remained silent. "Aren't you going to answer the question?" asked Weisskopf. "That was not a question, that was a statement," said Dirac.

I religiously copied the notes Dirac would write on the board, even though I rarely understood them. Many years later he visited me here in the States. I took out those notes, and then, miraculously, they made sense.

Many tales are told of Dirac's absent-mindedness. Here is a particular favorite, from when his wife, Eugene Wigner's sister, was pregnant. A student, seeing him wandering about distractedly, asked him what was the matter. "Oh," said Dirac, "Wigner's sister is having a baby."

Farmelo's book discusses the strange demise in 1958 of the Kapitza club (page 381), a group formed in 1922 by Peter Kapitza to discuss recent research. However, it held one final meeting in 1966 with Kapitza, Dirac, and John Cockcroft present. All evidence of the del squared V, a similar club of the era, has apparently vanished. I would be happy to learn what happened, since in my opinion, the most important discoveries of the time were discussed more in those two clubs than in seminars.

## Reference

1. J. Bernstein, *Am. J. Phys.* 77, 979 (2009).

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**Farmelo replies:** I thank the correspondents for their illuminating points. I am especially grateful to Ted Jacobson for drawing attention to Georges Lemaître's 1931 article on the quantum theory of the early universe; I had not previously heard of it. It is an impressive paper. Jacobson is surely correct

that Paul Dirac had probably read it before he wrote his 1939 Scott Lecture, though I expect that Dirac had forgotten about it; he was in the habit of doing that and would blame his "poor memory." That said, it seems to me that Dirac's words are a good deal clearer and more insightful than those of Lemaître, who goes off the rails with the specifics toward the end of his piece.

It was a pleasure to read Ron Edge's recollections of Dirac. I went to a lot of trouble to check the veracity of the Dirac stories still in circulation, including Dirac's famous "That was not a question, it was a statement." Dirac was not joking. He used the comment several times, beginning in the late 1920s. One of his closest friends, Leopold Halpern, told me in February 2006 that he once asked Dirac if he really did respond that way. Dirac replied, "Yes. Why do people find it funny?"

I agree with Edge about the importance of the del squared V and Kapitza clubs. I could not find detailed information about the former, but the papers of John Cockcroft in the excellent Churchill College Archive Centre in Cambridge, UK, contain a record of the meetings of the Kapitza club, along with charming photographs of its final meeting in 1966.

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## Cleaning up a name

I take issue with a title over the inset on page 24 of the January 2010 issue of *PHYSICS TODAY*. It reads "Nuclear Waste Dump Doubles as Low-Radiation Site for Science," and the story is written by Toni Feder. The Waste Isolation Pilot Plant (WIPP) is not a "dump," a term that carries the connotation of carelessness. Calling it such demonstrates a lack of understanding regarding the development, permitting, and successful operation of the facility. A review of the information on the website (<http://www.wipp.energy.gov>) might help.

A thoroughly studied, properly licensed and permitted, and well-documented disposal facility, WIPP is operated with every care given to safety. The contents and location of every waste container are well documented.

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## Stepping up to the computer

In reply to John Fang's letter "Step Away from the Computer" (*PHYSICS TODAY*, July 2009, page 12), I suggest that the writer has mischaracterized the potential use of computers and the internet. The internet offers the opportunity for high-quality teaching and research. I offer two examples from my own experience.

First, my own area of research—numerical methods for ordinary and partial differential equations and for mathematical ophthalmology and oncology—is interdisciplinary. Our research group can follow the current literature far more effectively and efficiently by using the internet than by going to a conventional library.

Second, we can now compute solutions to systems of ordinary and partial differential equations that could only be imagined before computers; certainly that is also true in physics—for example, in general relativity.

The perceived misuse or abuse of computers and the internet may be due to our failure as teachers to acquaint students with the opportunities they provide. In the absence of such guidance, students may squander those opportunities. But rather than blame the technologies or the students, perhaps we should do a little more introspection and improve our teaching to assist students in using computers and the internet more effectively.

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**I disagree** with John Fang's oversimplified statement about the internet. Any technology is just a tool. Its value depends on how people use it. Nuclear power, for example, can provide heat and light for our homes and businesses, or it can be developed as a deadly weapon. For scientists nowadays, the internet is essential for research. It saves us from having to run to the library to make a photocopy of that paper we need; instead, we can download the electronic file at our desks with a few clicks.

I believe Fang's observation stems from young people's frequent misuse of the internet. In my opinion, well-designed homework is the key to getting students to find answers in nature rather than from computers. Teachers who regularly assign homework whose answers are easily found on the internet

perhaps need to examine their teaching methods.

When I taught Newton's third law of motion, I demonstrated how to use a balloon to propel a small cart and explained why it worked. Then I gave students the homework assignment of finding other ways to move the cart or to improve its efficiency, and I required that they make their own carts. They could search the internet for instructions, but they eventually had to make a real cart, which involved their using technical skills. Since grading of the homework was based on how far the cart could go and how innovative the method was to propel the cart, my students spent much more time on testing their carts than in front of the computers. As a teacher, I also had to spend a lot of time on the internet so that I could judge whether the students' designs were really their own.

Finally, let me underscore that the proper uses of science and technology are keys to making life better, for ourselves and for the planet.

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**John Fang writes** that in his assessment, the motivation, sociability, and

intellectual skills of college students have diminished in the past 30 years. He provides no data to substantiate his claims, and I don't agree with him one bit. I have thoroughly enjoyed working with the students enrolled in my introductory physics courses in the past three years.

I would caution all teachers, especially physics teachers, who tend to operate on a different intellectual plane altogether from the rest of mankind, not to allow their assessment of their students, their attitudes toward teaching, their philosophies about teaching, or their behavior in the classroom to be shaped by anecdotal evidence. We are scientists, and we should look at all of our work-related ventures, even teaching, as scientists. When we sense that something is amiss in the classroom, we should seek to understand what and why and how we might change it; and in doing so, we should consult the literature.

There is truth in the idea that the internet has changed how people behave, but the critical question is how? The field of media ecology deals principally with the interaction between the media environment and the human mind. I direct anyone interested in the subject to read the works of Neil Postman,<sup>1</sup> who

was a high-school teacher, college professor, and principal contributor to the discipline. Undoubtedly, modern college students have far less contact with the natural world than students did 30 years ago. Today, work and play take place almost exclusively on the computer, in a virtual world. So to understand this generation of students, we must ask two questions: What is the nature of that virtual world? How does it affect how students interact with teachers, with one another, and with the natural world? Their media environment, not our classrooms, is the dominant force that shapes their lives. I'm not saying that we must move into their media environment—Postman would argue exactly the opposite, that we must preserve our media environment—but understanding one informs the other.

## Reference

1. See, for example, N. Postman, *Teaching as a Conserving Activity*, Delacorte Press, New York (1979), and "Informing Ourselves to Death," speech at the German Informatics Society meeting, 11 October 1990, available at <http://www.mat.upm.es/~jcm/postman-informing.html>.

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