The problem here is that despite the best intentions, the execution was faulty because the target was misjudged. Third-graders are not ready for complex concepts like "shape memory"; when we try to teach complexity to them, they regard it as magic or as delivered wisdom. They do not see it as a commonly occurring phenomenon in their world, something that is amenable to understanding. They do not see that by first mastering balloon power and boat motion, they can lead themselves to mastering an understanding of other features of their world. They do not see the amazing edifice of understanding that science has built, how one can know the universe by building understanding brick by brick.

Instead they see a *complex* phenomenon: a balcony high upon the edifice. They see no connection between that and their own world, outside the electronics laboratory. They think, "That stuff is neat, but too mysterious for me, and besides, who cares?" We need to teach science to third-graders using materials from their own world, examples that appear relevant and concepts that they can handle. We should save the liquid nitrogen for junior high school and the shape-memory wires for physics majors in college.

LEON THOMSEN
10/91 *Tulsa, Oklahoma*

THE PHYSICIST SHOWN ON THE SEPTEMBER 1991 COVER AND A COLLEAGUE REPLY: Mysteries are great drivers of curiosity and investigation. They motivate a search for solutions. Indeed, a group of elementary school children were recently drawn to their school library in an attempt to uncover the secrets of a magician's tricks. They wondered what it was that they were seeing, because they knew that it was *not* actual "magic." Whether presented with sleight-of-hand tricks or demonstrations of physical phenomena outside their daily experience, students are inspired in their amazement to ask questions and to look further.

A program such as the one pictured on the cover of the September 1991 issue of PHYSICS TODAY is not intended to take the place of a comprehensive course of study. Instead, it engenders an excitement about the process of physical inquiry. Examples from the students' everyday experience are used to introduce concepts. In fact, most demonstrations must yield concepts that firmly anchor themselves in the students' current level of physical understanding. However, some real stumpers are necessary to create the sense of mystery that promotes questioning.

The boat shown on that cover is very simple in form: a hull, a cover and a single loop of wire around two pulleys (one of which paddles the boat). One need not understand the complex concept of martensitic transformation, which underlies the function of the shape-memory wire, to understand that the boat is powered by an ice cube. No battery. No rubber band. Nobody pushing. Pretty amazing. Then the question: What does temperature have to do with movement and energy? The examples from everyday life flow forth.

A balloon-powered boat is a great idea. Children are hungry for people who can lift ideas out of the pages of books and into their lives. We encourage all readers who feel that they have something to share to go out into their local schools and coordinate their efforts with the teachers. If you make your presentations with a spark in your eye, you may find that the enthusiasm is contagious—both yours and the students'.

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Why Johnny and Janey Can't Think

As a graduate student working toward my PhD in applied physics, I am concerned about the dangerous lack of quality in physics and mathematics education in our nation.

Kids today do not know how to think critically. Colleges and universities are filled with examples. I teach a laboratory course at a medium-size Eastern state university. The class is designed to complement a first-year physics sequence for future scientists and engineers. Students are given handouts that contain both a non-cookbookish procedure and a survey of the theory behind the experiment. The procedure is not "step by step" on purpose: Our idea is to place the student in a situation where he or she must reason about how to use unfamiliar equipment to measure physical quantities.

Unfortunately, students do not come prepared to solve the new types of problems presented in the lab setting. They seem incapable of reasoning out the questions they come across. More often than not they seem *unwilling* to reason. Many times they fail to identify important questions. Students are invariably under the impression that they will be told everything they need to know and won't have to struggle with anything themselves.

One of our experiments uses an instrument with which few if any students are familar: the oscilloscope. Surprisingly, students seem to be terrified of this nearly unbreakable instrument. I don't think this is a case of "high-tech anxiety"; many stereo and TV systems are much more complicated. The students' terror comes from the realization that they have been presented with unfamiliar equipment and that they themselves are largely responsible for making the experiment fly.

It is my opinion that students can't figure out the oscilloscope because they do not *try* to figure it out. Students don't approach it with a system of trial and error. Instead of learning what the knobs, dials and displays do and mean, they memorize rules about how to make the instrument work. They have been taught by repetition, as well as reward and punishment, to perform a type of blind monkey-see–monkey-do.

I believe that these attitudes stem from the earliest "educational" experiences kids are exposed to in the US. Teachers in elementary and high schools mainly want kids to behave, to be quiet and not to do—or think about—anything they are not supposed to. This is largely detrimental to education. Paraphrasing the people who have played major roles in my own education, *chaos* is a necessary condition for learning. A person only learns what he or she is interested in and what that person believes is important to himself or herself. Further, since not all individuals ascend the educational staircase with the same zest and speed, why must all students be forced at intellectual gunpoint to conform to the same thoughts, expectations and lesson plans?

What are the solutions to the various pressures and problems that compel teachers to adopt this approach? To begin with, I believe teachers could certainly use trained help in the classroom. This would help to eliminate discipline problems. It also would allow students to receive more individualized attention. Qualified aides could encourage kids to think about things that a single teacher could never begin to encourage.

University instructors should develop pre-college programs stressing

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the fundamentals of different subjects. A survey of instructors who teach first-year university courses, asking what skills and knowledge they expect of entering students, would provide a solid basis for such programs. Equipped with programs of this sort, teachers could concentrate on *how* to teach instead of *what* to teach.

Changes also must be made at the university level, where teachers themselves are trained. An option should be added to the standard four-year bachelor's degree in education, in which students would receive a professional degree for doing an additional year of student teaching. The extra student teaching would both provide a pool of qualified aides in the classroom and give new teachers more experience.

As President George Bush recently recognized, the goals of the educational system in the United States must be critically reexamined, and the results of such thinking must be debated, explored and acted upon. The above suggestions would serve as a starting point for such reform.

DAVID M. HARTLEY
8/91 *Olney, Maryland*

The German Minds Behind Russia's Bomb

I would like to augment the letter from Abraham Pais (August 1990, page 13) about the history of the Soviet atomic bomb.

First, although Peter Kapitsa may have taken part in consulting with Stalin in November 1942 and led a series of lectures on general topics of nuclear physics in summer 1944, he was the only top-class physicist who refused to work on the bomb project for Stalin. Kapitsa was punished by being exiled from Moscow to his country house. That might explain why he apparently hadn't heard of Klaus Fuchs, who spied for the Soviets, when he entertained a group of US scientists (including Pais) in 1956.

Second, Pais made no mention of the role of the German scientists who were brought into the USSR at the beginning of June 1945. Ulrich Albrecht, professor of peace and conflict research at the Free University of Berlin, writes the following in the April 1989 issue of the German magazine *Bild der Wissenschaft*:

"Three groups of mostly forcibly relocated German scientists and engineers participated in the building of the Soviet atomic bomb:

▷ the group around Nikolaus Riehl—entrusted with the production of pure uranium
▷ the group around Gustav Hertz
▷ the group around Manfred von Ardenne.

"There also were single scientists like the physical chemist Max Volmer, the physicist R. Döpel and the physical chemist Peter A. Thiessen."

Albrecht's article makes a number of references that imply that the relocation of the German scientists was forcible, although it gives no direct evidence:

"Besides the Soviet descriptions of the development of the atomic bomb, there are . . . reports from those German scientists and engineers who participated, more or less involuntarily, in at least 12 groups working on the Soviet postwar armament—some of them in prominent positions.

"At the beginning of June 1945, before the first American nuclear explosion (on 16 July 1945), the most important German scientists were flown into the Soviet Union. In one systematic operation the NKVD [the Soviet secret police] fetched those German physicists who were to participate in the bomb project. . . . [NKVD head Lavrenty] Beria's deputy and the operational director of the Soviet bomb project, NKVD General-Lieutenant Abram P. Saveniagin, came to Berlin-Friedrichshagen expressly to get the researchers who had participated in the German uranium project."

As to the details of the work, Albrecht writes:

"The German group of experts began in summer 1945 to melt and cast the uranium metal that they had brought with them in powder form in dismantled ovens from Germany. . . .

"The Nobel Prize winner Gustav Hertz (a nephew of Heinrich Hertz of electromagnetic wave fame) and his working party made progress in the diffusion cascade for the large-scale production of U-235 for the Soviet Union after 1945. . . .

"The German expert Dr. Schütze developed a mass spectrometer for heavy atoms, with which one could precisely measure the isotope ratio in the enriched uranium. . . .

"In the beginning the uranium production did not go well, but at the start of 1946 the Riehl group produced within a few days several tonnes of reactor-grade uranium oxide. . . .

" . . . Physicist Heinz Barwich demonstrated a method for building gas-stream cascades for uranium separation without rectifiers. . . .

"The Germans were always deployed when there was no progress on the Soviet side. . . .

"The Russians had considerable problems with corrosion of the separation plants caused by uranium hexafluoride. Thiessen and Barwich participated in the troubleshooting. . . . The year 1946 brought the decisive technological breakthrough for the uranium project: a process, developed by the Germans, for converting raw uranium oxide to another fluoride compound, uranium tetrafluoride, as the basis for uranium extraction. . . .

About the role of espionage Albrecht writes: "According to the reports of the German scientists, the espionage results were brought repeatedly into their work. . . . Further there are peculiar changes in the direction of the Soviet project that suggest espionage." What's more, "one day the workers on the nuclear project got a memorandum that 'their' uranium was purer than the American weapons-grade material."

Finally, in an article about von Ardenne in the August 1990 issue of the German popular science magazine *Hobby*, entitled "He Served Hitler, Stalin and Honecker," Volker Petzold writes: "During the Hitler era the multi-genius von Ardenne already was working in an underground laboratory in Berlin-Lichterfelde on the development of an isotope separation plant. After the capture of Berlin the Russians shipped him, his coworkers and all the research installations of the 'Reichs-Laboratorium,' which he directed, to the East. In one strictly restricted research complex near the Black Sea town of Sukhumi, von Ardenne's team developed for the Soviets a plant for the production of nuclear fuel. . . . Stalin paid him a princely sum for it."

IGOR FODOR
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Speakers: Learn to Project (Slides, That Is)

In his article "Advice to Beginning Physics Speakers" (July 1991, page 42), James Garland fails to mention a most important aspect of showing transparencies and slides: They should be easy to read at the back of the room. It never ceases to amaze me how many senior lecturers present viewgraph after viewgraph of material that is effectively invisible to anyone beyond the fifth row. In such cases why bother to show anything at all? In this day of photocopying machines that enlarge, this flaw is particularly inexcusable.

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