

letters

look at a problem however he or she wishes, as long as the right answers are consistently obtained.

ROBERT LYNCH
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12/86

Researchers concerned with physics education and cognitive psychology often lack the proper feeling for physics, and vice versa. Therefore Frederick Reif's article encompassing both ingredients is to be highly appreciated. Notwithstanding this, let me raise a minor point that may be of some relevance with respect to the complexity of the field.

Students' conceptions are revealed when they are questioned in a qualitative, not completely and quantitatively defined, way. Are misconceptions not sometimes, at least partially, artefacts of the type of questioning? Figure 2 in the article, showing the bob of a swinging simple pendulum at various positions, may represent a typical example. The arrows representing the vector of acceleration at the maximum, half-maximum and zero displacement angles are drawn in the right directions but not to the right lengths.

I am not trying pedantically to expose a flaw, but rather to call attention to an issue of principle. Can students draw the arrows if they do not write down or at least reflect on the equations? Or more explicitly: Wouldn't more students answer a quantitatively formulated question than a question intended only to test whether they understand that both the tangential and centripetal components of acceleration are involved? (In the second case, the wording of the question would appear to be important.) In the first case, students can, using the laws of mechanics, test the consistency of the answer and correct it, whereas in the second case they must to some extent guess. Doesn't a qualitative question force the student to adopt a loose procedure involving vague concepts? Doesn't a well-defined and quantitative question force the student to use sharper procedures and well-defined concepts? One is reminded of the two levels of sophistication of colloquial language: a chat and the more precise professional language of a lecture. Would one connect the first level with misconceptions?

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1/87

REIF REPLIES: There is no reason to expect that computers used for teach-

ing will eliminate individual differences between students. However, they should make it somewhat easier to adapt instruction to individual differences by addressing more students on a one-to-one basis than is possible in traditional large classes.

Robert Lynch seems to assume that computers necessarily impose more rigid constraints on students than human teachers. But traditional homework assignments and examination questions often impose more rigidity than the exploratory environments made possible by well-designed computer software. Human teachers, computers, textbooks and other media can all be used as instructional means—and each of them has distinctive advantages and disadvantages. Good educational design should aim at a judicious combination of instructional means, one that best exploits their particular strengths and minimizes their weaknesses.

Qualitative and quantitative modes of thinking are *both* important, in complementary ways, even in a highly precise and quantitative science such as physics. Some physicists, among them perhaps Janez Strnad, underestimate the crucial role of qualitative thinking in formulating useful questions, in designing experiments, in suggesting explanations for observed phenomena and in planning solutions to problems before attacking them mathematically. The usefulness of qualitative thinking and back-of-the-envelope calculations is quite apparent in the work of Michael Faraday, Niels Bohr, Enrico Fermi and others. And many physics graduate students come to research poorly prepared because their prior classes have emphasized only quantitative precision and mathematical formalism.

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Uniting the fusion community

The 1960s proved that early fusion enthusiasts were hasty in their assessment of the magnitude of plasma heating and confinement problems, and it was realized that a lot needed to be done. In an inspired performance, American plasma physicists rose to the challenge. By 1980 they had chalked up impressive gains in tokamaks, reversed-field pinches and mirrors, and compact toroids looked to be full of promise. Then came the slide.

Based on the success so far, each group wanted a larger machine of its own to prove the usefulness of its concept as a reactor candidate. Dissension between the various groups set in, with the result that each group focused

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on the shortcomings of the other concepts, instead of demonstrating the merits of its own concept. This resulted in an overall loss of morale among researchers and a loss of public confidence in the fusion community. The destructive style of criticism of the leaders of the fusion plasma community became fashionable among young researchers, and today controlled thermonuclear fusion research in the US cannot boast of a unified community working with a unified purpose.

We in the fusion community have steadfastly refused to acknowledge our problems as a fault in the community or its leadership, blaming them instead on circumstances of budgets, inflation, recession and Presidential whims. But the fact that the high-energy physics community can stand together under the same conditions and propose a large project like the Superconducting Super Collider with confidence while the similarly priced Engineering Test Reactor is perceived as an impractical or even indecent proposition makes me sit up and take notice. That the ETR may not be the most appropriate project has nothing to do with this contrasting picture. It would seem that the American fusion plasma community has not built up its collective credentials to the point of proposing a large program that could pave the way toward the solution to the energy problem. If an alternative to this situation is not implemented soon, American fusion research will be severely stunted, and will lack strength and effectiveness. There is an opinion that the public will have to face up to the energy problem sooner or later and that a large fusion program will have to get funded. Again, I do not believe it is merely a problem of funding. Given unity of purpose, a sense of friendly competition and appropriate peer review, the community can make the most of any level of funding and a higher level of funding will be all the more effective. I therefore call upon the leadership of the fusion plasma community to begin a movement of consolidation and lead the researchers into developing a consensus on research approaches.

I suggest that the movement be based on the following principles:

► The national laboratories, the universities, the industry and DOE should formulate a procedure to realistically assess and review the present status of fusion research. The procedure should be such as to assure the constituents that their existence is in no way threatened by this review. Each group should be encouraged to talk about the

problems in its approach without fear of criticism. The leadership should clearly express appreciation of the contributions made by research groups so far and at the same time make it clear that the review is essential for long-term benefits. It should pay tribute to the solidarity of the US research base and express confidence that whatever the outcome of the review, the fusion community will benefit as a whole.

► Based on the procedure, a review of all research concepts and results should be conducted within two years.

► An elected or appointed group should develop an overall research strategy based on the review and on its own collective wisdom. The group should then popularize this strategy among individual researchers and make each of them a spokesman for the strategy.

► The community should communicate to the people, the Administration and Congress the urgency of the need to realize fusion energy. Popular communication channels should be employed and the industry should be persuaded to pitch in a major contribution.

► Special seminars and meetings should be held to involve the physics and engineering community at large. Strategies should be evolved to counter the competition of other physics areas for funds. The strategies should not be based on traditional lobbying techniques alone (which have not worked for fusion research), but should clearly present options to the nation. It should be made clear that the funding or absence of it for fusion research has nothing to do with funding for other areas but rather with national well-being.

► Strategies for national and collaborative fusion research should be presented to the Administration and it should be evident that these come from a united community.

► The spirit of cooperation among the constituents of the community should be kept alive by constantly invoking the above process.

RAGHAVAN JAYAKUMAR
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10/86

SDI, Lysenko: Fair to compare?

In his article in the July 1986 issue (page 26), Robert R. Wilson writes: "The parallel between the official Strategic Defense Initiative and Stalin's adoption of Lysenko's genetics, which destroyed Soviet genetics and kept the Soviets from developing good grain seed, is frightening." He does not bother to remember that hundreds of scientists were intimidated, fired or

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