Letters

College Calculus: How Should It Be Taught?

While industrial training programs and college education have different purposes, the principles of adult education apply to both. It is admirable that teachers of college calculus are trying to improve the learning of their students, but the recommendations described in Barry Cipra's article (Research News, 25 Mar., p. 1491) seem short of the mark.

Many of us who graduated a while back experienced the 4 years of high school mathematics that the Mathematics Association of America recommends. Some of us even enjoyed caring and capable teachers of calculus in college. However, after leaving the calculus class, even with 20 years of applied statistics simulation and some business economics, there has not been much opportunity to use what was learned.

In industrial training, when a concept or technique is introduced it is reinforced through subsequent use in training and on the job. Programs predictably fail when there is no subsequent utilization of the material. While understanding mathematics is important to any complete education, the failure to use the material covered in calculus suggests that the efforts are misfocused. No, the math department is not responsible when other departments' courses (for example, psychometrics or operations research) give only a "tip of the hat" to the assumptions on which their techniques are based. But, if this is the reality in a school, it must be factored into the design of the math program.

Unless the mathematics course is in promotive interaction with the subject matter covered elsewhere, it will acquire the status of a glass-bead game. And, that is the ultimate failure, for it allows students to believe that the material has no relevance other than a right of passage.

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Cipra lists all "the problems which beset calculus instruction at the college level," except one. This is the willingness of too many college mathematics instructors to teach watered-down calculus courses on the grounds that the poor preparation of incoming students makes it impossible to teach good courses. The result has been that good mathematics courses have become exercises in crank-turning in which students learn little but how to calculate derivatives and integrals. This is particularly ironic since there are now hand-held devices that perform these manipulations. The single greatest service that college mathematicians could do for education in the United States is to send a message to the high schools that as of, say, 1993 they are going to start teaching "old-fashioned" rigorous calculus, so the incoming students had better be ready.

Cipra accurately portrays the debate about how much technology should be used in teaching calculus and mathematics more generally. It is interesting that college mathematicians have been slower than their counterparts in the physical sciences and engineering to use technology in their teaching. They use technology even less than do secondary and elementary school mathematics teachers, who generally resist technology also. The result is that those who teach freshman calculus, at a cost of thousands of dollars per student, spend most of their time teaching students skills that can be performed by a $200 hand-held device whose cost will rapidly decrease.

Cipra is less accurate in his statement that discrete mathematics courses have been "generally found wanting." Against his one negative quote should be set the success that many colleges are having teaching discrete mathematics to freshman and sophomores and the fact that more than 30 texts have been published in the past 3 years for lower division discrete mathematics courses. In particular, the suggestion by computer science majors at the University of Denver that discrete mathematics has "nothing to do with the computer science they were studying" is, if true, a criticism not of discrete mathematics but of the computer science program at the University of Denver. Finally, it needs to be noted that, while Cipra's statement that Dartmouth's freshman-year course was dropped as a requirement by the Computer Science Department is correct, the reason was not because the course failed. Rather it was because of pressure applied by physical science and engineering departments who wished to have their students take computer science courses without the discrete mathematics prerequisite. The unsatisfactory result is that the discrete mathematics necessary for these computer science courses must be taught in the courses rather than in a separate course. It is as if physicists had to teach calculus in physics courses.

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The 3 K Microwave Background and Olbers' Paradox

Gerhard Herzberg's letter (4 Dec., p. 1341) recalled that, as early as 1940, McKellar (*1*) derived from the molecular spectra of CN an excitation temperature of 3 K. There are many other observations giving a similar temperature when there is no internal heating in the molecular cloud. The interstellar gases absorb the radiation emitted by hot remote radiating energy sources: "the stars." It has also been well known for many years that dark matter is an important constituent of the universe. Dark matter that includes particles of various diameters (for example, >1 mm) must also be at a temperature of about 3 K, being also in thermal equilibrium with light emitted by stars. Dark matter heated by the sun in the Oort cloud is also calculated to have a temperature around 3 K (*2*). Blackbodies from all galaxies must emit 3 K radiation because of their internal temperature.

There is no way to imagine that blackbody radiation is not emitted from interstellar matter located in each galaxy. At the corresponding wavelength ($\lambda \approx 1$ mm), the universe must appear uniformly illuminated as in Heinrich Olbers' model. His paradox no longer exists, since the sky is uniformly bright at that wavelength, as observed by Penzias and Wilson (*3*). Naturally Olbers' apparent paradox exists at visible wavelengths because, then, that radiation is screened by dark matter. The natural emission of blackbody radiation at 3 K from dark matter of billions of galaxies distributed over the radius of the universe explains its high isotropy.

It is generally believed that the 3 K cosmic primeval radiation (*4*) is issued from far behind the interstellar matter of all galaxies. How can we recognize it? The 3 K radiation predicted from the cosmic primeval big bang should not be so isotropic (*5*). Why does the matter in the universe not produce attenuation? Does missing mass in galaxies appear invisible because it emits at 3 K? And where is the blackbody radiation emitted by all the dark matter of the universe?

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REFERENCES

1. A. McKellar, *Proc. Astronom. Sec. Pacific* **52**, 187 (1940); *Publ. Dom. Astrophys. Obs.* 7, 251 (1941).
2. G. Corriveau, personal communication.
3. A. A. Penzias and R. W. Wilson, *Astrophys. J.* **142**, 419 (1965).
4. P. S. Henry, *Science* **207**, 939 (1980).
5. D. T. Wilkinson, *ibid.* **232**, 1517 (1986).