Letters

Essay Tests Can Be Standardized

Barr's suggestion (Letters, 7 Aug., p. 533) that *Science* offer a forum for discussion of bias in standardized tests impresses me as such a wise one that I should like to attempt a contribution.

"One very important element in such a discussion," Barr says, "would be the exploration of alternatives to multiple-choice testing." Obviously, essay tests furnish one possible alternative and their potential is vastly underestimated. I have two general points: (i) The scoring of essay tests can be standardized and rendered more "objective" than is commonly supposed. (ii) Tests serve other very important functions in addition to grade determination; with respect to these extraneous functions, essay examinations are eminently superior to multiple-choice.

Experimental psychological evidence now suggests some effective ways to reduce "subjectivity" in scoring essay tests. Among these are (i) avoidance of distortion due to "prestige suggestion" by having the identity of the examinee concealed; (ii) reading half-a-dozen randomly selected examinations before grading any, so as to reduce "order effects" and "residual factors" in the judgmental set; (iii) grading all examinations under the same quiet physical and psychological conditions, when not fatigued, when neither elated nor depressed, and so on; (iv) having the generally acceptable answers in the back of one's mind to furnish anchorages against suggestibility; and (v) attending not merely to answers to specific questions but noticing also the relations between answers in an effort to reward good theoretical-thinking ability and creativity. "Subjectivity" which continued to creep into the grading of essay tests would be more than compensated for by their much greater potential for tapping the wells of thoughtfulness.

An important extraneous function which essay examinations serve far better than multiple-choice concerns *motivation.* If students know they will have to take standardized essay exams, they will study differently, I believe. When preparing for multiple-choice tests they probably spend most of their time memorizing facts; when preparing for essay exams, they will spend a considerably higher proportion of their time thinking about relations between facts, and with a problem-solving attitude. Everyone from William James and John Dewey to Max Wertheimer to Albert Einstein would agree that this orientation will render the work more interesting and meaningful to the student (and it may equip him with a better memory than were he to concentrate on memorization per se). Through standardized essay exams we can avoid what Banesh Hoffmann, in his book *The Tyranny of Tests*, has so rightly and brilliantly deplored—the awarding of the highest grades to the most superficial students.

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Science and the Election

I feel that the section "News and Comment" is entirely out of place in *Science*. I am not the slightest bit interested in Greenberg's "Goldwater: an effort to evaluate the effects that his election might have on scientific activity" (14 Aug., p. 685), and I believe that if you took a sampling vote of members of the AAAS they would agree with me.

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My respect for *Science* fell substantially after reading the article on Senator Goldwater, or more specifically, the anti-Goldwater story by D. S. Greenberg, which was much more political than objective and was scarcely proper for a publication reporting in the field of science. We get quite enough of political twists in the routine news publications.

Among scientists there are doubtless some leftists and also some of the pork-barrel persuasion, but for the most part, scientists are concerned with truth and not political pitches to the left, and science has its good share of conservatives.

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Greenberg's analysis of Goldwater's possible effect on U.S. science is interesting, timely, and in many ways delightful. It also was most appropriately placed following Boring's article, "Cognitive dissonance." Greenberg's positions and implications are viable only in the light of two hidden assumptions: (i) that federal support of science in its present form is good for science and the community; and (ii) that withdrawal of some, or all, federal support as part of a return to fiscal responsibility would not provide the basis for increased nonfederal support.

Without implying, or agreeing, that Goldwater would necessarily reduce overall federal support of the basic sciences, I assert that an honest examination of the sciences in countries with highly centralized support and control demonstrates the undesirability of overwhelming federal support here. Fiscal responsibility, reduction of taxes, and arrest of inflation would make other sources of support much more effective and also allow the establishment of additional sources.

Admittedly many in the scientific community painlessly suffer cognitive dissonance between their scientific and their political standards of thought. That some of these individuals might not want to work with Goldwater is not surprising. In fact it might provide one of the best stimuli for most scientists to support the senator.

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Your note on the formation of the committee Scientists and Engineers for Johnson (21 Aug., p. 848) recalled a similar committee that I initiated four long years ago. The New York Demo-

cratic State Committee of Scientists and Engineers for Kennedy, of which I was cochairman, was, I believe, the first and, at that time, the only group of its kind. . . . A few of the prominent names associated with the present Johnson committee were also supporters of the Kennedy committee.

I found that, in general, scientists were willing to lend their name and perhaps give a contribution, but that they avoided active politicking. . . . I wonder if this year will see a change in the essentially apolitical nature of most scientists. . . . In 1960 we could speculate that the scientific vote in New York state provided the slim margin of victory for Kennedy—a switch of less than 200,000 votes from the Democratic to the Republican column would have given New York state to Nixon, and he would have won the election by five electoral votes.

In any case, I feel that scientists should try to shape their political environment, and I wish the present committee well.

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Able Students Still Choose Science

The subtitle of Robert C. Nichols's article "Career decisions of very able students" (12 June, p. 1315) reports a declining interest in careers in science and engineering. The actual data, however, indicate that this is true for engineering but not for science, nor does Nichols make this claim in his own analysis. If we include mathematics among the sciences, we find (Table 4) that in 1958, 36.44 percent of male National Merit semifinalists chose one of these six fields: biology, chemistry, geology, mathematics, physics, and psychology; in 1963, 40.96 percent of the students chose these fields. There was an increase in biology, chemistry, psychology, and mathematics, and a decrease in geology and physics. The 6.57 percent decrease in physics was more than compensated by a 7.64 percent increase in mathematics. The data indicate some shifts in popularity of individual fields of science, but not a general decline of interest in science, as implied by the subtitle.

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The Lunar Surface

In recent months it has become more and more common for scientists to discuss the surface of the moon as though it were in a state akin to the average back yard. A case in point is the report in *Science News Letter* (22 Feb. 1964) which quotes Thomas Gold, director of the Center for Radiophysics and Space Research, Cornell University, as saying that "the action of micrometeorites on the moon's surface cannot fail to produce at least a thin layer of finely pulverized material like dust."

Estimates of the number of meteorites weighing from 10 to 7000 pounds which strike the earth each year have generally agreed with those of C. C. Wylie, who estimated the numbers to be at least 6000 to 7000 [*Contrib. Univ. Iowa Obs.* **7** (1936), pp. 226–27]. Since Wylie's publication my own estimates, based on observations of fireballs, surface features, and weight of some 7000 meteorites in museum collections, observations of meteorite craters, and evaluation of the adequacy of field data, have been revised slightly upward from his.

On the earth most meteorites in this weight range produce no noticeable results, since during their passage through the atmosphere they are for the most part reduced to inconspicuous particles. On the atmosphereless moon, however, the results are quite different. A meteorite weighing only ten pounds, striking the lunar surface at a speed of 20 miles per second, would, according to Ralph Baldwin's estimates (*The Face of the Moon*, Univ. of Chicago Press, Chicago, 1948), create a crater 48 feet in diameter and 15 feet deep.

If the frequency of fall per unit area is the same on the moon as on the earth, then in the past half billion years 23.4 craters per acre (15,000 per square mile) have been formed on the lunar surface by meteorites of the 10- to 7000-pound range alone.

Meteoritic rubble of varying degrees of coarseness must reach to great depths on the surface of the moon, but it is evident that dust-like deposit created by the action of micrometeorites is a very minor constituent of this rubble. Hence, the lunar surface cannot be covered by a thin layer of dust alone.

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