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THE CHANGING VALUES OF SCIENCE¹

By DR. R. C. WALLACE

PRINCIPAL OF QUEEN'S UNIVERSITY, KINGSTON, ONTARIO

THERE is no need to elaborate the assertion that changes of emphasis are taking place in our time in the values of science. This has been a matter of perception and of observation. Men whose responsibility it is to make contributions to the advancement of their own fields of science have felt the change. Others who are not scientists have spoken about it, and have not infrequently misunderstood its meaning. It is a formidable task to endeavor to interpret the changes which are taking place, more particularly because we are in the middle of the current. We have not a position of objective independence. But it is of value to the speaker at least, whose day-by-day thinking is perforce confined to the field of educational values, to clarify in his own mind the shift in emphasis and in

meaning which science, as a tool of thought, is experiencing before our eyes. It may not be out of place to take the occasion of the Hector Maiben lecture, which you have honored me with the invitation to deliver, for the presentation of such thought on this subject as I may be able to place in coherent sequence.

It is, after all, somewhat of a paradox that there should be any change of attitude in the scientific way of thinking. So much of the contribution of science in the last three centuries is a permanent readjustment of the thought of mankind and is not subject to change. The rationalism of the scholastics of the middle ages gave way under the revolt of the Renaissance, and the growing demand for facing facts. It was this demand which led to the development of modern science, and to its great victories in the exploration of nature and the harnessing of her forces for the use of man. When he finished his treatise on the "Principles of Psychol-

¹ The Maiben Lecture delivered at the meeting of the American Association for the Advancement of Science, Ottawa, June 30, 1938.

the rank method, when applied to the academic case here considered, fails to satisfy the following postulate, which may be regarded by many people as a fundamental principle:

Postulate of relevancy. The relative position of any two teams—or the relative position of any three teams among themselves—ought to be determinable on the basis of the actual examination-grades obtained by the members of these teams alone. In other words, in determining the relative standing of any teams among themselves, it ought not to be necessary to take into account the performance of any contestants who do not belong to these teams.

To show that the rank method fails to satisfy this postulate, we construct the six following examples, each of which is a hypothetical, but entirely possible, case. There are four teams of three men each: "team A" has members A_1, A_2, A_3 ; "team B" has members B_1, B_2, B_3 ; and similarly for "team C" and "team D." The actual scores obtained by each of the twelve con-

TABLE II

Case VII			Case VIII		
C_1	99	1	C_1	99	1
A_1	98	2	A_1	97	2
			B_1	95	3
B_1	94	3			
A_2	93	4	A_2	92	4
			D_1	91	5
			B_2	90	6
B_2	89	5	D_2	88	7
D_1	88	6	C_2	87	8
C_2	87	7	B_3	86	9
B_3	85	8			
D_2	84	9	C_3	81	10
C_3	81	10	A_3	79	11
A_3	80	11	D_3	78	12
D_3	78	12			
B	16		A	17	
A	17		B	18	

testants, in each of the six cases I, II, III, IV, V, VI, and shown in the table; and the question is, how shall we determine the relative merits of teams A, B, C, in each of the six cases?

If we accept the postulate above, the relative standing of the teams A, B, C, whatever it may be, must obviously be the same in all six cases, since the actual grades obtained by the members of these teams do not vary from case to case. On the other hand, if we adopt the method of ranks, we see from the table that each of the six possible orders ABC, ACB, BAC, BCA, CAB, CBA, is represented by one of the six cases. The actual scores recorded in the six cases differ only in the scores obtained by two men, D_1 and D_2 ; and yet the variation in these two supposedly irrelevant items is enough to upset completely the order of merit among the three teams A, B, C.

No such ambiguity arises if the sum-of-the-grades

method is employed. This method gives A 268, B 267, C 266, thus determining the order ABC.

As an even more striking illustration of the paradoxes which may result from the rank method, we construct two further examples, VII and VIII, as shown in the second table. Here there are four teams A, B, C, D, and the question raised concerns the order of the two teams A and B. In passing from case VII to case VIII every member of team B has improved his grade, while every member of team A has lowered his grade. Yet if the method of ranks is adopted, B starts out higher than A in case VII and then falls below A in case VIII. The change which has brought about this reversal of order is due entirely to changes in the grades of two men, D_1 and D_2 , who do not belong to either of the teams A or B.

This paradoxical situation would not occur if the sum-of-the-grades method were used. According to this method we would have A 271 and B 268 in case VII, and B 271 and A 268 in case VIII, so that the change in the final order of merit in passing from case VII to case VIII would reflect in a natural manner the improvement in B's grade and the deterioration in A's grade.

These examples may suffice to show that if the postulate of relevancy is accepted, some method other than the method of ranks must be adopted.

E. V. HUNTINGTON

HARVARD UNIVERSITY

BOOKS RECEIVED

- BECK, REGENA C. *Laboratory Manual of Hematologic Technic, Including Interpretations*. Pp. 389. 79 figures. Saunders. \$4.00.
- BENSLEY, R. R. and S. H. BENSLEY. *Handbook of Histological and Cytological Technique*. Pp. viii + 167. University of Chicago Press. \$2.00.
- CROWTHER, J. G. *About Petroleum*. Pp. viii + 181. Illustrated. Oxford University Press. \$2.25.
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- National Research Council of Japan. *Japanese Journal of Botany; Translations and Abstracts, Vol. IX, No. 2*. Pp. vii + 121-267 + 98. *Japanese Journal of Geology and Geography; Translations and Abstracts, Vol. XV, Nos. 1 and 2*. Pp. iv + 129 + 37. Both illustrated. The Council, Tokyo.
- SKINNER, B. F. *The Behavior of Organisms; An Experimental Analysis*. Pp. ix + 457. 148 figures. Appleton-Century. \$5.00.
- TINKER, MILES A. and KENNETH H. BAKER. *Introduction to Methods in Experimental Psychology*. Pp. vi + 222. 26 figures. Appleton-Century. \$2.75.
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