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## A Comparison of the Abilities of Secondary Teachers and Students of Biology to Understand Science

PHILLIP E. MILLER

*Abstract.* A comparison of the level of understanding science between secondary teachers and students has been conducted. The biology teachers were made up of two groups. The newly certificated group had just completed their college training; and the other group was made up of experienced, on the job, teachers. The biology teachers were compared with groups of secondary biology students in grades 7-12 inclusive. Significant differences were found between the 7th grade group and all other groups, except the 8th grade group.

The implications of teachers with less understanding of science than a sizable group of their students is discussed. There is a call for increased professional standards and improved college curricula designed to train teachers better in the ways of science and the scientist.

It has been stated often and influentially that our greatest resource in the headlong race for national supremacy lies in the minds of the educated. Therefore, of utmost importance is the question of the proficiency and qualifications of our science educators.

In a study made by the University of Wisconsin (1), six characteristics of good educators were discovered. The first characteristic was intelligence. The second characteristic of a good teacher was a "thorough understanding and basic knowledge of and about the subject matter taught."

### PURPOSE

In this study, restricted to the subject matter of biology, the major items considered were how well teachers and students understand the scientific enterprise, scientists, and the aims and methods of science. Specifically, this is a study of the comparison of the abilities of secondary biology teachers and students to understand science.

### METHOD

Present and prospective students of biology, as well as secondary students who had just completed a course in general

biology, represented the five student groups in grades seven through twelve. The five different groups of students used in this comparison were composed of 87 11th and 12th grade high-ability students, 63 10th grade biology students, 52 9th grade students, 328 8th grade students, and 205 7th grade students, selected at random from eight different schools.

The group of 51 biology teachers used in this comparison was composed of 29 beginning teachers and 22 practicing teachers from at least 20 different high schools in Iowa.

The high-ability 11th and 12th grade students, selected for their high-quality work in science, were chosen from 60 different high schools.

The tool used to determine abilities to understand science was the *Test On Understanding Science* (TOUS), form W, developed at Harvard University and printed by the Educational Testing Service, Princeton, N.J.

The means of the six groups (one teacher group, and five student groups) were assumed to be identical—thus the Null Hypothesis was used in order to determine if significant differences existed between the groups.

#### OBSERVATIONS

As can be seen in table 1, there is a correlation between the grade level of the student and the student's ability to understand science. The 7th and 8th grade means are very similar, as can be seen also in table 1.

Table 1. Mean Scores of Students and Teachers

Group	Mean
Grade 7	23.6146
Grade 8	24.5122
Grade 9	31.1346
Grade 10	29.0952
11 & 12 Hi. Ab.	42.1149
Biology Teachers	43.5882

Table 1. Tested: Equality of the means using the t statistic. The critical region was  $-2.62$  to  $+2.62$ . The hypothesis of equality of the means was retained for the 7th grade versus the 8th grade, but rejected for the other groups compared with grade seven. The .01 level of significance was used in all cases.

The 9th grade mean is higher than the 10th grade mean.

The means of the 11th and 12th grade high-ability students and the teacher group are not statistically different.

The range of scores is great, as can be seen in Fig. 1.

Table 2 shows the percentage of students in each group that scored higher on the TOUS test than 25% and 50% of the biology teachers. In this study, 25% of the biology teachers scored below 39. Fifty percent of the biology teachers scored below 45.

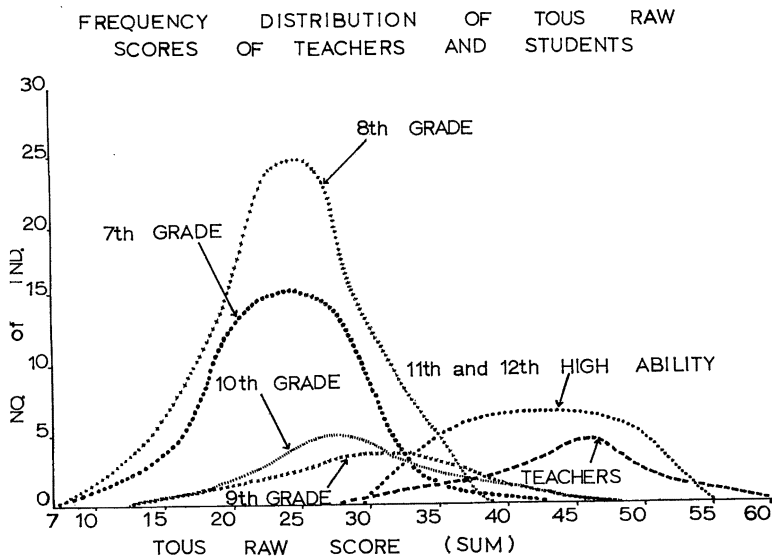


Figure 1. An indication that too many secondary science teachers understand science less than substantial proportions of secondary students.

Table 2. A Percentage Comparison of Biology Teachers with Students

Group	No. Ind. in Group	No. Ind. Above 25% of Teach.	% Above 25% Teach. Scores	No. Ind. Above 50% of Teach.	% Above 50% Teach. Scores
Grade 7	205	2	1%	0	
Grade 8	328	2	1%	0	
Grade 9	52	10	19%	3	6%
Grade 10	63	7	11%	0	
11-12 H. A.	87	59	68%	33	38%

Table 2. Most secondary teachers teach to high-ability students during their career. These data suggest that too many science teachers understand science less than the students they are "certified" to teach.

It can also be noted that many actual scores of teachers were lower than the higher individuals of each group. For comparison of teachers scores with those of each of the five groups of students, see Fig 1 in which the frequency distribution curves are combined for comparison.

#### DISCUSSION

The 9th grade scores were probably higher than the typical 9th grade class because the 9th grade sample was taken entirely from one school which happened to have I.Q. and I.T.E.D. scores averaging well above the state average. This 9th grade class was not typical.

Although only about 12-15% of the high school biology classes are taught in 9th grade, some evidence for moving the biology class down from the 10th grade suggests that 9th grade students of biology show little difference in achievement when compared

to 10th grade students of biology. In such a study at the University Laboratory School at the State University of Iowa, Yager (2) discussed the possibility of biology courses in the 7th and 8th grades.

This study indicates that if science in the biology class can be understood readily in the 8th grade, chances are quite good for similar success in the 7th grade, as is evidenced in Figure 1.

If 8th grade success is shown in Yager's study now underway, then the well acknowledged enthusiasm and curiosity of the 7th grade, plus 7th grade ability to understand science, should prove biology a success at this level of student. With this plan, the more advanced biology course, involving organic chemistry and physics could be taught in the senior year, and be superior to present college freshman biology courses. Such an advanced biology course would ideally follow 11th grade physics, with advanced algebra or calculus preceding physics.

However, the serious question arises: Who is to teach these advanced courses and the basic biology courses as well? What can be expected to become of high-ability biology students, half of whom apparently understand science better than one-fourth of their biology teachers?

We cannot afford to have practicing high school biology teachers who spew out facts and figures, and judge and grade 10th grade students when some of these teachers do not understand science any better than some 7th graders!

At this point, even more important questions arise: How are these people getting college degrees and teaching certificates? Are our college courses designed to increase understanding of science? Or do they tend to be passively "ladled-out" segments of known facts?

The answers are readily available. Now is the time when we must come to grips with these problems. We must persistently attempt to provide teachers with substantially more than a minimal level of scientific understanding, for too many of them are down right incompetent. These are the ones who dole out good facts in a disconnected, even isolated, and frequently meaningless manner. These teachers do not understand science as well as their students, much less understand science well enough to teach it effectively.

Also, we must improve the economic, prestigial, and professional aspects of teaching to the point where our most capable teaching minds will be attracted, not repelled.

#### Literature Cited

1. Escher, J. G. *Education Summary* March 12, 1962.
2. Yager, R. E. 1963. Analysis of effects of placement of general biology in grade nine. *School Science and Mathematics* 63(4):305.