AN EXPERIMENT IN BIOLOGY TEACHING

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During the first semester of 1956, an educational experiment was carried on in the Biology Department of Bowling Green State University. The experiment included all students registered in the two general biology courses (about 750) and all except one of the ten staff members in the department. It consisted in giving all students open book objective type examinations at three week intervals during the course. The examinations were all prepared by the same author, and students were informed at the beginning of the course that these examinations would be given. They were also supplied with a list of reading assignments covering the entire semester, and were informed that they would be permitted to use their books during the examinations.

The examination questions were all of the multiple choice type, containing five choices for each question. For example: The elements hydrogen, carbon, oxygen, and nitrogen account for about—
(a) 10% (b) 26% (c) 52% (d) 65% (e) 96%
of the material in protoplasm. The information needed to answer this question correctly is contained in a table in the text, the student only needs to add up the percentages of the elements mentioned to obtain the answer of 96 percent. More than half of the questions on each examination were of this general type, requiring only a reasonable familiarity with the textbook, and an ability to read comprehensively. Each test contained twenty questions and the students were given a fifty minute period for taking the test.

In addition to the simple type of question described above, each test contained several questions which required more refined analysis. For example: Figure 4:9, page 96, contains information indicating that *Chlamydomonas* is:
(a) motile (b) capable of photosynthesis (c) capable of storing food (d) all of the above (e) none of the above. The figure referred to shows this small aquatic plant and identifies its flagella (which impart motion), its chloroplast (which is an agent of photosynthesis), and its pyrenoid (a food storage structure). In other parts of the text the function of these structures is described so the student must recognize these functions when he examines the figure in question. He must also recognize that the only acceptable answer to this question is "(d) all of the above," because no credit is given for selecting one of the "correct" statements but failing to recognize that the other two are also correct. Questions requiring such more refined analysis comprised about one-third of the twenty questions on each test.

The two general biology courses differed considerably. One was a one-semester nonlaboratory course in which the sections contained about 45 students and were met in three one-hour meetings per week. The other was a two-semester laboratory course in which sections did not contain more than thirty students and the students attended two one-hour meetings and two two-hour laboratories per week. Moreover, the nonlaboratory course was taken by students who did not intend to take additional biology courses, while the laboratory course was taken by students who were planning more intensive study in biology. Most biologists are agreed that a nonlaboratory course is inferior to a laboratory course, and that a one-semester "terminal" course provides only a superficial survey of biology. It is interesting to compare the performance of the two groups of students in these courses. Data gathered in this experiment are shown in table 1. The average grade in the nonlaboratory course was 64 percent, and the average grade in the laboratory course was 58 percent. Thus, it appears that the addi-

tional time spent in the laboratory course, and the presumably greater motivation for careful study on the part of students who intend to continue in biology, did not enable these students to understand the textbook and the examination questions more clearly than did the students who were taking the nonlaboratory course.

In the laboratory course some double sections were met in a lecture room for the one-hour meetings and these sections were met in laboratory by graduate assistants who were completely responsible for the laboratory instruction. A total of eight sections was handled in this fashion. In the other eleven sections both lecture and lab were met by the same instructor. A comparison of grades in these groups did not show a significant difference. The students who attended "single" lecture sections and were taught by the same instructor in laboratory did not show a clearer understanding of the textbook and the examination questions, than did the students who had to attend lecture in larger groups and had graduate students for laboratory instruction.

Moreover, the methods of instruction varied considerably from one instructor to another. Some instructors lectured extensively, others used primarily a recitation-discussion procedure. Some instructors had many years of experience,

TABLE 1

Comparison of grades (percentage correct) of various groups

	Avg.		Number of sections in sample
Nonlaboratory course	64	(92–30)*	5
Laboratory course	58	(86–31)	17
Large lecture section with graduate students responsible for laboratory instruction	58	(86–28)	8
Small lecture sections. Laboratory and lecture by same instructor	58	(86–31)	9
Sections of experienced instructors	58	(86–30)	10
Sections of first year instructors	59	(86–29)	7

*The values in parentheses indicate the average range within sections.

others were in their first year of employment. A comparison of the performance of students subjected to these different methods and different degrees of instructor's experience did not reveal consistent differences which could be correlated with a particular teaching method or level of experience. Moreover, the sections taught by the author of the open book tests showed no significantly higher performance than the other sections.

The low average performance on these open book tests was revealing. It demonstrated that the average college freshman understood only about 60 percent of the material sampled from the text, and that the added instruction provided in laboratory and the presumably greater skill of experienced teachers did not improve this performance. (From experience on faculty committees, observing the frequency of misunderstandings, I am convinced that the efficiency of communication between faculty members also is less than 60 percent.)

One consistent correlation observed in this study was in the performance of individual students on successive tests. Those students who obtained high scores on the first test were usually able to repeat this performance on subsequent tests, and the students who scored low were usually unable to improve their performance on subsequent tests (see Verduin, 1950, for more detailed informa-

tion on open book objective tests). There was also a highly significant, positive correlation between the final grades given by each instructor and the performance of the students on open book tests, although several instructors gave only 10 percent weight to the open book test scores in determining student grades. The degree of correlation can be expressed by noting that if the instructors had based the grades entirely on the open book tests the students would, in 63 percent of the cases, have received the same letter grade as they actually did receive on the basis of all the evidence gathered by the instructor, and in less than 2 percent of the cases did the grade actually given differ by more than one letter from the grade indicated by the performance on open book tests. Tests of this type, therefore, can provide valuable criteria for grading the student.

The data in table 1 do not warrant the conclusion that biology students did not profit from laboratory experience, only that their ability to analyze open book objective type questions was not improved by it. Obviously an examination in which biological specimens were introduced, would place the laboratory group at a distinct advantage, and the evident intellectual satisfaction derived from laboratory experience is unquestioned.

One tangible result of this experiment was the rearrangement of the general biology curriculum to combine the nonlaboratory course with the laboratory course into a single one-semester Biology offering, providing one two-hour laboratory period and two one-hour discussion periods each week. This course now serves as a cultural course for those who plan no further study of biology and as a foundation course for those who plan to specialize in the life sciences. The evidence in table 1, that the students selecting the nonlaboratory course were not inferior to the others in their ability to understand biological concepts justified this amalgamation.

LITERATURE CITED

Verduin, J. 1950. An open book objective examination for science courses. School Sci. and Math. 50: 213–221.