bank dealing with pressures and crises inside its own national frontiers, it will be able to oppose and to disarm all serious adverse speculative and other temporary disturbances, and thus to furnish the essential element—time—which is required until these disturbances can correct themselves.

This reorganization of the Fund and of its operations is also, I think, the remaining major step required to get the U.S. dollar back on a sound basis. The present Fund is too small, in terms of the resources which now seem likely to be available, and it is ordinarily too restricted in the use of these resources to do the job adequately. But if reorganized in the way that has been proposed, the Fund can provide an essential temporary buffer, both in terms of the absorption of short-run pressures on dollar (or other) exchanges and in terms of time. Such a buffer is necessary until the other measures described —chiefly increased foreign participation in the costs of mutual defense and of aid to underdeveloped countries and increases in the efficiency of our own industries—can take hold, and thus eventually assure an enduring equilibrium in our balance of international payments.

References and Notes

1. From July 1945 to the end of 1953 the total of our foreign aid was $47.8 billion, of which $35.3 billion was essentially economic aid and $12.5 billion military aid. By the end of 1960 the respective totals were $82.7, $54.9, and $27.8 billion.
2. These are unofficial estimates by a skilled observer. Of the Fund's own holdings of currencies, totaling $11.46 billion on 30 September 1961, roughly $6.7 billion were estimated by the same observer to be convertible (the Fund does not publish these data). Of this it was estimated that U.S. dollars constituted roughly $2.4 billion; pounds sterling, $2.5 billion; other European convertible currencies, $1.0 billion; and Canadian dollars and Japanese yen together, $0.7 billion. The "official" sterling holdings of members of the IMF include the reserve balances of the sterling area countries.
3. In the first 8 months of 1962 we lost another $808 million of gold, and our short-term foreign debt increased another $1663 million, making a total further deficit, net of increase in our own "official" holdings of convertible foreign currencies, of $2137 million. This is somewhat larger, on an annual basis, than the 1961 deficit.
4. These banks also held or renewed maturing claims on pounds and dollars, instead of presenting them for payment.
5. The average economic output of the United States, per capita and as measured in real terms, increased only 5 percent from 1953 through 1961, and only 2 percent in 1957–61.
6. The recent heavy reductions in the duty exemptions of American tourists abroad are increasing the federal revenues somewhat, however.
7. This is also true of the proposal to abandon the 25-percent gold-reserve requirement for Federal Reserve notes and deposits. I think this requirement should be reduced or abolished, but for a different reason. As long as gold continues to be used as a major means of settling net international payment balances, lowering the requirement would give us a bigger cushion of "free" gold than we would otherwise have, with which to absorb international shocks and pressures.
8. It is also often argued that the total supply of international reserves ("liquidity"), either in existence or obtainable, is grossly inadequate. This may or may not be true, since "adequacy" is at best a relative concept. What is not debatable is that the supply is badly distributed, as shown in Table 1. Four-fifths of the Western world's total stock of monetary gold is held by only eight countries, and over 40 percent by the United States alone. The "official" holdings of foreign exchange are somewhat more evenly distributed, but they are almost entirely holdings of U.S. dollars and British pounds. It is also obvious that in the last 10 years the total holdings of gold and "official" foreign exchange have not increased nearly as rapidly as world trade or industrial production. The percentage increases for the free world from 1951 to mid-1961, as given in *International Financial Statistics* and *Monthly Bulletin of Statistics*, were as follows: Gold stock, 15; "official" foreign exchange, 48; total gold and "official" exchange, 25; exports (dollar volume), 54; exports (quantum), 70; industrial production, 53.
9. E. M. Bernstein, "International effects of U.S. economic policy," *U.S. Congress Joint Economic Committee Study Paper No. 16* (25 Jan. 1960).
10. See *International Financial News Survey* (29 Sept. 1961); *ibid.* (6 Oct. 1961); *ibid.* (12 Jan. 1962).
11. Legislative ratification will also be required in the case of the United States and of certain other countries.
12. R. Triffin, *Gold and the Dollar Crisis* (Yale Univ. Press, New Haven, Conn., 1960).
13. Fund deposits held by a member, if created by its sale of either gold or second-country currencies to the Fund, would normally bear interest. This provision would make such deposits as attractive to hold as second-country currencies themselves.
14. For a fuller statement of these proposals and of my criticisms of Triffin's plan, see J. W. Angell, *Economic J.* (Dec. 1961).

The Chemical Bond Approach Course in the Classroom

A 3-year evaluation shows that the course is within the capabilities of high school students.

Arthur H. Livermore and Frederick L. Ferris, Jr.

Education in chemistry in secondary schools of the United States has fallen progressively behind the accelerating pace of development in the science of chemistry itself. While our knowledge of chemistry has been doubling every decade since the 1920's many of our high school textbooks on chemistry have barely emerged from the 19th century.

Until as recently as 1959, most high school chemistry teachers were virtually isolated from professional chemists in the nation's colleges and universities. Sizable numbers of high school chemistry students were going on to college or terminating their formal education with little appreciation of the science of chemistry as an experimental or investigative method of inquiry. More often than not, work in the high school laboratory had little relevance to the rest of the course and was conducted in "cookbook" fashion. All too frequently the students thought of chemistry as little more than an abstract manipulation of mysterious symbols and formulas.

At the same time, the climate of opinion in many universities was cool toward the inclusion of any form of chemistry instruction in the curricula of the secondary schools. Professional chemists in the colleges felt obliged to "unteach" the "evils" perpetrated in the secondary schools. "Teach them English and mathematics and leave the chemistry to us," was the attitude on most campuses.

This lag between the high school classroom and the university laboratory had reached such serious proportions by the late 1950's that it was clear some unprecedented effort would have to be made to rectify the situation. In 1957 (*1*) a group of high school and college teachers met to discuss the problem. A survey of existing high school text-

Dr. Livermore is professor of chemistry at Reed College, Portland, Oregon. Dr. Ferris is affiliated with the Educational Testing Service, Princeton, N.J.

books revealed that chemistry was being presented as a miscellaneous collection of topics to be studied in any order. Moreover, it showed that the general facts of chemistry were being presented in an authoritative and didactic manner, with a notable lack of unity and sequence. What was needed to do justice to chemistry as a science, this group concluded, was to give high school chemistry courses a central theme (*2*).

At a similar conference, held a year later (*3*), another group of high school and university teachers agreed to experiment with a course based on chemical bonding as the central theme. In 1959, with the support of the National Science Foundation, this project became a reality. At a writing conference held at Reed College (*4*), nine high school teachers and nine professional university chemists prepared the first text and laboratory guide for what was to become known as the Chemical Bond Approach [CBA] Project.

Participants at this writing conference made three crucial decisions, as follows.

1) The new course, because of the realities of the current high school situation, would have to be appropriate for 11th- or 12th-grade students. Further, because of the lack of any standardized science sequence in the nation's high schools, the new course would have to be independent of any prerequisite courses, such as physics.

2) The new course should have unity and not be a disjointed compendium of chemical knowledge. This concept of unity was to be embodied in the principal theme, chemical bonding.

3) Because of the radical nature of the new course it was decided to implement a system of continuous feedback in order to evaluate all phases of the program. In this way, the program could be modified and revised while it was in operation.

The course that resulted from the Reed College Conference has put the student into the laboratory. The laboratory program stresses investigation as opposed to mere demonstration of facts already known. Instead of concentrating on the body of chemical knowledge built up through the ages, the course stresses the ways in which chemists arrive at such knowledge through scientific inquiry. To put it another way, the project emphasizes inquiry as well as the results of inquiry, methodology as well as recorded discovery.

An outstanding feature of the new course is its emphasis on observation and experimentation, on having the student see and do things for himself. Indeed, the student is aware of this emphasis in the very first project he encounters in the laboratory. This is the so-called "black box" experiment, in which each student is given a sealed box containing an unknown object and asked to formulate a simple scientific model with respect to its contents. He is free to shake the box, to weigh it, or to do anything he wishes to it except open it. His work is judged not on his ability to guess correctly what is inside the box but on the way he uses the evidence he has obtained from observation and inference. Though seemingly far-fetched, this little exercise epitomizes the methodology of the chemist, who is constantly dealing with "black boxes" in making inferences about things he never sees.

Table 1. Enrollment in the Chemical Bond Approach course since 1959.

Academic year	Teachers (No.)	Students (No.)
1959–60	10	850
1960–61	83	5,500
1961–62	200	10,000

Model building on all levels is stressed throughout the CBA course. The charge cloud model (*5*) of the atom, for example, is presented to the student, and he is then required to determine the extent to which assumptions implicit in this model are borne out by observable evidence. Finding evidence that is not satisfactorily explained by this model, the student is introduced to the orbital model of the atom. Geometry is also used extensively for describing and drawing inferences from the relationships inherent in chemical bonding. Energy and electrostatics are likewise used extensively throughout the course (*6*).

All in all, the new curriculum attempts to present to students a bold and imaginative approach to the study of chemistry, one which brings them to the very frontiers of chemical knowledge. Throughout the course the student is collecting facts and using models to explain his observations. Only through such direct participation, it is believed, can he obtain a genuine appreciation of chemistry as a science.

Table 2. CBA test results, 1960–61. Statistics for all the tests are based on the same sample of 972 students.

Test No.*	Mean	Standard deviation	Reliability	Correlation with SCAT†, form 1A
1	16.1	5.5	.74	.65
2	19.1	6.2	.80	.62
3	16.9	5.6	.74	.53
4	12.4	4.7	.65	.44
5	27.1	9.0	.86	.61

* Tests 1 through 4 contained 35 questions each; test 5 contained 70 questions. † School and College Ability Test.

During the academic year 1959–60 —the initial tryout year for the course at nine secondary schools—a twofold evaluation program was established. This dual system of feedback (which has continued from 1959 to the present) involves, among other things, evaluation of direct teacher reaction to the course material. In the beginning, when only nine schools were involved, it was possible to ascertain this reaction through roundtable discussions with teachers of the course. Eventually, however, as more and more schools became involved in the project, the roundtable system became impractical. At that point, representatives of the project began a program of visiting the schools.

Since enthusiasm is apt to be high in the initial stages of any new venture in education, anyone interested in an objective appraisal of the course would want more than glowing accounts from enthusiastic teachers. Thus, a systematic achievement test program was introduced to serve as a check on the subjective judgments obtained from teachers of the new course.

The objective, in constructing the achievement tests for the new course, was not only to provide feedback and supplement the information obtained from teacher reports; the tests were also constructed for the purpose of guiding the student. It is a well-recognized fact that a student's reaction and approach to any course of study can, in large measure, be influenced by the nature of the tests he must take from time to time.

To the student, the tasks presented to him on these tests serve to define the nature of the course objectives. He is quick to sense the basis on which he is "rewarded," and if such reward is based on his ability to recite facts and formulas from memory, then this will influence his approach to the course. If, on the other hand, the tasks presented to him on tests throughout the year require him to reason from the facts he has learned in order to solve new problems, then this will be his approach to the course.

In developing the achievement tests

for the CBA course, therefore, heavy emphasis was placed on reasoning ability rather than on the memorizing of facts. Laboratory problems with which students had had no previous experience were included as questions in the tests to elicit evidence of their ability to think and to use their knowledge in a manner consistent with the objectives of the course.

For completely reliable and rapid scoring, the questions were of the multiple-choice type. Testing for trivial aspects of knowledge is, of course, all too easy with this technique. Thus, the construction of tests consistent with the aims and objectives described constituted a formidable endeavor, comparable to the development of other materials related to the new course.

The achievement tests designed for the CBA course do not look like conventional objective tests with large numbers of discrete, multiple-choice questions. In every instance the student is given a broad problem situation, and the individual multiple-choice questions serve merely to measure the extent to which he can cope with various facets of this broad problem from various desired points of view.

The following example, taken from one of the CBA achievement tests, illustrates the technique involved.

Questions 1–9 relate to the following information.

Certain physical and chemical properties of elements and compounds readily follow from the model of the atom which was presented in Chapter IV of the text. Suppose that the model were changed slightly by assuming a new exclusion principle, namely:

With sufficient attractive forces present, three, but no more than three, electrons can simultaneously occupy the same region in space. (All other features of the original model remain the same, including the implicit assumption that the number of charge clouds about a central one will be the maximum number possible, not to exceed four.)

1. The new model for an atom of hydrogen (atomic number 1) would
(A) be exactly like the original model of hydrogen
(B) be like the original model of helium (atomic number 2)
(C) be like the original model of lithium (atomic number 3)
(D) predict that hydrogen is inert
(E) require one more electron cloud than does the original model

2. What would be the formula for a hydrogen molecule?
(A) H
(B) H_2
(C) H_3
(D) H_4
(E) None of the above

3. What would be the total number of charge-clouds in an atom of oxygen (atomic number 8)?
(A) 6
(B) 5
(C) 4
(D) 3
(E) None of the above

4. The formula for hydrogen oxide would be
(A) H_2O
(B) H_3O
(C) H_4O
(D) H_5O
(E) H_7O

5. What would be the formula for the hydride of helium (atomic number 2)?
(A) HeH
(B) HeH_2
(C) He_2H
(D) HeH_3
(E) None of the above

6. In terms of the new model, which element would be chemically inert?
(A) Hydrogen (atomic number 1)
(B) Helium (atomic number 2)
(C) Neon (atomic number 10)
(D) Oxygen (atomic number 8)
(E) None of the above

7. What would be the symbol for a molecule of lithium (atomic number 3)?
(A) Li
(B) Li_2
(C) Li_3
(D) Li_4
(E) None of the above

8. What would be the atomic number of the second inert gas element?
(A) 6
(B) 9
(C) 12
(D) 15
(E) None of the above

9. In terms of the new model, what would be the relative amounts of energy needed to remove successive electrons from an atom of beryllium (atomic number 4)?
(A) A large amount to remove the first electron and small amounts to remove the last three.
(B) A small amount to remove the first electron and large amounts to remove the last three.
(C) Small amounts to remove the first two electrons and large amounts to remove the last two.
(D) Small amounts to remove the first three electrons and a large amount to remove the last one.
(E) Removing the first electron would require the same amount of energy as removing any other electron.

Five achievement tests constructed along these lines have been built to accompany the CBA course. The first four of these tests cover specific segments of the course, in sequence; the last is a final comprehensive examination on the year's work. These five tests, in other words, serve as an integral part of the instructional process itself. They are given to students at spaced intervals throughout the academic year and are designed to represent the kinds of learning the authors of the course hope the students will achieve. In this way, both teachers and students can see, at regular intervals during the course, what they should be teaching and learning, respectively.

The Chemical Bond Approach course is now being used for the fourth year in the nation's schools. Throughout this period, school and college teachers, as well as the authors of the course, have been evaluating its strengths and weaknesses and making appropriate revisions. What are the results of these evaluations?

Generally speaking, the course has met with an enthusiastic reception on the part of many professional chemists and secondary school teachers. Perhaps the most dramatic evidence of this interest on the part of the schools is the growth of the project itself. In Table 1 is shown the increase in enrollment in the CBA course since 1959.

The testing of students over the past several years has not been done with a view to comparing the CBA course with some other kind of secondary school chemistry course. Actually, no external criterion exists with which the new course can be usefully compared. The emphasis has been, rather, on an internal evaluation or appraisal of the extent to which the objectives of the course have been met. The principal question to be answered by this internal evaluation has been this: Can the CBA course be effectively taught to 11th- and 12th-grade chemistry students, for whom it was designed?

To determine this, it was necessary first to define the group taking the new course—to determine the scholastic ability of the CBA student population and the extent to which that group was comparable to high school students who typically take chemistry.

To obtain a description of the scholastic ability of CBA students, a scholastic aptitude test (the School and College Ability Test) was given to all students enrolled in the CBA course. The results of this testing over the past 3 years reveal that CBA students collectively comprise a broad spectrum roughly comparable to the group of students who take the Scholastic Aptitude Test of the College Entrance Examination Board. Precise data on the scholastic ability of students who typically take chemistry in the nation's high schools are not available; however, the best indications are that the CBA population has a somewhat higher ability level, on the average, than this national group. The results of this research also suggest that, although on the average the students taking the new course are somewhat abler than the students who typically take high school chemistry throughout the nation, there are substantial numbers of students among the CBA population with scores in the lower scholastic aptitude ranges.

How did the CBA group perform on the achievement tests designed for the new course? Data obtained thus far indicate that the course materials are being communicated to the hoped-for degree. The tests, which, in the opinion of the authors of the course, reflect the kinds of student learning stressed, were designed with the expectation that the average student would get about half the questions right. Table 2 gives a summary of the performances of the sample of 972 students who took all of the tests during the academic year 1960–61.

It is interesting to note, in Table 2, the descending pattern of correlation between results on the CBA achievement tests and results on the scholastic aptitude tests. The correlations (not shown in the table) between results on one CBA achievement test and those on another are equally interesting and consistent. The correlation for "neighboring tests" is relatively high, whereas the correlations for tests separated by large periods of the academic year tend to be low. The reasons for this phenomenon and for the descending pattern of correlation between the CBA results and the scholastic aptitude results are not entirely clear. Similar patterns have been obtained in connection with the Physical Science Study Committee high school physics course.

All the evidence to date suggests that the original goals of the CBA project are within reach. Data from the evaluation studies indicate that this course is appropriate for high school, and appropriate for a student group with a broad spectrum of abilities. In a few colleges where the course has been used, teachers report that the course is appropriate regardless of a student's major field—whether it be chemistry or English literature. Moreover, the results of the CBA study to date clearly indicate that we have vastly underestimated the potential capabilities of the American high school student. The evidence is clear that, even though modern theories of chemistry are used throughout to explain observed chemical phenomena, the course content *can* be effectively communicated to students of a wide range of scholastic abilities. Thus, the chemistry course developed by the Chemical Bond Approach Project, together with similar studies in physics, mathematics, and biology, should go a long way toward developing citizens who are far better informed in the scientific humanities than the average citizen is today.

References

1. *J. Chem. Educ.* **35**, 54 (1958).
2. L. E. Strong and M. K. Wilson, *ibid.* **35**, 56 (1958).
3. M. G. Burford and H. F. Lewis, *ibid.* **36**, 90 (1959).
4. A. H. Livermore and L. E. Strong, *ibid.* **37**, 209 (1960).
5. G. E. Kimball and E. M. Loebl, *ibid.* **36**, 233 (1959); J. R. Platt, *Handbuch der Physik*, S. Flügge, Ed. (Springer, Berlin, 1961), vol. 37, pt. 2, pp. 258, 259.
6. L. E. Strong, *J. Chem. Educ.* **39**, 126 (1962); *School Rev.* **70**, 44 (1962).

What Is To Be the Function of the Section on Statistics?

In formulating its plans and purposes a new scholarly group must consider activities of existing societies.

Jerzy Neyman

At the last annual meeting, in December 1961 in Denver, Colorado, the Council of the AAAS authorized the organization of a new section, Section U (Statistics), and Morris Ullman was appointed section secretary. At the forthcoming annual meeting, in Philadelphia, Section U will appear as an independent body, with its own program of sessions. These are described elsewhere in this issue (see p. 1148). The evening session of Saturday, 29 December, will be given over to a discussion of plans of future activities of Section U; this article is intended as preparation for that discussion.

Ordinarily, creation of a fresh scientific society follows recognition of the need for a new organizational framework—perhaps a minor revolt—on the part of a group of scholars who feel that the existing societies do not provide them with adequate facilities.

Frequently this occurs when a new, fertile subdomain of an earlier broad domain of research suddenly bursts into existence and attracts a considerable number of scholars. Such was the origin of the Institute of Mathematical Statistics. Such, also, must have been the origin of the Ecological Society, of the Society for Study of Evolution, and of others. The viability of a new scientific group depends very much on the importance of the novel domain of study, on the number of active scholars attracted by it, on the energy of the organizers, and on the services provided the membership. These services are, generally, an adequate forum for discussions and a specialized channel for publication.

To anyone who follows the developments of scholarly life in any modern country, the process described must be familiar. Its consequences are, broadly, twofold. First, except for those cases where the newly created societies are not viable and quickly die out, availability of the new facilities is accompanied by a vigorous development of a domain of research. Second, a further step is made toward compartmentalization of knowledge. The first of these consequences is undoubtedly advantageous. As to the second, there is

The author is director of the Statistical Laboratory, University of California, Berkeley, and chairman of AAAS Section U.