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Science Vocabulary and Teaching

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If it should be necessary to relate the work here reported to a theoretical background or to some current problems, such relationships could easily be found in the developing concepts about the psychology and philosophy of the thinking process and in the current discussions concerning critical thinking and the philosophy of science.

In his book, *HOW WE THINK,* which is twenty-five years old but now a classic, John Dewey maintains the view that language is necessary for thinking as well as for communication. He points out that language includes more than oral and written speech, but in his discussion of the importance of words for thinking he says:

"Everyone has experienced how learning an appropriate name for what was dim and vague cleared up and crystallized the whole matter. Some meaning seems almost within reach, but is elusive; it refuses to condense into definite form; the attaching of a word somehow (just how, it is almost impossible to say) puts limits around the meaning, draws it out from the void, makes it stand out as an entity on its own account."

Susanne Langer in her book, *PHILOSOPHY IN A NEW KEY,* published more recently by the Harvard Press, adds further clarity to the idea just referred to from John Dewey by using the word "symbolization." She says:

"In the fundamental notion of symbolization—mystical, practical, or mathematical, it makes no difference—we have the keynote of all humanistic problems."

With especial reference to words, the following quotations:

"The fact is that our primary world of reality *is* a verbal one. Without words our imagination cannot retain distinct objects and their relations, but out of sight is out of mind."

"This phenomenon of 'holding on to the object' by means of its symbol is so elementary that language has grown up on it. A word fixes something in experience, and makes it the nucleus of memory, an available conception. Other impressions group themselves round the denoted thing and are associatively recalled when it is named."

While the above makes a good theoretical background for this work, it is a matter of fact that the importance of vocabulary in the teaching of science was brought to my attention by an elementary teacher who was taking my course several summers ago. It was observed that she was making a list of words that were new to her in the course. She was encouraged to expand her work and to make her study one of the special projects required in the course. On the basis of her study and some additions made by the teaching staff we subsequently devised the list which we have used in our science vocabulary studies. The number of words in the tests have varied with the experimentation. We first used 88 words, then expanded it to 108, and later reduced it to 40, where were selected statistically on the basis of their degree of difficulty and their power of discrimination. Some of the results to be discussed here have been based on one of these forms and other results on other forms, but we feel that the results can be considered together.

Words were selected from all areas of physical science including astronomy, meteorology, chemistry and physics, and for purposes of analytical study scoring keys were made for the different subjects. Words which might be learned in different courses, for example "atoms," "molecules" and "calories" which could be encountered in physics as well as chemistry were included in each key; however, such words are counted only once in obtaining the total score results.

The test was made up in multiple choice form, with the word in question at the head of the column of foils or possible answers. Instructions given were to associate the word with the best of the five statements. Also, instructions made it clear that the correct answers were not necessarily accurate definitions, but rather, ideas which might be associated with the word in question. This use of idea association rather than accurate definition is valuable for getting at the total meaning of the term. In our opinion, the total implications of the varied meanings of a term are often more important than a simple definition. In our routine testing on smaller segments of the course the same word is often repeated to get at ideas which are to be associated with it under varying conditions or contexts. Some samples of the items used will illustrate.

1. Quantum
   1. large number of atoms
   2. fragment of a nucleus
   3. small quantity of energy
   4. ionized molecule
   5. particle consisting of two protons and two neutrons
2. Diastrophism
   1. electrolysis
   2. tidal wave
   3. two star collision
   4. electrical transmission through a metal
   5. movement of earth's crust
3. Isobar
   1. Spanish physicist
   2. same pressure
   3. constant temperature
   4. edge of a glacier
   5. piece of glassware
4. Hypothesis
   1. tentative explanation
   2. the longest side of a right triangle
   3. a law always obeyed by experimental data
7. Cosine
   1. reciprocal of a number
   2. 3.14159
   3. ratio of two sides of a right triangle
   4. drug obtained from opium
   5. low-boiling type of benzine
8. Alpha Particle
   1. electron
   2. neutron
   3. ionized atom of neon
   4. positron
   5. Helium atom nucleus
9. Ampere
   1. unit of electrical power
   2. electrical transmission cable
   3. instrument for measuring electrical charge
   4. unit of electrical current
   5. instrument used to measure ionization
10. Hydrocarbon
   1. any compound containing only carbon and hydrogen
   2. carbon containing large amounts of adsorbed water

4. an error in measurement
5. chemical reaction with an exchange of radicals but no electron transfer

5. Refraction
   1. bending
   2. reflection
   3. dispersion
   4. shattering
   5. refining
6. Kilowatt
   1. unit of force
   2. unit of energy
   3. unit of heat
   4. unit of power
   5. unit of work

3. lubricating mixture of graphite and water
4. animal fat
5. extremely porous type of coke

11. Magma
    1. magnesium-containing mineral
    2. interior of the sun
    3. mineral possessing natural magnetism
    4. molten rock under the earth's surface
    5. residue from vinegar fermentation
12. Oxide
    1. active form of oxygen
    2. mixture containing oxygen
    3. combination of oxygen with another element
    4. type of strong leather
    5. any compound which contains over 25 per cent oxygen.

The reliability of the test was estimated with one group of 140 tests by use of the split-half procedure. Using the Spearman-Brown formula, a reliability value of 0.91 was obtained.

The vocabulary test, along with a science reading test, was first used as a pre-test to determine the backgrounds of the students in the physical science course. In order to have some standard of reference, our professor of inorganic chemistry agreed to give it to his students in general chemistry, and the results of the two groups were compared. The physical science course is designed for and taken by non-science majors, and the general chemistry course by chemistry majors, engineering, pharmacy and pre-medical students.

The results shown in the table below give the comparison of the two groups. The table gives the number of right answers for each group of students in the fall at the beginning of the courses.

Table 1
Median Scores on the Physical Science Proficiency Examination—Part I—Vocabulary (88 Items)

Vocabulary Classification	No. of Items	Pre-test September, 1950 General Chemistry Students (N - 113)	Physical Science Students (N - 185)
Astronomy	23	12.0	11.1
Chemistry	35	19.3	15.8
Geology	28	12.1	11.4
Physics	39	21.6	18.0
Total	88	42.8	37.8

It was not surprising to find that in every category the chemistry students made better scores, since students planning for some kind of a science career would generally include more science in their high school program. In fact, this immediately gave us a little feeling of confidence in the test. It might be added here that we have often obtained science interest scores from such inventories as the Kuder Preference Records, and have always found that the science interest of students taking the physical science course run well below the standard distribution for all students.

Some additional feeling of confidence in the test was received from the results of the post-testing at the end of the year when comparative results were as shown in the next table. It is recognized that the test was designed for the physical science course, and that the objectives were different even in the parts of the course which relate to conventional chemistry content. Nevertheless, there is an elementary chemistry vocabulary involved in both of them. Again, the results were as might be anticipated. The chemistry students showed their major gains in chemical vocabulary, but only small gains in other areas. The table below shows the comparative results, scores again give the number of items answered correctly.

Table 2
Median Scores on the Physical Science
Proficiency Examination—Part I—Vocabulary (88 Items)

Vocabulary	Post-test—May, 1951 Physical Science Students			Chemistry Students		
Classification	Fall	Spring	Gain	Fall	Spring	Gain
Astronomy	11.4	16.6	5.1	12.0	13.3	1.3
Chemistry	15.8	25.4	9.6	19.3	24.7	5.4
Geology	11.5	21.3	9.8	12.1	14.6	2.5
Physics	19.0	28.3	9.3	21.6	25.0	3.4
Total	39.6	64.9	25.3	42.8	50.9	8.1

While the percentage gains were very satisfactory, the actual numbers involved in the gains were small; therefore, the following year the number of words in the test was increased by twenty to give a total of 108.

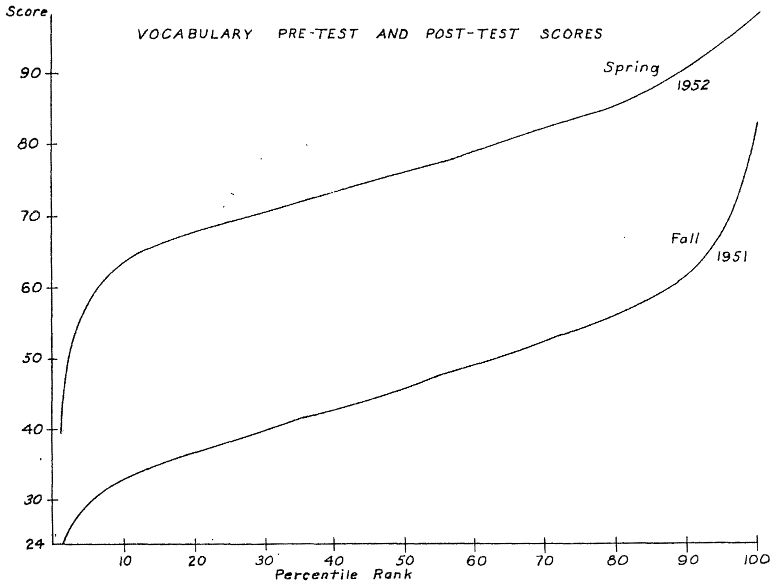
This test was given in the fall as a pre-test, and again in the spring as a post-test, to students in the physical science course. The distribution of scores made by the class at the two times is shown on Graph 1. As might be anticipated, although not with certainty, all the scores on the post-test were above almost all of the scores at the pre-test. The individual gains ranged from 9 to 53 words.

In answer to the question as to who made the greatest gains, it was found that while the gain varied with the individual, the average gain was greatest for the students in the lowest quarter in the pre-test, and the average gain was least for the upper quarter on the pre-test.

Vocabulary Gains
From Fall, 1951 to Spring, 1952

Highest Quarter	Average	21.5
Second Quarter	Average	27.0
Third Quarter	Average	31.0
Lowest Quarter	Average	35.5

All of these results seemed to indicate that the vocabulary test was measuring at least a part of the course outcomes, so that correlation



studies between the vocabulary scores and the total course scores were next made. These were easy to make since course grades have always been established on the basis of a sum total of points obtained from the regular tests, the final examination, the regular laboratory work and the scientific method projects. The correlation coefficient between the post-test vocabulary scores and the course grade scores with the 108 word test and the 1951-52 class turned out to be an amazing .82. With the 88 word test and the previous year course grades the correlation coefficient was .62.

Someone might interpret this to mean that apparently all the course does is to teach vocabulary, and more about that will be said later, but some of our studies now in process begin to give evidence of other outcomes of the course. About this, a brief statement will be made, but more complete report must wait until a later time.

In common with many such science courses, a major objective is to give the non-science student some understandings of the methods of scientists. This is attempted in lectures, readings, discussions and in certain new types of laboratory experiences. The teaching staff has also been trying to devise methods of evaluating the students progress toward this objective by use of testing items, specifications for evaluating certain interpretive reports and the individual projects; so that while we do not have the confidence in these evaluations that we have in conventional subject matter testing, we do have a composite score on the methods of science separate from the achievement score on basic principles and subject matter. A recent study of of these scores and the vocabulary test scores seems to indicate a good correlation between factual materials and vocabulary, and also a reasonably good correlation between methods of science and vocabulary; but between the factual material and the methods of science there is very little correlation. We also have individual case records that seem to indicate that not all students who make good subject matter achievement can handle the methods of science materials; likewise, there are students who handle the methods of science materials well who achieve much less in the regular subject matter materials. We are hopeful, therefore, that some progress is being made in teaching the methods of science, as well as the conventional development of science vocabulary and comprehension of basic principles.

In conclusion it might be said that there is nothing startling about these science vocabulary studies, but they have had some interesting and valuable effects upon our own teaching. In the first place, the vocabulary studies have given us a greater appreciation for the importance of words in the learning process, and we are coming to agree more and more with the ideas expressed in the first quotations, and to believe that there must be a thorough acquaintance with words and symbols in order to think in the field of science or in any field. We are, therefore, giving more emphasis to vocabulary in our teaching. Secondly, we believe that an increased efficiency in teaching has been achieved by this emphasis upon vocabulary. We expect to get some check on this at the end of the year by repeating certain evaluation tests that were used in our evaluation study five years ago.

Another by-product of the vocabulary study is that we have modified our testing procedures in the basis of the results. We have reasoned that since there is such a high correlation between vocabulary testing and conventional subject matter achievement, we can use a higher percentage of vocabulary items in our regular tests to determine grades. Grades, possibly unfortunately, are still based mainly on subject matter achievement. Since, also, the vocabulary items take much less time for students to answer, we have been adding more items requiring interpretation of data and critical thinking without increasing our total testing periods. These kinds of reflective questions require so much time that previously we did not give many of them. Now they have become a part of every test.

In summary then, we believe that the vocabulary testing has helped us to do more effective teaching, a better job of routine testing and grading, and indirectly to make progress in our objective of giving our students a better understanding of the methods of science.

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