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The Teaching of Chemistry with the Behavioral Outcomes Approach

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THE TEACHING OF CHEMISTRY

WITH THE BEHAVIORAL OUTCOMES APPROACH

(TITLE)

BY

GULAM HABEEB

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~~THESIS~~

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An objective is an intent communicated by a statement describing a proposed change in a learner -- a statement of what the learner is to be like when he has successfully completed a learning experience. It is a description of a pattern of behavior (performance) we want the learner to be able to demonstrate.

-- Robert Mager

The goal of education is not to increase the amount of knowledge but to create possibilities for a child to invent and discover; to create men who are capable of doing new things.

-- Jean Piaget

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Infinite are pleasures of "sweet" efforts. Such pleasures walk with us like our own thoughts. No effort, no activity, no act of man came into being all by itself: man is not apart in any process whatsoever. This is most apparently so in the realm of learning -- in the pursuit of knowledge. The activity here is sacred and inspiration is what this activity is rich in. Such an activity is always a cooperative effort.

Sweet are the uses of adversity. Joys that have resulted will keep reminding me of my toiling and moiling, in the midst of which came from my great teachers encouragement and inspiration. These two elements to me were like a blessing, for upon me they bestowed the spirit of patience along with new styles of thinking and new capabilities towards coping with the problems.

To this knowledge and inspiration which the Department of Educational Administration and Supervision infused me, I pay tribute of my appreciation. Prof. Walter C. Garland, who supervised this work and, in fact, with whose efforts all this could become possible, lent me ideas, concepts and styles which enabled me to embellish this effort. His philosophies, thoughts,

and reflections are indeed a guide along my journey toward future destinations. With profound depths of my heart, to him I pay homage -- the act which will ever keep my head raised with pride and honor.

The insights which I gained through the lectures and discussions by Prof. Gerhard C. Matzner and Prof. Donald W. Smitley in the courses of Curriculum Development and Administration and Supervision of Secondary Schools respectively helped develop my own philosophies which I was able to focus in this paper. To them I am elatedly grateful.

I express my highest gratitude for Prof. Robert V. Shuff, my adviser. In his vivacious extensions of mind flourished my work with ease and smoothness. He is the beginning and end of this "adventure". Into the depths of my heart shall remain eternally my profound reverence for him.

TWO WORDS PRIOR
TO INTRODUCTION

The Behavioral Outcomes Approach -- in any teaching-learning situation -- actually rotates around the behavioral objectives. The behavioral objectives movement is not new today. Novel, of course, is the new trend which seeks new but solid, integrated patterns in the direction of perfect instructional achievements. This common trend -- of course, that is not widely common yet, but that surely is one widely discussed -- is the introduction of behavioral objectives to the entire educational process. This new trend, furthermore, might get directed towards the Behavioral Outcomes Approach. This approach can be an alternative to other existing techniques. In fact, in spite of the fact that this approach, like any other one, has hang-ups, some major, some minor, it at least -- and at best -- prevents us, the educators, from becoming the victim of ambiguity, doubt, and dimness. It is a sure method. It assures the result -- regardless of whether it is negative or positive -- with greater clarity. It makes us identify the facts whatsoever. For the results or facts are right before our eyes which we can observe and which our minds can grasp. Complex is the structure

of life -- and therefore of all systems. In instructional processes we are concerned with the individuals -- or, more appropriately, individual differences -- which means complexities of behaviors of all types and at all levels. In pursuit of new approaches in order to deal with these, we should, as a rule, be far from confusion: we can no longer add more complexities to the existing ones. One simple, clear, precise, definite approach, then, seems to be that of the behavioral outcomes.

The creator of this approach is Dr. Ralph W. Tyler -- the father of behavioral objectives as he is called -- to whose mind the idea of defining the objectives in terms of behavior first occurred in 1929 at the Ohio State University. At that time, Dr. Ralph Tyler was assigned the task of investigating ways and means for the improvement of instruction. As the head of the Division of Accomplishment Tests in the Bureau of Educational Research, he worked with faculty members deeply concerned with constructing better educational examinations and finding effective ways to improve instruction. His first attempt was studying the undergraduate biology program. Then he worked with other departments and put forth objectives in each situation.

Dr. Tyler's personality was extensively recognized in the sphere of education when he was first involved in the Eight-Year Study of Secondary Schools (1933-1941). This study concerned reviewing the degree of desirability of traditional college entrance requirements for the high school students to insure their success in college. That also aimed at fixing the new curriculum guidelines in the place of the customary requirements if these were to be discontinued. When he was directing this study, he was appointed as the University Examiner at the University of Chicago in 1938 -- the position in which he remained until the end of 1953. Here, he was mainly concerned with the construction of the comprehensive examinations. As director of the examinations staff from 1943 to 1953, he played a significant role in the development of the tests and examinations for the U.S. Armed Forces Institute. Also directed by him was the Twenty-Two College Study -- actually, the Cooperative Study in General Education -- from 1939 to 1945. His major concerns here were the curriculum and evaluation programs. In 1953, Dr. Tyler was offered the directorship of The Centre for Advanced Study in the Behavioral Sciences at Stanford, California. The year 1965 made him receive the second PDK-AERA Award for Distinguished

Research in Education. Later, he became associated with the Educational Advisory Board for Science Research Associates in Chicago.

The major responsibility of the teacher, maintains Dr. Tyler, is to see what it is that the student can learn. Learning, to Dr. Tyler, is actually the act of determining what the student can do with what he has been instilled.

ONE: INTRODUCTION

EXPLANATION:

A Preview in Prospect of Significance

Teaching is a sacred thing. Children are the trust of the future; they are sacred too. Teachers are the care-takers of these future hopes. They are pure -- like knowledge that guides the right path and excites the child to walk on in new directions, with new styles, towards countless destinations! Actions or behaviors lead him along the way, thus constituting the teaching-learning process. To determine his ability in terms of what speed he walks with becomes essential. To see his gain in terms of how much improvement he has made means to point out the outcome. He knows water is a flowing thing. To make him know that ice is water and that steam is water too means to add to his knowledge -- obviously not by verbalization but by putting him to actual experience; by letting him think by himself, know by himself, and say it by himself. This is cognition, direction of energy being emphasized and conscious experience and external stimulus conditions maximized.

He sees the water freeze or turn into steam. He feels cold or hot. Consequently, he is pleased with the experience and wonders how this all has come about.

This is the affective domain; in which case the unconscious material has been maximized.

He puts a piece of ice into a glass of water, drinks it and enjoys it. He brings his palm into contact with the evolving steam; his palm becomes wet. He takes delight in his "own" skills. This is psychomotor phenomenon.

Each and every behavior of his is directed and observed; accurately interpreted and carefully evaluated. The director, the observer, the interpreter, and the evaluator is the teacher. In due course of time, the child directs his own activity, observes his own actions, interprets and evaluates his own outcomes. To examine, then, the observable actions in terms of the objectives set and to touch the depths of his feelings and emotions in terms of discovering his attitudes is an indispensable role of the teacher.

Such a striving, thinking, and reacting child is the center of the Behavioral Outcomes Approach. The Behavioral Outcomes Approach includes all these phases, aiming at changing the child's behavior in a creative, constructive, and desirable manner. This approach develops in free atmosphere in which "relationships" get closer and closer and ease and simplicity prosper.

In the midst of ease and freedom exists mutual

respect, which makes instruction glorious and sacred!

So as to allow the child to learn on his own and in his own way, such pattern as controls his behavior will be most yielding. To control behavior means here to attempt to make it consistent with the desired goals. Chemistry is essentially a "learning-by-doing" subject, where a vigorous mental activity ever prevails. "One of the greatest pleasures and satisfactions in the study of chemistry," writes Voelker, "is the intellectual game of expanding horizons -- of broadening concepts -- so that more and more facts and figures can be interpreted, correlated, systematized and remembered on the basis of fewer and fewer principles."¹ The Behavioral Outcomes Approach, through its "teaching-thinking-learning" experiences, has much to give to the child's mental process. For instance, in order to make him know what the common salt is, the teacher will have to cause him to pass through different cognitive stages: starting from the concept of elements (periodic table) to the synthesis of compounds. (Of course, this whole process is the one that can only be introduced at a

¹ Alan M. Voelker. The Relative Effectiveness of Two Methods of Instruction in Teaching the Classificational Concepts of Physical and Chemical Change to Elementary School Children. Wisconsin University, February 1968, p. 2.

higher level.) All this is accomplished through intelligent questioning. A responsive environment is created, and there will, in turn, be a flow of wise questions from the side of the child. The "what's, why's, and how's" are all that constitute chemistry -- or any science. The Behavioral Outcomes Approach deals with these aspects in a series of constant change -- change and novelty in behavior. Such a change is essential to learning. It is an essential constituent of this approach.

Voelker quotes Bigge's (1969) concept of change:

. . . Learning is a change in a living individual which is not heralded by his genetic inheritance. It may be a change in insights, behavior, perception, or a combination of these.²

Change that is measurable -- that is, which is observable -- and that is the upshot of the actual, original course is all-important in chemistry -- or any other science -- instruction.

The Behavioral Outcomes Approach, through its affective domain, which involves attitudes, interests, values and the development of appreciation and adequate adjustment, stresses, for instance, in the child such phenomenon as a drive to investigate new things or ideas, drive for additional information, asking for evidence to

²Ibid. p. 2.

support conclusions made from scientific materials, interest in scientific issues, and a drive for explanations. The attitude of curiosity is thus reinforced. As a matter of fact, the attitude itself gets "nourished" in the sense that when it grows to come to prominence, it proclaims its full existence; which means the mode of its behavior -- be it positive or negative -- becomes manifest. The teacher is then ready, with available findings, either to move back or proceed further. To move back means to review the structure in the case of the particular individual, rearrange the materials, change the objectives, if necessary, and start afresh. The objectives will be changed in the light of the individual's interests, capacities, and resources. What is observed is a reality that exists. What is assessed is something that has eventuated. What is decided as the next step is that which is indispensable. In the event of the positive consequences, the same three steps will lead the achievements to further and higher objectives, greater demands, and superior destinations.

The Behavioral Outcomes Approach well grows in an environment which minimizes physical and mental discomfort of the child. Some of the elements of discomfort are pain, fear, anxiety, frustration, humiliation, embarrassment, and boredom. All these are best learned from observation of models.

Cognitive behavior, purely a mental activity, proceeds from simple to complex and in all its phases heralds the modes of occurrences -- occurrences that are molded in a particular desired fashion.

The two-way classification of cognitive objectives, as suggested by Baird³ in the light of Bloom's system,⁴ is indeed a distinctive feature of the Behavioral Outcomes Approach; for it does form the principal purpose of the instructional activity. According to that, at the lowest cognitive level, the performance requires recalling and reproducing previously learned information. At the higher cognitive level, the performance requires mental manipulation of the information, such as comprehending, applying, analyzing, synthesizing, and evaluating.

The psychomotor phenomenon is concerned with motor

³Hugh Baird. A Behavioral Approach to Teaching.
W. C. Brown, 1972, p. 67.

⁴Ibid. p. 66.
Bloom's system prescribes these six stages -- from easy to less easy:

1. Knowledge: Recall from appropriate signals or cues.
2. Comprehension: Use of materials or ideas of a communication.
3. Application: Selection and use of an appropriate abstraction.
4. Analysis: Breakdown of a communication into its constituent parts.
5. Synthesis: Putting together of elements and parts.
6. Evaluation: Formation of judgments for some purpose, using criteria and standards.

(neuro-muscular) activities. These objectives serve as means of self-learning.

The psychologists view that attitudes are not easily taught; they rather are changed by changing behavior. And that is why behavioral objectives.⁵

A number of studies support the behavioral objectives as an adjunct to learning. The research by Dalis⁶ and Nelson⁷ affirm that behavioral objectives lead to enhanced

⁵Report of Curriculum Committee on the Proper Use of Performance Objectives. Journal of Chemical Education, 49(1), January 1972, p. 35.

⁶Gus T. Dalis. Effect of Precise Objectives Upon Student Achievement in the Health Education. The Journal of Experimental Education, 39(2), Winter 1970, p. 20-23.

This study was designed to provide data on whether student achievement can be influenced significantly by providing students, in advance of instruction, information on what is expected of them as an outcome of instruction. 143 subjects were selected from five tenth-grade health and safety classes taught by the same teacher. One-third in each class was randomly assigned to one of three treatment groups. For treatment groups one through three, the participants received precisely stated instructional objectives, vaguely stated ones, and short paragraphs of health information respectively. Subjects receiving prior to instruction precise information on what was expected of them showed greater achievement than those who received vague or related information. (20).

⁷D. L. Nelson. The Effect of Specifically Stated Instructional Objectives Upon the Achievement of Collegiate Undergraduate Economics Students. University of Minnesota, 1970, p. 3.

achievement. The research by Huck and Long⁸ revealed that the behavioral objectives had a desirable effect on student achievement.

Above all, in Conroy's words,⁹ the behavioral objectives (1) inform the student, teacher, administrator, and the lay citizen of the purpose of the instructional program in a clear and a measurable way, (2) provide the criteria for accountability and information feedback for program improvement, (3) offer a powerful tool for the individualization of instruction.

The significance of the Behavioral Outcomes Approach is now evident. Especially, the approach is most favorable in the teaching of scientific subjects. We want solid

⁸Schuyler W. Huck and James D. Long. The Effect of Behavioral Objectives on Student Achievement. The Journal of Experimental Education, 42(1), Fall, 1973, p. 40-41.

In this study, the subjects were 19 senior and graduate students enrolled in a research course in educational psychology. Subjects, randomly assigned to two groups, were separated before treatment. One group received a list of precise instructional objectives, while the other group discussed an unrelated topic. The two groups were reunited, exposed to the same lecture, and then administered a twelve-item quiz concerning a day's lesson. The results showed a positive effect of behavioral objectives on student achievement.

⁹William G. Conroy, Jr. The Synthesized Behavioral Objective. Educational Technology, 13(8), August 1973, p. 29.

results without any traces of ambiguity; and these will certainly be achieved when we will let this approach grow and flourish!

BEHAVIORAL OBJECTIVES:

An Elaboration

Jean Piaget has said:

The goal of education is not to increase the amount of knowledge but to create possibilities for a child to invent and discover; to create men who are capable of doing new things.¹⁰

Invention, discovery, and novelty, the homogeneous words, pertain, in their true sense, to creativity, which is the characteristic of a fully functioning individual. Perception¹¹ and behavior play an outstanding role in structuring his creative world. Perception and behavior, again, develop as a result of experiences rich in simple but astounding facts of life.

¹⁰James V. DeRose. Independent Study in High School Chemistry: A Progress Report. Marple Newton School District, 1970, p. 3.

¹¹Although perception is a kind of behavior too, this has been differentiated here in this statement from behavior, since creativity is being dealt with, which is solely a part of mental activity and which therefore essentially concerns perception. Behavior, then, here means actions which describe practical experiences.

Introducing of scientific thinking in problematic situations, one of the objectives, therefore, will prepare the child's mind for that before-hand mental process which confers on him the extensions of thoughtfulness and appreciation, an ever-developing synthesis of scientific "integrity". "The intellectual aspects," says Swartney, "are at least coequal in importance with the material."¹²

Science is for life adjustment, as Swartney views.¹³ Making the child relate what he has seen in the classroom and what he has done in the laboratory with his everyday experiences would mean making his activity meaningful as well as useful.

The carefully-phrased behavioral objectives will clearly answer the question, "What can young people learn that is transferable to the world beyond the school so that they are truly educated for living and doing things of value in this world?"¹⁴

¹²Ilene Joyce Swartney. Learning Difficulties Encountered by Students Studying the Chemistry Study Program. Bureau of Research, Washington, D.C., 1969, p. 2.

¹³Ibid, p. 2.

¹⁴Ralph W. Tyler in: "Ralph Tyler Discusses Behavioral Objectives" (by June Grant Shane and Herald Grant Shane). Today's Education, Vol. 62, September-October 1973, p. 46.

Knowledge and enterprise, the important aspects of science teaching, comprise scientific concepts and their application in new situations. Hence, to impart these scientific concepts and principles will be among the most important aims of science instruction. This also means the creating of ability in the child to apply facts and principles to problems requiring abstract or critical thinking and the attainment of desirable attitudes, ideals, and interests.

Interpretation of scientific phenomenon of common experiences, use of methods of study and gaining of appreciation of the scientific attitudes are considered to be necessary aspects of such activity. To let the child know why the water, exposed to open air for several hours, gradually disappears means to make him interpret the process in a scientific manner, which is the characteristic of deductive reasoning. To show him, for instance, the step-by-step preparation of chlorine in the laboratory and have him observe the physical and then chemical properties of the gas will teach him the ways and methods of studying chemistry. Further, making him aware of the definition of the atom, of the power it contains, and of the tremendous use it has, will fill his heart with the strong sense of appreciation.

Deduction actually controls the individual ideas or situations through the application of principles, rules, definitions, laws, axioms, or other forms of general knowledge. What precedes is the "problem" itself. To let the child become aware of what is to be worked on will establish the direction which is to be taken. The very next step in a deductive process is the study of details. This involves search for principles and definitions. Thirdly, in the light of whatever is obtained as a result of this search, anticipated results will be hypothesized. To verify or to negate what has been hypothesized, in the fourth place, experiments are conducted, observations made and conclusions drawn and finalized.

Here is the above-mentioned example of water: the problem is why the water which is exposed to open air for several hours begins to disappear soon. Following this problem, both the teacher and the child will know the purpose of the study and what the former expects the latter to learn; and that is somewhat like this: the child will be able to interpret, either verbally or in writing, the process in a scientific manner. This is the main objective, which specifies the child's general behavior as to its major achievement that is expected of him. "Process" and "scientific manner" are the two key words here, which will now be defined. This "defining" will automatically

break this major objective down into more than one part -- or, more appropriately, constituent. The word "process" refers to the detailed study comprised of search for principles as well as definitions. Many a skill is involved in this one process: requirement of library use -- preparing notes and bibliography or securing a certificate from the librarian regarding proper and satisfactory use of library; requirement of teacher consultation (i) to keep the teacher informed of progress being made and (ii) to ask questions, clarifying doubts and seek further guidance -- preparing a list of questions and topics to be discussed; requirement of experimenting the problem in the laboratory -- using laboratory materials and recording appropriate data; and requirement of demonstrating the spirit of "quest" with reference to application and advanced knowledge.

The term "scientific manner" refers to expression of learned ideas in the form -- or with the help -- of scientific vocabulary. For example, evaporation -- the term used to designate the above phenomenon concerning water. In view of the total search made, all possible reasons will be put forth by the learner. This is "hypothesizing". The learner will then experience the actual situation.

In all these stages, behavior that can be observed has been stressed. The outcomes -- the desired modes of

behavior -- will be the precise reflection of the behavioral objectives, both main as well as subsidiary, established originally. It is now clear that the deductive system can well be blended with the behavioral objectives setting up the Behavioral Outcomes Approach. In order to keep the intricacies from arising the following precautions need to be observed:

1. Let not the child become utterly concernedless with the teacher.
2. Let the teacher be patient in assisting the child and let this "assisting" be a continuous process.
3. Let it be made sure that the child is reasonably well prepared to act upon the recommended or required procedure -- meaning he possesses the knowledge of general principles.
4. Let the child use his own skills as well as previous knowledge to gain mastery over new situation.
5. Let every bit of action manifest itself in order that the evaluation process may be eased and greater success assured.

The importance of already-possessed general principles is obvious in Smith's (1960) statement which Swartney quotes

here:

We are often asking the student to become acquainted with substances with which he is not familiar. In the case of gases, in particular, we assume that the student already knows what a gas is. But this is a material that he usually cannot see, cannot touch, cannot hold, cannot associate with definite shape, characteristic, size, or any of the other criteria with which he is accustomed to associate familiar objects.¹⁵

That is to say, observation power should here be intertwined with the faculty of imagination; which becomes another objective of chemistry teaching.

It is as well important to develop skills in using textbooks and reference material in chemistry -- which aspires to create interest, broaden the scope of the understanding of the subject, and keep the child informed of new trends. This will help him deal with theoretical as well as practical knowledge. The types of skills desired may further be explained and elaborated. If the preparation of chlorine gas is being studied, the behavioral objectives as to the use of the textbook might be as follows:

1. To enable the child to use the index in the given textbook and locate by himself all the needed sub-headings underlining the preparation of chlorine.

¹⁵Swartney, op. cit., p.12.

2. To have him note down briefly the
 - i) occurrence of chlorine
 - ii) materials needed for preparation
 - iii) procedure
 - iv) results
 - v) properties
 - vi) uses.

(This type of activity might follow the child's real experience in the laboratory.)

The behavioral objectives as to the library use might be:

1. To enable the child to select appropriate reference book (Handbook of Chemistry, for example)
2. To have him note down salient features of the preparation of chlorine gas in the laboratory excluding those already described in the textbook.

Practical work and accurate observation are meant to make conclusions based on fuller confidence. These two elements can be blended with either inductive or deductive process. That means that one important purpose of chemistry teaching would be to let the child learn to validate his own conclusions. Self-confidence will thus be gained. Allied to this is the aspect of ability to record and

interpret data in a systematic manner.

The importance of arithmetical problems -- their reading, analyzing and solving -- can not be neglected as it is basic to chemistry. This involves manipulation of numbers in addition, subtraction, etc., solution of simple equations, and interpretation of graphs, charts, and tables. Hence, skill performance in this area needs to be stressed much and will be another important objective.

Both the teacher and the child will be held responsible for finding as many questions as possible. The teacher will act as a reinforcer when he will provide the child with a list of questions to be solved. When the child is "moved", so that his ever-growing curiosity goes on producing a series of questions, thus revealing the vigorous activity of mind, the affective domain here prospers, creativity flourishes.

The act of appreciation is reflective of affective domain. DeRose's definition of appreciation is:

Knowing the flavor and zest of the scientific enterprise, developing and maintaining a continuing curiosity and desire to know, to recognize, and conduct honest and unbiased evaluations of data, enjoying generating new knowledge, respecting and considering the ideas of others, and being flexible, and open-minded, and learning how to learn.¹⁶

¹⁶James V. DeRose. A Basis for Improving and Evaluating Chemistry Courses. Journal of Chemical Education, 48(10), October 1971, p. 678.

Beauchamp divides the objectives into six categories: knowledge, exploration, abilities, attitudes, ideas and habits, and interests. The most important behavioral aspects concerning these areas are:

1. a) to acquire knowledge which will produce a better understanding of our environment
b) to acquire scientific vocabulary
c) to acquire knowledge necessary for further courses in chemistry or to prepare for college
2. To give the pupil a view of the field of science so that he may explore his interests, capacities, and abilities
3. To develop the ability to use the scientific instruments common in the laboratory
4. To develop attitudes of appreciation of
 - a) the contribution of scientific methods and of science to mankind
 - b) the great men of science
 - c) natural laws
 - d) the importance of quantitative thinking and original research
5. To acquire ideals of accuracy, persistence, and self-control

6. To acquire wholesome interests which may be used to enjoy spare time.¹⁷

The formation of concepts is essential to the learning of chemistry. The relationship between major concepts and supporting minor concepts should be established in the manner easily identifiable. And these should obviously be dealt with in the order they will be being taught.

Critical and creative thinking is subject to concept formation. These two events will be apparent either in the child's verbalization or in his actions or, sometimes, in both. One instance of creative behavior will be to help the child find out by experiments some facts essential to the solution of his problem.¹⁸ Or, to ask the learner to think about why water disappears if allowed to remain in open air for hours and to respond to this in a communicable form.

One instance of the aspect of critical behavior will

¹⁷Wilbur L. Beauchamp. Educational Objectives Listed in the Courses. Instruction in Science. U.S. Government Printing Press, 1932, pp. 11-12.

¹⁸Example: providing the child with a set of apparatus for the preparation of chlorine gas and telling him to arrange them in a proper order so it can be readily available for use. (It will be made sure that he has never experienced this kind of situation before.) This is an example of psychomotor phenomenon conveniently belnded with creativity.

be to develop in the child resourcefulness in the attack upon problems, and to ask him to react to a certain problem in relation to the contrary views on that given issue (for example, conflict in peers' views).

Zirbus writes:

Creative seeing is necessary -- perceptively clear, critical awareness, which deals with images and conceptions insightfully and dynamically. To aid and encourage creative self-perception and self transformation, requires a non-threatening approach -- an approach which is not antagonistic or coercive. It also requires exceedingly creative empathy and rapport.¹⁹

Atkinson sets forth variable length modules with reference to operationally defined learning goals and critical path organization of curricula. The six steps in the construction of such a module are as follows:

One: Enabling objectives: Knowledge and skills necessary; additional knowledge and skills and attitudes helpful and desirable. Things the learner is presently able to accomplish or call.

¹⁹Laura Zirbes. *Spurs to Creative Teaching*. Putnam, 1959, p. 47.

- Two: Terminal objectives: Differences in knowledge, skills, and attitudes to be brought about. Learning that is to take place during the learner's work; their focus being on learner.
- Three: Criteria: Demonstration of achievement of the differences. The learning achievement must be communicable -- and communicated -- by the learner.
- Four: Evaluation tests: Determination of evaluative measures. Comparisons with the objectives.
- Five: Relationship of the content on hand with higher levels of learning. $\cdot\ddot{X}\cdot$
Strengthening of affective and cognitive domains.
- Six: Instructional modes: Appropriate activities. For example, private reading, laboratory work, seminars, lectures, group

$\cdot\ddot{X}\cdot$ Of value is to judge the quality of the learned experiences in a particular area -- the structure of an atom, for example -- in order that the degree of facility in learning with reference to the child's higher classes -- say, those at the college level -- may be determined.

projects, etc.²⁰

²⁰George F. Atkinson. Network Analysis and Explicit Objectives. Journal of Chemical Education, 51(5), May 1974, p. 324.

Along with the objectives, the conditions under which the learning is to take place will be specified.

Example: The electrolysis of water.

1. The learner will prepare himself for a test on electrolysis of water as dealt with in his textbook.
2. There will be four sessions, each session consisting of a lecture followed by group discussions.
3. The learner may, if he chooses, do some outside reading on electrolysis. In such case, he will be required to submit to the teacher salient features of his reading, which shall include only things which add to his textbook knowledge.
4. There will be a one-hour written test, all test items being objective type.
5. At least seventy-five per cent of the test must be accomplished correctly for a learner to pass the test.
6. Twenty per cent of the test will be comprised of outside reading, wherever appropriate.

Atkinson suggests -- rather recommends -- a network diagram for the course units, for he maintains that such a diagram will be able to clarify for the learner the patterns of prerequisites and the place of each course in the program, and that it simplifies decisions on course and topic objectives and on time allocations to topics in the course. pp. 325-326.

The learner's involvement in the process of determining objectives is of paramount importance. Following an inspiring activity related to the unit and a brief interesting lecture as to its significance or meaning, the learner may be exposed to possible objectives already set by the teacher. He may be allowed to react to these and state some of his own. Both the learner and the teacher may then modify the objectives. The objectives having been determined in terms of behavioral change, the learner may be exposed to pertinent activities previously identified. Addition may take place to the already-existing ones as a result of interaction from the learner's side. The activities having been finalized, the learner may be assigned the role he is supposed to play in the potential activities.

Actually, these are the conditions for true learning. It is obvious that the inspiring activity suggested above is in truth a drive or motive which makes the child want or wish something. The brief, interesting lecture does work as a cue or stimulus which makes the child notice something. Response soon turns up in the form of action and as the child directs himself successfully -- and successively -- towards destination, reward is introduced. Encouragement via praise is the warmth of this sort of reward. It "keeps" the activity -- the child -- going.

Here is a seven-step formula which Alvir has suggested for the improvement of objectives:

- One: Start: Writing a simple behavior objective.
- Two: Visualize: Editing the verb so as to make it an action verb. Examples: analyse, calculate, classify, construct, describe, draw, outline, predict, synthesize. Such activity-oriented verbs cause the child to think particularly about a special point.
- Three: Aim: Revising the objective to make it child-centered.
- Four: Specify: Removing ambiguities to attain operation clarity.
- Five: Measure: Chopping up the criteria into degrees of excellence.
- Six: Evaluate: Pinpointing the conditions under which the child will perform. To be removed are all unnecessary things.
- Seven: Experiment: Asking a total stranger for his opinion of the above-mentioned objectives.²¹

Indeed, indispensable is the developing of system,

²¹Clair Gelinas Alvir. Seven Steps You Can Take to Improve Your Objectives. Francophone International Learning Module Systems. February 15, 1974.

order, and neatness to the end that they shall function in the ordinary affairs of academic life. Noteworthy would be the fact that an amplified system, order and neatness will let the learner demonstrate that he has learned by actions, conditions, and criteria.

The main purpose of the laboratory teaching is to create in the child the sense of responsibility for investigating and reporting. Two, it is meant to develop trained men with real scientific attitude. Three, periodic laboratory assignments will familiarize the child with the assembling and manipulating of devices and the most common chemicals.

Among those described by Frank are three points worth mentioning here:

1. The habit of reading directions carefully and accurately
2. The habit of recording results when the work is done
3. The habit of cleaning glassware and other apparatus and keeping them clean
4. The habit of punctuality in attendance and in preparation of work in class and laboratory.²²

²²J. O. Frank. Teaching First-Year Chemistry, 1921. (More details unavailable.)

The laboratory work involves all the three essential domains: affective, cognitive, and psychomotor.

Examples:

1. Psychomotor: lighting (a burner); bending (a glass tubing); setting up (an apparatus for preparation of chlorine)
2. Cognitive: naming (common salt in chemical terms); demonstrating (the experiment of chlorine -- also a psychomotor phenomenon); applying (a rule)
3. Affective: In the sphere of values and attitudes -- selecting (voluntarily); seeking, persisting, obeying, attempting, rejecting, proposing, recommending.

Intelligent directions and adequate tests will test the degree of improvement in all such habits.

A behavioral objective must be clear and concise; simply stated, brief and relevant. The form must be consistent, objectives parallel in construction with other objectives in the statement. The limits must be specified, the component meanings readily derived from the main objective. The objective must be important and pay off in the days ahead. It must "deal with a single learning outcome (no 'and')." ²³

²³Victor W. Doherty and Walter E. Hathaway. Designing Behavioral Goals, K-12, Oregon ASCD Curriculum Bulletin No. 320, Vol. 27, December 1973, p. 14.

It must be flexible.

With these characteristics, the behavioral objectives can well be used for

1. materials selection, development, and modification;
2. effective grouping of students on common objectives and design of pupil-directed group activities;
3. motivation of students through the provision of directionality and relevance; and
4. establishment of criterion measures and pupil-progress indicators.²⁴

All this takes time. The insights and attitudes can not be internalized or transformed hurriedly. The new self-image and aspiration is achievable only when the entire process is facilitated.

²⁴Lanny E. Morreau. "The Structural Analysis and Classification of Objectives", Educational Technology, 14, March 1974, p. 48.

TWO: THE APPLICATION OF
THE BEHAVIORAL
OUTCOMES APPROACH

PROBLEMS:

A Critical Review in
Prospect of Constructive
Approaches

To identify problems, faced by the children of chemistry, prior to inception of systematic teaching, is extremely important. For it is in this view the objectives are defined, syllabus is arranged, methods are proposed, and correct understanding of the child is gained.

Swartney points out the following difficulties the children of beginning chemistry experience:

1. Lack of comprehension of pre-requisite science knowledge
2. Deficiencies in mathematical abilities
3. Inadequate vocabulary -- technical and general
4. Inability to visualize theoretical models utilized in explaining chemical phenomenon
5. Inadequate ability to select facts

critical to the solution of the problem.²⁵

The problem of low interest perhaps stems from a general dislike for mathematics and quantitative thinking. Secondly, the curricula does not fairly emphasize the value of chemistry learning. Thirdly, decrease in stimulus teaching obviously cannot promote scientific thinking in children. Four, insufficient stimulus in lower grades makes the arousal of interest difficult in the later stages. Five, poor study habits and ill preparedness are great obstacles to the learning of the subject. In the sixth place, foreign language of chemistry with strange substances and equations has little attraction for the learners. Other problems include non-availability of sufficient time for the teacher to work on instructional materials, non-availability of in-service or seminar-type workshops, inadequate background of the teacher, lack of proper use of diagnosis and continuous evaluation to measure the child's progress, non-existence of laboratory period, and irregular attendance of the child.

The everyday life is so rich in scientific phenomena that even a young school-going child can hardly stay away from these experiences. His entire physical body is profoundly involved in such events. Even a pre-school child

²⁵Swartney, op. cit., p. 6.

perceives these happenings to the extent of reacting to them fairly apprehensively. Right from the beginning if the child is instilled, by and by, these realities, he will keep getting infused with what is inevitable. The foremost thing that needs to be implemented, then, is change -- change in the basic curriculum, goals, and methods of instruction, in order that a "more complete" individual may be "created". A more complete individual is, in fact, an "outside" agent who is able to attack the problem in the first instant -- perceive it and solve it; create things at best.

A very simple example is common salt. A five-year old child knows what it is, or, at least, what it is for; but he does not understand it. Considering that a child is in grade one at age six, this common salt may be introduced to him, as he grows on and on, with increasing levels of difficulty -- from simple to complex. ✧

The behavioral objectives set upon the child greater responsibility for his own learning. In his learning, a greater degree of proficiency is anticipated as well. In the situation of chemistry teaching, it is more true, particularly for the reason that not many children are well grounded in the subject background. Not only in the subject but also in other areas of dealing with problems

✧ An illustration is given in Appendix B.

and using skills to make literary search are they deficient. For instance, if the child is introduced the formula of sodium chloride at grade nine, in the absence of a previous knowledge as to what a symbol is (referring to Na and Cl), and what the common salt is, he might encounter great difficulty in grasping the content. That would certainly be an undesirable weight on his part. How can, then, he turn proficient in his area of learning, especially when the concepts -- with reference to sodium chloride, (Na, Cl) for instance -- are so hard to form? This, however, never means to say that behavioral objectives impose unnecessary burdens of responsibility and undue requirement of proficiency upon the learner's mind. What is meant here is that preparation for these tasks should begin well in advance at the appropriate grade level. Again, it would be worth noting that complexities are to be avoided in the first stages. Let the introduction of scientific phenomenon begin with commoner, simpler things without the learner's mind being taxed unjustifiably. This will ease the thing. The thing that is to be imparted in the days ahead will thus get facilitated in being received by the child.

The involvement of the learner in matters of making choices as to what, how, and where they will learn is indispensable in an instructional structure. The "what"

constitutes the objectives -- goals, that means -- to be defined in behavioral terms, and the content. The "how" stands for the methods, ways and means by which learning will take place. The "where" designates the place -- the classroom or the laboratory, for instance.

In Denton's words:

Let students be allowed to choose their own objectives from alternatives, creating a sense of purpose and personal commitment.²⁶

Obvious as it is, to aim at this is not an easy task. That is to say, to get the desired, aimed-at consequences both the learner as well as the teacher -- and several others -- have to go through "toiling and moiling". Time, effort, and a variety of materials are involved in this one process.

Let the child's learning be guided in terms of infusing him the correct use of behavioral objectives. For example, if the objective reads "to make the child able to read, more intelligently and with greater interest, articles on chemistry in magazines and in scientific books of a popular character"²⁷ the following measures may be taken so as to

²⁶Jon J. Denton. "Student and Teacher Cooperatively Selected Behavioral Objectives," Audio-Visual Instruction, 19, May 1974, p. 12.

²⁷Guy Montrose Whipple (ed.). A Program for Teaching. The Thirty-First Yearbook of the National Society for the Study of Education, Part I. The University of Chicago Press, 1947, p. 257. It is here assumed that this objective is the result of the joint effort of the teacher and the learner.

make sure the child well understands every bit of it:

1. Have the child read and reread the objective.
2. Have him interpret it in his own way
 - (a) have him elaborate certain key words²⁸ in the objectives
 - i) "More intelligently" -- requiring him to interpret literature
 - ii) "Greater interest" -- requiring him to suggest any activities for himself in relation to the particular reading
 - iii) "Articles" -- on solubility, for example
 - iv) "Magazines and scientific books" -- Journal of Chemical Education, for instance
 - (b) have him describe what is expected of him. Let the word "able" be elaborated in terms of the extent, conditions, and methods
3. Have him describe and express any problems or difficulties he might be anticipating during

²⁸"Key words" here refers to certain terms in the statement which point to the desired behavior stressed, instruments to be used, etc.

the course process²⁹

4. Correct any misunderstandings, misinterpretations, doubts and views.

The learning difficulties that arise from time to time must be corrected instantly and before proceeding further. The objectives, however, do not need to be changed simply on the ground of the child's inability to cope with the problem. A little extra time becomes unavoidable in the event of the occurrence of extra-ordinary difficulties, which mainly reflect the learner's slowness in that particular area. In such a case, the teacher may move forward as a counsellor, make special arrangement for the learner for the time lost, and, if necessary, change the evaluative procedures without marring the effectiveness and the purpose.

As for the staff problem, a teacher with interest in all phases of science and a strong background in chemistry is preferable over others. He must be willing to adjust to a new situation and cooperate with colleagues and use some ingenuity in the program. He must have the ability to demonstrate leadership.

²⁹Some anticipated ones may include: access to materials, scope of interpretation, duration of course, testing procedures, etc.

Two final words in the range of problems: communication and flexibility. Let communication be made meaningful; let the internal and the non-observable be made "legible"; let clarity dominate objectives. Let flexibility flow in the "spirit" of behavioral objectives; let it -- with slight exaggeration -- domineer our goals.

TOOLS: Measures of effectiveness

It is extremely essential that operational definitions be explained early in the course. Of course, this explanation will not be direct. Rather, the child will define it as a result of what he perceives, sees or experiences. However, a systematic and more appropriate description of definition will then be established. In order to introduce chemical change, the child will be made to observe -- or think about -- a piece of wood burning. The child will see a gas -- carbon dioxide -- evolving during the reaction and a black substance -- coal -- left behind after the reaction is over. What happened to the piece of wood? What was evolving? What has remained (or been left behind)? Obviously, these three questions will be stressed. The child, in response to these questions, will be able to say that there was a piece of wood in the beginning, which, upon burning, gradually disappeared, giving off heat and a gas, and finally turned into coal. He will then be made to

observe the properties of the new substance in comparison to those of the original one. This involves four aspects of understanding concerning the child's visual or conceptual experience.

1. Disappearing of the substance initially present
2. Appearing of one or more new substances
3. Differences in the properties of the products as compared with those of the original substance
4. Release of energy in the form of heat during the change.

What has been learned by the child as a result of this experience will be evaluated by making him interpret the total process in his own words, "change" being emphasized throughout. Finally, in question to "what happens in chemical change?" the simple answer -- elicited from the child -- will be: "initial materials (or reactants) will be replaced by a new set of materials (or products)"; which is the precise reflection of what the pupil in actuality has seen or experienced.

This, in addition, strengthens the concept of concepts in the child. This entire process provides him with the expanding levels of thinking as the reaction proceeds. The next most important tool, therefore, is the development of concepts in him in the manner which excites his reasoning

faculty. According to Pella,³⁰ concepts are useful to the individual in gaining some grasp of a much larger field of knowledge than he has personally experienced.

Describing the significance of concepts, Voelker writes:

concept formation in the scientific enterprise is a system of organizing knowledge (imposing order) based on observation and experiment. It provides for economy of effort; it provides for freedom of thought and eventually frees us from concrete experiences.³¹

He says that theories in science are concepts. As a matter of fact, it is the mind that creates theories, their first origin being in encountered experiences. Efficient teaching, consequently, becomes possible from the psychological point of view. One need of the child is to belong and identify, which can be met through concepts. To let him know that the original term for iron is "ferrum", that it has been derived from Latin, that it means iron, and that it is represented by the symbol Fe, is the first-level experience in the sense that it is the initial stage in concept formation. Again, to show that valency is used to describe the combining capacity of an element and that this is therefore important in making a chemical formula, is an

³⁰The bibliographical details are presently inaccessible to the writer of this paper.

³¹Voelker, op. cit., p. 2.

attempt to form a concept in his mind at a less easier -- that is, a higher -- level. Furthermore, at a higher level will be the concept of introducing the formula of iron -- ferrous -- sulphide (FeS), where the ratio of combination is 1:1. At a still higher level will be the concept of ferric sulphide (Fe_2S_3) -- in which case FeS will as well be called ferrous sulphide. At this stage, it will be introduced that iron has two different terms in terms of its valency: Ferrous:1, Ferric:2. All this will be introduced through "whats", "whys", and "hows".

Levels of Concept Formation

Grades	12 -		
	11 -		$\text{Fe}_2\text{S}_3 \rightarrow 2:3$; Ferrous \rightarrow Ferric
	10 -		$\text{FeS} \rightarrow 1:1 \rightarrow$ Sulphur, Sulphide
	9 -		Valency \rightarrow Chemical formula
	8 -		Iron \rightarrow ferrum \rightarrow Latin \rightarrow iron \rightarrow Fe

It is manifest that the power of concept is gradually being increased with the increasing level of the child's mental development. In Piaget's words, learning occurs only when the mind has developed to the proper level of assimilation.

The introduction of terminology will be gradual that it might be followed with understanding. It should be seen that it is repeatedly used in questions asked both by the teacher and the pupil. Besides, this can be done in many other ways: by writing each technical term on the blackboard

of the class and the laboratory; by talking with the child about it; by getting him to write several times in his notebook; by using -- and asking about -- them in quizzes.

Another effective tool is the assignment. This, for example, may be done in two ways: by giving the child a set of questions relating to the next-day topic; by assigning him the reading of a chemistry magazine containing information on any recent developments.

After demonstration, giving the child an opportunity to hear an enthusiastic lecture, highlighted by pertinent illustrations will, to him, be a sort of review. Too, such a lecture by the teacher will be an insight into his vast cognitive world.

The child will be made to be critical concerning his peers' views and give better suggestions in terms of what he considers to be better. Also, he will be allowed to defend himself by means of sound arguments.

So as to motivate interest in the child, wide reading of biographical material will be encouraged. Such aspects as what motivated the person to become a scientist, what developmentary stages he had to pass through and what contribution he has made in the field of chemistry may affect his pattern of perceiving, knowing, and acting. The teacher's responsibility will be to deal with this phase with great care, so that his interest can not be marred with any

negative feeling at any stage and so that he can see only the facts which are simple but full of adventure.

Independent study program is meant for letting the child enjoy the freedom to plan and direct his own activities for learning. This is, of course, within a framework set partly by the teacher. Moreover, the child will be free to exploit his own particular talents and interests in an area beyond the basic requirement of the course. Accomplishment of new things with new styles will be emphasized throughout. This may not be in great depth (at this stage) in a particular situation. But this should aim to prepare him thoroughly for the work in advanced years of high school and college. The teacher will have to supervise his work and schedule tests from time to time to keep him active and alert during the course. Such tests will specially test creativity "exerted" by him.

Reference materials are to be recommended for three important reasons: one, rapid developments in chemistry; two, differences in interest among learners; three, variety in materials, views, practices. Up-to-date literature should be made accessible. Of value to teachers are research reports on abreast-of-the-times developments and methods of teaching in chemistry.

The basic purpose of audio-visual materials rotates around four principles. Motivation, stimulus, participation, reinforcement. The coincidence of these supplemental materials with the content of classroom teaching and laboratory work will provide the maximum learning potential.

Sometimes, theoretical or practical topics are common in more than one science. In such a case, consideration should be given to the relationships between chemistry and that particular branch of science. Example:

Chemistry: Geology :: NaCl : NaCl

In chemical terms, sodium chloride is a salt, a compound, or a chemical. The same sodium chloride, in geological terms, brings forth the conception of minerology and mining. A behavioral objective here might read: To compare the relationship between geology and chemistry using three simple examples; or, more specifically, for instance, to describe sodium chloride in terms of a chemical compound and in terms of a mineral.

Local chemistry teachers selected from various grade levels may be made to work together as a committee. One project they can work on could be defining behavioral objectives for different topics.

The child may be given a simple experiment to be done in the laboratory some time before the next laboratory period. An eighth-grade child, for example, may be asked

to see what happens when a copper wire is allowed to react with dilute as well as concentrated hydrochloric acid, sulphuric acid, and nitric acid respectively. He may first be required to read the textbook and related material to be able to identify all products. He may, furthermore, be directed to set questions about the things not clear to him. This is the experience of learning by doing.

Demonstration-followed-by-questions method will be still another effective tool. After each step of demonstration the teacher will ask questions as to what did happen. Soon after, the "how" and then "why" will appeal to his reasoning power. The child will take down the questions, put to him, answers to which he will write down later in his own words. The laboratory-centered approach can here be successfully intertwined with the Behavioral Outcomes Approach from which the slower pupil will profit much.

Weaver makes suggestions as to when a demonstration can be made. He writes:

1. When your class needs a change of pace
2. When a concept needs illustration
3. To avoid excessive verbalization

4. When you have something to show.³²

He also suggests dramatization during demonstration. A good, successful demonstration will be facilitated by use of large equipment and improvement of visibility.

Field trips to industrial and research laboratories open the doors to the world of action. "What can be the purpose of an industrial or research laboratory?" may be asked of the child. Let him discover himself what types of activities go on in these laboratories and what equipment is being used and in what manner. Such question as

1. What can that yellow solution in that test-tube be? (make him recall everything he knows relating to this.)
2. Why does this gentleman seem to be so careful in pipetting the solution? (make him see -- or know -- the significance of accuracy.)
3. That large bottle contains distilled water as its label tells. What kind of water is it?

This will indirectly let him acquire a great deal of knowledge along with the acquisition of useful skills in the learning of chemistry. That is to say, ability to think, reason, and create will be reinforced.

³²Elbert C. Weaver. "Demonstration in Teaching". Science Teacher, Vol. 31, February 1964, p. 34.

Whenever possible, open-ended and research-type laboratory experiments may be allowed. Open-ended experiments possess these distinct features: the child is unaware of results before starting the experiment; he is left to himself -- viz., to his own skills -- to predict and then to verify or disprove it. The specific objectives may focus on such aspect as principles of chemistry and their application, for example, to industry, agriculture and everyday living.

Sufficient time will be allowed to teach leisurely.

Suitable testing procedures will be used in order to assess what the child has gained and what changes his learning has brought about and to what extent the teaching material has been useful.

Let the teacher's classroom behavior be less authoritarian. "A successful teacher," write Sutton and Lippincott, "requires experience, enthusiasm, knowledge, constant hard work, and deep affection for young people."³³ He will bring to the class interesting things to inspire them to turn into live "paragons" of behavioral objectives.

³³Richard M. Sutton and William T. Lippincott. "College Teachers Look at High School Science. Science Teacher, 23, May 1956, p. 184.

TECHNIQUES:

Steps to Reinforcement

As mentioned earlier, exploration as to what basis the child has in terms of the knowledge of the subject being introduced and the child's capacity to absorb and understand will be the starting point. Questions, discussions, and written examinations on creative aspects are the most powerful means to determine this phenomenon.

Presentation of the subject material in the manner which arouses interest will appeal to his productivity. The things to be introduced will be thought-provoking.

Example: I asked my eight-year-old daughter to clean the thermometer. As soon as she put the thermometer in a tray of hot water in an attempt to wash it, the thermometer was instantly broken. Why?

Assimilation will enable the child to acquire understanding the unit has provided; which is possible by assigning reading and home study, by supervising the activity and experimentation, and by creating opportunities for educational visits.

Organization -- an arrangement of the products of learning -- will systematize teaching-learning activities.

Xan writes:

The teacher must enter the laboratory as eager and open-minded as the humblest student.³⁴

In truth, only then can a fair, responsive environment be established.

By allowing the children to make up their own problems and experiments and dividing them into small groups with a leader and then rotating the leader often, a great deal of creativity can be developed.

In order that new styles and patterns may be established, it would be wise for the teacher to circulate projects and experiments from group to group. Many a new idea will thus emerge from this process.

Prizes for the best ideas, styles, experiments will keep the activity ever alive, ever creative. Individual differences should be taken into account, so that the fast and the slow learners can achieve relative to their potential.

An eye should be kept on each and every activity of the child and a record of his behavior in terms of achievements of desirable goals and objectives and habits maintained.

Let every effort be made to keep the child working to his maximum capacity.

³⁴John Xan. "Laboratory Teaching", Journal of Chemical Education, Vol. 31, October 1954, p. 519.

THREE: EVALUATION

One significant phase of the Behavioral Outcomes Approach is evaluation: seeing how much gain has been made by the child as a result of the teaching. Good, in his Dictionary of Education, defines evaluation as "consideration of evidence in the light of value standards and in terms of the particular situation and the goals which the group or individual is striving to attain."³⁵ Evaluation measures effectiveness -- effectiveness of a teaching method or a set of instructional materials. It helps predict future goals and to determine the role of the learner in the days ahead. The chief objective of continuous evaluation will be to arrange and rearrange learning experiences in accordance with the needs and requirements identified. This is called evaluation as a feedback device -- part of the mechanism for learning. Involved is the recording of steps of progress toward the goals. This is called evaluation as an administrative device. The determination of the child's behavior as to the formation of concepts in relation to the material

³⁵ Robert B. Hawsam. "Teacher Evaluation", National Elementary Principal, Vol. 43, November 1963, p. 6.

instilled is all evaluation is concerned about. This is precisely in coincidence with the theory that chemistry concepts are basic to learning. What is accomplished, first and foremost, is to obtain exercises that sample adequately the several patterns of behavior students are being helped to learn. Prior to this, however, a profile will be set which will indicate necessary steps to be taken. The following is one way such a profile can be set:

- Defining what is to be evaluated in terms of behavior
- Establishing a standard
- Selecting appropriate situations in which to observe performance
- Preparing measuring devices
- Exploring possible techniques
- Getting a record
- Summarizing the evidence.

The tests will measure the objectives. The results will be manifest in the learner's behavior. Knowledge, comprehension, application, analysis, and synthesis will be what the tests chiefly focus upon. The aspect of knowledge deals with recall or recognition of the material taught. Comprehension aims at finding out the level of understanding without relating to other materials and full implications. Interpretation of the given phenomenon is assessed as well.

Application items will provide for concrete situations as well as abstractions including general ideas, methods, and procedures. Analytical questions require making relationships and recognizing organizational principles. Questions based on synthetic processes require that abstract relationships or a set of operations be put together. The essential need, however, is that both qualitative as well as quantitative assessments relating to methodology be made. Psychomotor and affective domains will be given due consideration.

Short-answer questions have their own value. Thought questions may be framed in the form of essay questions. They are effective measures when the child is asked to compare and contrast or to react to a certain phenomenon or to express opinion. Essay questions involve applications of general principles to situations or problems novel to the child. As well, they are helpful in interpretation of data new to him. Hoffmann and Kolb express their thoughts about essay questions, writing:

It is desirable to have other teachers of the subject evaluate the exercises with respect to fairness, freedom from ambiguities, and the elimination of the two obviously incorrect answers. Also, (it is desirable) to have other teachers attempt to key the exercises.³⁶

³⁶Richard L. Hoffmann and Doris K. Kolb. "An Approach to Teaching Physical Science", Journal of Chemical Education, Vol. 47, May 1970, p. 383.

Other types include true-false, multiple choice, matching, completion, and story problem. Still another set of forms could be oral examination, role playing, exhibiting behavior of a certain kind, making something, etc.

Evaluation should take into account every activity undertaken during the program of a course. These may include tests, themes, reports, discussions, boardwork, projects, laboratory, homework, and guided self-activity.

Bowley recommends the following rules:

1. Avoid ambiguous or vague phraseology
2. See that real knowledge is being tested and not superficial tidbits (tidbits)
3. The questions should all be capable of being answered if the work has been learnt properly
4. Avoid the complications of half marks
5. Read out the correct answers to the class
6. Repeat the good questions, answered badly, in the second test to emphasize its importance.³⁷

³⁷R. L. Bowley. Teachers without Tears. Philosophical Library, 1961.

Two more tips, as Callahan sets forth:

1. a) Avoid an overriding preference for either subjective tests or objective tests
 - b) Avoid consistent use of a specific type of test if it is strongly disliked by a majority of students
 - c) Recognize the strengths and weaknesses of each type of test
 - d) Review each test with class members after it has been corrected
 - e) Prepare an examination that tests unit content and serves as an effective summary
 - f) Include difficult as well as easy test items to accommodate differing achievement levels
2. a) Inculcate specific as well as general observations among evaluation procedures
 - b) Observe the undirected and out-of-class behavior as an indication of subject-matter acquisition and retention

- c) Make use of individual conferences with students as a part of the evaluation procedure.³⁸

Appraisal, with all these elements within, will touch the depths and widths of the child's mind and consequently discover or reveal "new" facts about the ever-continuing process of teaching and learning, of change and improvement.

³⁸ Sterling G. Callahan. Successful Teaching in Secondary Schools. Scott, Foresman & Co., 1966, p. 127.

ACCOUNTABILITY

V/S

BEHAVIORAL OBJECTIVES

There are many an issue on accountability ❖ which is now being put to practice. The individual -- that means, a member of the community, a citizen -- that pays taxes may ask for evidence of the effectiveness of the work of educators. An administrator may ask a teacher this same question. The question that now follows and which bears utmost significance, specially on the teacher's part, is: What are the means by which effectiveness can be measured? The Behavioral Outcomes Approach might be one answer. In this approach, the outcomes of learning are observable in

❖ John W. Porter's (Leau M. Lessinger and Ralph W. Tyler (eds.). *Accountability in Education*. Charles A. Jones Publishing Co., 1971, p. 42) definition of accountability is:

The guarantee that all students without respect to race, income, or social class will acquire the minimum school skills necessary to take full advantage of the choices that accrue upon successful completion of public schooling, or we in education will describe the reasons why.

the form of the child's molded behavior. For three solid reasons, this approach is reliable: one, it pays for results rather than promises; two, it identifies each child's characteristics and entrance level to begin with; three, it specifies in advance desired outcomes of the individual child's performance.

Accountability carries one strong merit: it informs the parent/taxpayer why the child's psychomotor domain (for instance) in the learning of chemistry is so weak in a particular school. Because of lack of funds for the chemistry laboratory? The parent -- the taxpayer -- does understand also why the child is so deficient in the affective domain. The taxpayer, if he is really sincere, concerned, interested -- and really cares for the taxes he pays -- will feel pressed and be forced to think about his own right to question the deficiency in the school budget!

Accountability is here to stay!

Who does not realize money is vital to learning?

INTRODUCTION OF THE
CONCEPT OF COMMON SALT
TO THE CHILD -- WITH
INCREASING LEVELS OF DIFFICULTY
(FROM SIMPLE TO COMPLEX):

An Illustration

Grade One:

What do you call this? (Salt) What color is it?
What do you do with it (what do you use it for)?
How does it affect the taste? (enhances)

Grade Two:

What does it taste like? What difference does it
make if you use too much of it? In what form is it?
What happens if you put it in water? What happens if
you put a solid piece of it in water? What is the
difference between these two experiences? (The child
will be made to experiment this by himself.) Here, at
this stage, he may be encouraged to ask questions.

Grade Three:

Where does salt come from? What U.S. states are
rich in salt? What are the other sources of salt?
(Sea water, for example)

❖ See page 40.

Grade Four:

In what amount is salt found in sea water?

(Introducing of the waters of The Dead Sea and the Great Salt Lake: 23%) In what form is salt found in nature? How is salt obtained from the earth? (By mining or by forcing water down into the deposits and pumping to the surface)

Grade Five:

What is chemistry? What is the chemical nature of this common salt? What condition is it in as we get it direct from earth? (Pure, impure)

What impurities is it composed of? How is sodium chloride purified? (The simplest procedure: by dissolving it in water)

Grade Six:

What is a mineral? Why is sodium chloride called a mineral? What is a crystal? What are some other minerals? Why does water gradually disappear if allowed to remain in open air for hours? (Introducing the phenomenon of evaporation for future use with regard to sodium chloride) What is this process known as?

Grade Seven:

How is sodium chloride purified? (Advanced knowledge: by dissolving it in water, concentrating the solution by evaporation -- often under reduced pressure -- and allowing the crystals to form again)

Grade Eight:

How are the impurities separated from the original salt -- sodium chloride? How are the less soluble impurities separated from the salt? (Introducing the process of counter-current washing) What is a symbol?

Grade Nine:

What is a formula? What is the formula for sodium chloride? (Valency has not been introduced yet, therefore complex formulae like Na_2S (Sodium Sulphide) will be avoided or postponed until an appropriate time. Also, questions like "What does it mean?" will be avoided.) How is sodium chloride prepared in the laboratory? (The child will be put to actual experience.)

Actually, each question above may also serve as a final test item which tests the student's performance behavior.

The right answer to each question is at the same time a behavioral objective in itself.

AN ILLUSTRATION OF
TEST ITEMS IN RELATION
TO STUDENT ACHIEVEMENT

CLASSROOM: Sample for Grade Ten

Knowledge:

1. What is the valency of potassium? Of sulphate?
What is, then, the formula of potassium sulphate?
2. The difference between stannous sulphide and
stannic sulphide is that . . .

Comprehension:

1. A blue litmus paper was dipped into a solution
contained in a test-tube. The litmus paper turned
red. What did that mean?
2. A small amount of potassium chlorate and
manganese dioxide was heated in a test-tube.
Reaction took place. At the end of the reaction,
the total amount of manganese dioxide remained
unchanged. The reason was that . . .

Application:

1. You are given hydrochloric acid and sodium
hydroxide in separate test-tubes. You are

asked to find out which is which. What method will you adopt?

2. A few drops of concentrated nitric acid have come in touch with your fingers. There is no ready help available and you are not in a position to leave the experimental table. In such a case, the first thing you should do would be . . .

Analysis:

1. How can water be separated into its component parts? (Answer in not more than three sentences.)
2. The ratio of the quantity of hydrogen and oxygen in water can be found out by . . .

Synthesis:

1. $\text{Na}_2\text{O} + \text{H}_2\text{O} \rightarrow 2 \text{NaOH}$
Describe the equation in words.
2. Sodium bisulphate can be prepared in the laboratory by . . .

LABORATORY: Sample for Grade Seven

Knowledge:

1. Which of the given apparatus is used in the preparation of ammonia?

2. The acid contained in the test tube is . . .
(To be identified by its physical properties)

Comprehension:

1. Correct the mistake, if any, in the arrangement of these apparatus.
2. Although the reaction is taking place in the flask, the gas is not collecting in the jar, because . . .

Application:

Given are manganese dioxide and potassium chlorate. Mix them in the test tube for the purpose of preparing oxygen. (The quantity of each taken will be examined, as the ratio should be 1:4.)

Analysis:

Disconnect and separate the set apparatus from one another. (The style and neatness will be examined.)

Synthesis:

Arrange the given apparatus for the preparation of nitrogen.

All these aspects will manifest

1. The extent the child is able to recall, select, and evaluate relevant facts
2. The way he organizes his facts and applies them to the situation
3. His critical judgment
4. The values and attitudes acquired
5. The skills developed in problem solving.

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