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ED 013 221 SE 002 925

THE ART OF QUESTIONING IN SCIENCE, SUMMARY AND IMPLICATIONS.

LOS ANGELES CITY SCHOOLS, CALIFORNIA
REPORT NUMBER LACS-IB-EC-131 PUB DATE 67
EDRS PRICE MF-$0.25 HC-$1.36 34P.

DESCRIPTORS- *ELEMENTARY SCHOOL SCIENCE, *QUESTIONING TECHNIQUES, *TEACHING TECHNIQUES, INSTRUCTION, PROBLEM SOLVING, TEACHING GUIDES, LOS ANGELES CITY SCHOOLS, LOS ANGELES, CALIFORNIA, BLOOMS TAXONOMY OF EDUCATIONAL OBJECTIVES,

THE EFFECTIVE USE OF QUESTIONING IN THE TEACHING OF ELEMENTARY SCHOOL SCIENCE IS DISCUSSED IN THIS BULLETIN. SAMPLE QUESTIONS ARE USED TO ILLUSTRATE (1) WAYS IN WHICH KEY WORDS AFFECT PUPIL INVESTIGATIONS AND (2) PATTERNS OF QUESTIONING THAT RESULT IN STUDENT DECISION-MAKING AND PUPIL-DIRECTED PROCEDURES. A BRIEF REVIEW OF THE COGNITIVE AND AFFECTIVE DOMAINS INCLUDED IN THE "TAXONOMY OF EDUCATIONAL OBJECTIVES" IS USED TO INTRODUCE LEVELS OF LEARNING AND RELATED QUESTION TYPES. THE COGNITIVE DOMAIN INCLUDES KNOWLEDGE, COMPREHENSION, APPLICATION, ANALYSIS, SYNTHESIS, AND EVALUATION. THE AFFECTIVE DOMAIN INCLUDES RESPONDING TO STIMULI, VALUING, CONCEPTUALIZATION, ORGANIZATION, AND CHARACTERIZATION. THE RELATIONS BETWEEN THE DOMAINS ARE DISCUSSED AND THE RATIONALE FOR USING PARTICULAR QUESTIONS TO ILLUSTRATE SELECTED LEVELS IN THEM IS CONSIDERED. SUGGESTIONS FOR THE IMPROVEMENT OF STUDENTS' ABILITIES TO STRUCTURE AND ASK QUESTIONS, QUESTIONING GUIDELINES FOR TEACHERS, AND A BIBLIOGRAPHY ARE INCLUDED. THIS DOCUMENT IS ALSO AVAILABLE AS BULLETIN NO. EC-131 FROM THE LOS ANGELES CITY SCHOOLS, DIVISION OF INSTRUCTIONAL PLANNING AND SERVICES, CALIFORNIA. (AG)

For Workshop Use

THE ART OF QUESTIONING IN SCIENCE

Summary and Implications

LOS ANGELES CITY SCHOOLS
Division of Instructional Planning and Services
Instructional Planning Branch
Instructional Bulletin No. EC-131
1967

FOREWORD

This review of research on techniques of questioning in elementary school science has been developed to assist teachers, administrators, specialists, and supervisors. The following are emphasized: (1) how key words in teacher questioning affect pupil investigation, (2) effective phrasing of questions to provide opportunities for pupil discovery, (3) how teachers' questions provide opportunities for varying levels of learning, (4) the relationship of interests, attitudes, and values to questioning, (5) the place of pupil questioning in scientific inquiry, and (6) suggested teacher guidelines for questioning.

Grateful acknowledgment is expressed to the academic supervisors, the Science Center specialists, and the science and agriculture supervisor, who reviewed the manuscript.

Acknowledgment and appreciation are extended to JAMES PHILPOT for his assistance in the preparation of the manuscript.

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TO THE TEACHER

The elementary school science program builds on the pupil's natural curiosity and wonder about the world around him. Like the scientist, who continually searches for truth, the pupil wonders, questions, explores, and investigates in seeking explanations. Pupils want to know the what, why, and how of the world in which they live. This searching is part of the great enterprise of science. The teacher preserves, stimulates, extends, and gives depth to pupils' interests in science by providing numerous concrete learning activities through which they explore their environment.

Effective questioning is an important key to science exploration and learning. A central part of all learning activity, particularly of scientific inquiry, is the asking of questions by pupils and teachers to give purpose and direction to investigation. Teachers' encouragement and cultivation of the use of questioning are among the important objectives of science instruction. Pupils need to understand that a questioning attitude is encouraged, that their questions are important, and that questions often result in exciting exploration, discovery, and other types of learning. The teacher establishes this "learning climate" by arranging for situations which stimulate questions. His techniques of questioning serve as models for pupils as they develop and improve their own skills.

The dynamic nature of our present society requires that all pupils be provided with opportunities to question, to investigate, and to find answers, and then to question and seek further. To meet their needs, classroom instruction must instill in pupils the spirit of science--the spirit of intellectual inquiry.

FACTORS RELATING TO THE ART OF QUESTIONING

HOW DO KEY WORDS IN TEACHER QUESTIONING AFFECT PUPIL INVESTIGATION?

Questioning has many approaches and purposes. The use of timely, carefully selected questions in logical sequence and discriminate phrasing is vital to the achievement of the goals of science instruction. In this section, the teacher will find suggestions concerning the way in which identification of key words and choice of phrasing will contribute to pupil investigation.

According to Dr. Paul Blackwood, "There is no recipe for teaching science that will serve all teachers equally well. Yet surely there are elements of good science teaching that every teacher needs to consider as he assesses himself and develops his own best teaching patterns. One of these elements is through thoughtful questioning involving key words such as how, what, when, and why. Emphasis is placed on how to find answers rather than on getting immediate, direct answers to the question."[1] The following are examples of questions which vary in their effectiveness in stimulating investigation and speculation. The rationale for the procedure is provided in the right-hand column.

TEACHER QUESTIONS FOR INVESTIGATION (MAGNETISM AND PLANT GROWTH)	RATIONALE
Example A Teacher Question: How can we find out what magnets will pick up? Rather than: What will magnets pick up?	Note the differences in the types of teacher questions. Some can be answered with a yes or no response or by a few words placing a premium on the final answer. Other questions emphasize pursuing various methods to find answers. Learning how to investigate problems and find answers is an objective of high priority in science teaching. Through this questioning approach, the teacher builds into science lessons the opportunity for pupils to learn that science includes methods of finding answers as well as knowledge gained through investigation. It is agreed generally that pupils develop greater understanding when they have been engaged in carefully planned activities involving investigation.
Example B Teacher Question: How can we discover ways to strengthen an electromagnet? Rather than: What makes an electromagnet stronger?	
Example C Teacher Question: How can we find out if plants need water to grow? Rather than: Do plants need water to grow?	

[1] Paul E. Blackwood, "Elements of Good Science Teaching," Education Today, Bulletin No. 60 (Columbus, Ohio: Charles E. Merrill Books).

TEACHER QUESTIONS FOR SPECULATION (EARTH AND THE UNIVERSE)

In the process of speculating or making hypotheses, pupils draw on their knowledge and past experiences to arrive at the presently best answers. This discussion leads to further explanations. Class members are most likely to engage in imaginative and creative thinking when they know it is permissible to speculate. Teachers should encourage pupils to state their best guesses, to "go out on a limb" intellectually, to say "maybe," "perhaps," or "probably," and to express their ideas.

Example A

Teacher Question: What do you think causes rain?

Rather than: What causes rain?

Example B

Teacher Question: How do you imagine rocks are formed?

Rather than: How are rocks formed?

Example C

Teacher Question: How do you think a rocket works?

Rather than: How does a rocket work?

RATIONALE

The particular phrasing of a question by pupils or the teacher either opens up or closes the door to speculation. Notice how the first question listed under each example permits the pupil's response (speculation) to lead directly into further investigation. In this manner the importance of scientific inquiry is reflected as an outgrowth of the questioning procedure. Why would the second question identified under each example restrict pupils' opportunity to speculate?

The "why" approach to questioning should receive particular emphasis. Dr. Agnes Snyder states that "Teachers, like journalists, find much of their work centered around simple, one-syllabled words: Who? What? When? Where? How? Why?, and that teachers are continuously involved--and often simultaneously in all six; and it is their answer to the sixth, the why, that in a large measure determine the quality of answers to the other five. It is safe to assume that the Why behind the Who, What, When, Where, and How has been neglected." [2]

Teachers who limit their questions to who, what, when, where, limit the possible answers to person, fact, time or place. This approach, if used exclusively, tends to reinforce the kind of "learning" which fails to penetrate beyond the literal meaning and which depends mainly upon the rote memory processes. The focal point is the "why" of things. Science is fundamentally a means of understanding why things happen as they do. The dynamic involvement of the pupil investigator searching for answers to "why" provides the fuel for the vehicle of investigation.

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[2] Agnes Snyder, "Who? What? When? Where? How? Why?" Childhood Education, 40 (September, 1963), 5-10.

HOW CAN TEACHERS' PHRASING OF QUESTIONS PROVIDE OPPORTUNITIES FOR PUPIL DISCOVERY?

The extent to which pupils are involved directly in discovery may be determined by the nature of the teachers' questions. In this section, three examples of questions are presented. Teacher-pupil interaction and the degree of pupil involvement in scientific inquiry and the "excitement" of science also are illustrated. Because of the significance of this point of view, the following examples are adapted from the findings of Alphoretta S. Fish and T. Frank Saunders.[3] The pupil statements should be considered as examples of response.

EXAMPLE A: TEACHER QUESTIONS WHICH ENCOURAGE DECISION-MAKING BY PUPILS

The teacher intends that pupils "discover" (i.e., rediscover, or find out what others know) that like poles of magnets repel and unlike poles attract. Pupils are provided with bar magnets, several of which are suspended. The class is instructed as follows:

TEACHER-PUPIL INTERACTION	RATIONALE
Teacher: Boys and girls, bring your magnet with the end marked "N" toward the north pole of the suspended magnet. What happens?	Decisions regarding the conceptual scheme and procedures are made by the teacher and imposed upon the pupils.
Pupil: They push away.	
Teacher: Now, bring the south pole of your magnet toward the north pole of the suspended magnet. What happens?	Opportunity for pupils to predict results of experimentation or to formulate hypotheses is not provided for in the questioning procedures.
Pupil: They pull together.	Although pupils may generalize, the "by-products of discovery" is provided. They do not develop their own procedure leading to discovery. Pupils are not involved in divergent thinking and investigations. Instead, closure is evidenced.
Teacher: What have we learned from this experiment?	
Pupil: Like poles repel; unlike poles attract.	

EXAMPLE B: TEACHER QUESTIONS PROVIDE OPPORTUNITIES FOR PUPIL-DIRECTED PROCEDURES; INITIAL PUPIL INVESTIGATION SUGGESTS NEED FOR ALTERNATE METHODS

TEACHER-PUPIL INTERACTION	RATIONALE
Teacher: How can we find out how magnets interact (react) with each other?	The teacher provides an opportunity for pupils to decide upon the frame of reference from which the magnets will be examined. The pupils decide upon a strategy in which some questions (i.e., establishing an experimental situation, recording of data) are not discussed but remain to be investigated.
Pupil: We could experiment with magnets.	

[3]Alphoretta S. Fish and T. Frank Saunders, "Inquiry in the Elementary School Science Curriculum" School Science and Mathematics, LXVI (January, 1966), 13-22.

TEACHER-PUPIL INTERACTION	RATIONALE
Teacher: How will we gather our data? Pupil: We can observe carefully and keep accurate records.	Pupils employ their strategy and become actively involved in experimentation.
Pupils investigate how magnets interact with each other. They report that magnets interact by "pulling together" and by "pushing away."	
Teacher (holding a bar magnet in one hand): If I move this magnet toward the suspended magnet, will it be "attracted" or "pushed away"?	At this point, the teacher causes a "discontinuity" or confrontation to arise. This provides an opportunity for pupils to recognize that alternative conceptual schemes are possible (polarity of magnets; north pole-south pole relationships). The pupils, however, have neglected to designate the conditions under which magnets "attract" and "push away." It is at this point that the pupils begin to question the adequacy of the strategy selected, i.e., recognizes that alternative strategies are possible. Here, too, the pupil is most likely to be ready to speculate with regard to his initial investigation and to formulate alternative hypotheses and procedures.

EXAMPLE C: TEACHER AND PUPIL QUESTIONS PROVIDE OPPORTUNITIES FOR PUPIL DIRECTED PROCEDURES INVOLVING ALTERNATE METHODS

TEACHER-PUPIL INTERACTION	RATIONALE
Teacher: What is our problem? Pupil: We did not observe the specific conditions under which the magnets will "attract" and "repel." Teacher: Why? Pupil: Because, although we looked carefully, we did not observe the specific conditions under which the change occurred (north and south pole relationships).	This is the review phase of the lesson. Pupils are guided to recognize that alternate methods and conceptual schemes are possible.

TEACHER-PUPIL INTERACTION

Teacher: What does it mean when we say that we have a decision to make before investigating a question (problem)?

Pupil: It means that a question (problem) can be investigated in more than one way and that we have a choice of ways to answer it.

Teacher: How could we have decided upon the best choice to make? Remember that our original problem was: How can we determine how magnets interact with each other?

Pupil: We could have asked what you meant by the words "how magnets interact."

Teacher: What have you decided that I meant by those words?

Pupil: Under what conditions does a magnet "attract" another magnet and under what conditions does it "push away"?

Teacher: If we have two magnets (using actual magnets or chalkboard) [N S] [N S], what hypotheses could we suggest?

Pupil: There are several possible hypotheses:

N-N repel	N-N attract
S-S repel	S-S attract
N-S attract	N-S repel

Teacher: How will we know whether our hypotheses can be supported?

Pupil: After proving (testing) our hypotheses through investigation, we will be able to <u>describe or predict</u> what will happen when a magnet is brought near another magnet.

RATIONALE

This is the second phase of the lesson in which pupils are provided opportunity to state and work from other hypotheses.

Pupils recognize that, usually, there are many approaches to investigating a problem.

Here the pupils are guided to think critically about questions and to recognize their responsibility for raising questions.

Pupils gather data and formulate the interpretations which are reflected in their hypotheses.

In summary, the teacher and pupil techniques of questioning are key elements in determining the extent to which pupils are involved in inquiry. Dr. Fish and Saunders state, "It is desirable and profitable to expose pupils to the procedural aspect of 'scientific method' where inquiry behavior is the end to be attained. The assumption is that pupils become aware of the excitement of inquiry and refine and extend their inquiring behavior as they are guided to 'self-judge' and 'self-correct' their own inquiry strategies. Furthermore, pupils are moved forward on several fronts simultaneously: Skills basic to searching and critical thinking are developed, science concepts are extended and refined and an understanding of the structure of science is developed at the same time inquiry behavior is being expanded and reconstructed."

LEVELS OF QUESTIONING IN SCIENCE AND SUGGESTED TEACHER GUIDELINES

HOW CAN TEACHERS' QUESTIONS PROVIDE OPPORTUNITIES FOR VARYING LEVELS OF LEARNING?

In this section, types of questions in science which employ a wide range of thinking skills are identified, defined, and illustrated. The questions are categorized by levels and include both the structure and terminology employed by Benjamin S. Bloom in Taxonomy of Educational Objectives.[4] The taxonomy is one of several frameworks that have been developed as a result of a need to identify objectives at various levels of abstraction and to facilitate communication. David R. Krathwohl writes that "The taxonomy of educational objectives is basically a classification scheme just as the biological taxonomy is a classification scheme for animals into class, order, family, genus, and species. In the educational objectives taxonomy the kinds of behavior we seek to have students display as a result of the learning process are classified. The taxonomy is hierarchial in nature, that is each category is assumed to involve behavior more complex and abstract than the previous category. Thus, the categories are arranged from simple to complex and from concrete to abstract behavior."[5] Each level within the taxonomy therefore demands the skills and abilities which are lower in the classification order.

The levels of learning and questioning relationships are structured as a continuum. The levels within this continuum include: Level I - Knowledge; Level II - Comprehension; Level III - Application; Level IV - Analysis; Level V - Synthesis; and Level VI - Evaluation. Each level is defined and illustrated with specific questions that might be raised and discussed in the study of Matter and Energy (electrical and magnetic energy) and Living Things (growth and development of plants) at both the primary (K-2) and upper-grade (3-6) levels. The questions related to a given conceptual framework are stated in a variety of ways for comparison. The fine distinctions between the levels or the exact titles assigned to them are considered to be of minor importance. What is important is to develop questions that promote more productive thinking on the part of the pupil and which avoid placing an undue emphasis at any one level.

Level I: KNOWLEDGE (Questions that develop memory skills)

This level includes those behaviors which emphasize what a pupil remembers, either by recognition or recall, of ideas, materials, or phenomena. The level includes the recall of specific complex learnings, such as facts, terms, definitions, or formulas. It also may include the memorization of learnings which are quite complex as a complete plan or a set of criteria. This is a level which is basic to working at any other level but should not be considered an end in itself.

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[4]Benjamin S. Bloom, Taxonomy of Educational Objectives, Handbook I: Cognitive Domain (New York: Longmans, Green, 1956), 207 pp.

[5]David R. Krathwohl, "Stating Objectives Appropriately for Program, for Curriculum, and for Instructional Materials Development," The Journal of Teacher Education, XVI, (March, 1965), 83-92.

LEVEL II: COMPREHENSION (Questions that develop skill in gaining the meaning and intent of a material)

This level emphasizes a grasp of the meaning and intent of a "material" (i.e., a communication in oral or written form, in verbal or symbolic form, or in concrete form). It may be a pupil's ability to put something into his own words (translation), his ability to make an interpretation of events or data (interpretation), or his ability to predict or estimate on the basis of observations or data (extrapolation). This level includes knowledge but requires the pupil to go beyond the recall level to apply the knowledge to some situation.

Level III: APPLICATION (Questions that lead to an application of past learnings in a new situation)

This level emphasizes the selection of an appropriate learning to solve a problem or to deal with a new situation. In science, a pupil might select certain understandings or techniques to solve a problem. This area differs from that of comprehension in that the pupil must select from past learnings the appropriate understandings and process to resolve a problem when no mode of solution is specified. Comprehension requires the pupil to know an abstraction well enough that he can demonstrate correctly its use when specifically asked to do so. The application category requires comprehension of the method, theory, principle, or abstraction applied. This is a significant area because most of what pupils learn is intended for later use in dealing with problems or situations.

LEVEL IV: ANALYSIS (Questions that emphasize the organization and structure of a "communication" such as a series of observed phenomena)

Analysis emphasizes the breakdown of material into constituent parts, the detection of relationships, and the organization of parts. Analysis may be divided into three types or levels: (1) to identify or classify the elements of a communication, (2) to make explicit the relationships among the elements, and (3) to recognize the organizational principles, the arrangement and structure, which hold together the communication as a whole. For example, in science, the question "How do environmental conditions differ for the growth of green and non-green plants?" requires pupils to analyze each environmental condition and to make a comparison. Bloom states that no entirely clear lines can be drawn between analysis and comprehension or evaluation. Analysis contains elements of knowledge and application but differs in emphasis.

LEVEL V: SYNTHESIS (Questions that organize separate elements in a new creative structure)

This level emphasizes creative behavior in the organization of many elements from many sources in a new structure. In science, this could include the statement of new hypotheses; the development of a plan to investigate a certain hypothesis; or the preparation of a demonstration to illustrate an understanding. In each case, there is some new way to communicate, and it is this element which distinguishes synthesis from the other levels. Activities at this level motivate pupils because it emphasizes ideas about material. In guiding pupils to synthesize, the teacher must allow them enough freedom to pursue creative thought.

LEVEL VI: EVALUATION (Questions that produce a value judgment about a material or work)

The evaluation level involves the making of value judgments about some purpose, ideas, works, solutions, methods, material, etc. It employs the use of criteria or standards for appraising the extent to which particulars are accurate, effective, economical, or satisfying. The judgments may be either quantitative or qualitative, and the criteria may be either those determined by the pupil or those which are provided him. Although evaluation is placed last in the framework because it is regarded as requiring to some extent all the other categories of behavior, it is not necessarily the last step in thinking or problem solving. It is quite possible that the evaluative process will, in some cases, be the prelude to the acquisition of new knowledge, to a new attempt at comprehension or application, or to a new analysis and synthesis. In science, the criteria may be data compiled by experts, which is compared with conclusions reached in investigation. Criteria also may be developed by the class from investigations and may be used as a basis for comparison.

LEVELS OF QUESTIONING IN SCIENCE

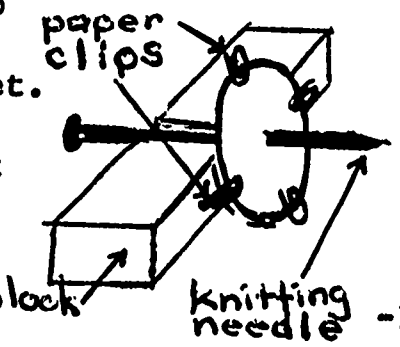
Primary Grades - Electrical and Magnetic Energy

LEVELS OF QUESTIONING	RATIONALE RELATED TO QUESTIONING
LEVEL I: KNOWLEDGE (Questions that emphasize memory skills) Discussion Teacher: Do you remember the names of these objects? (Referring to various types of magnets.) Pupil: I remember, this is a horseshoe magnet and the other one is a bar magnet...	The teacher asks the pupil to remember the names of different types of magnets and to be able to identify them. The question calls for a level of thinking involving essentially memory or recall. The behavior of the pupil in the recall situation is similar to his behavior in the original learning situation, when he acquired certain information and was expected later to remember it.
LEVEL II: COMPREHENSION (Questions that emphasize skill in developing the meaning and intent of a situation) Discussion Teacher: As a result of our experiments, what kinds of objects do you believe a magnet will attract? Pupil: We found (discovered) that magnets seem to attract objects made of metal...	The teacher asks the pupil to translate the experimental evidence into verbal communication (translation). The pupil comprehends the relationship between the parts of the experiment and secures some total view of what the communication contains (interpretation). The overall experience may involve discovery on the part of the pupil. At this point, however, the pupil interprets and communicates his findings. This level also includes knowledge but requires the pupil to move beyond the recall level to other levels...
LEVEL III: APPLICATION (Questions that lead to an application of past learnings in a new situation) Discussion Teacher: How do you think we could remove these nails that have fallen into this box of sawdust? Pupil: We have learned that magnets appear to attract metal objects. Could we use our magnets to remove the nails from the sawdust...?	The teacher asks the pupil to select data about the interaction of magnets with other objects. The pupil applies past learnings related to magnets to a new situation or problem.

LEVELS OF QUESTIONING IN SCIENCE
Primary Grades - Electrical and Magnetic Energy

LEVELS OF QUESTIONING	RATIONALE RELATED TO QUESTIONING
LEVEL IV: ANALYSIS (Questions that emphasize the critical examination and identification of factors or elements within a given phenomenon) Discussion Teacher: If magnets attract most metals, then how can we discover if these (untested) metals interact with magnets? Pupil: We should experiment by observing which metals are attracted by our magnets...	The teacher asks the pupil to examine how magnets interact with specific metals. The pupil may hypothesize (predict) how untested metals will interact with the force of magnetic attraction and then proceed to verify his findings.
LEVEL V: SYNTHESIS (Questions that organize separate elements in a new and creative structure) Discussion Teacher: How do you think we could develop a plan to investigate whether all metals interact with magnets? Pupil: We could set up an experimental plan where samples of different metals, such as lead, tin, iron, and copper, would be exposed to a magnetic field, etc. One method of testing for magnetic attraction could be ...	The teacher asks the pupil to select from previously learned science processes and content (i.e., various methods of establishing an experimental situation, understanding of the interaction of materials with magnets, etc.). The pupil puts together or synthesizes his ideas into a new and creative plan.
LEVEL VI: EVALUATION (Questions that produce evaluative judgments about a specific project or activity, such as a series of investigations or a record of data) Discussion Teacher: How could we find out if our information about the interaction of materials with magnets is accurate? Pupil: We could review our experiments to see if our information is accurate. We will need to give very careful attention to using the same procedures...	The pupil is guided by the teacher in the making of judgments, such as those which concern values, purposes, methods, or materials, involved in the experiment. The judgments may be either quantitative or qualitative. Criteria for evaluation may be either those determined by the pupil or those which are given to him. Evaluation not only involves some combination of all of the other behaviors but also is a major link with the affective behaviors in which values, liking, and enjoying are involved.

LEVELS OF QUESTIONING IN SCIENCE
Upper Grades - Electrical and Magnetic Energy

LEVELS OF QUESTIONING	RATIONALE RELATED TO QUESTIONING
LEVEL I: KNOWLEDGE (Questions that emphasize memory skills) Discussion Teacher: What do you remember about the definition of magnetism? Pupil: I remember it is the property of a magnet that enables it to attract certain metals...	The teacher asks the pupil to remember a definition. The question calls for a level of thinking involving essentially memory or recall. The behavior of the pupil in the recall situation is similar to that which he was expected to have during the original learning situation. At that time, he "stored" certain information and was expected later to remember it.
LEVEL II: COMPREHENSION (Questions that emphasize skill in developing the meaning and intent of a situation) Discussion Teacher: As a result of our experimentation, how do you think the number of wire windings around this iron nail affect the strength of the electromagnet? Pupil: I observed that additional windings seem to increase the strength of the electromagnet...	The teacher asks the pupil to translate his knowledge into verbal communication (translation). He comprehends the relationship between the devices used (wire windings, iron nail, power source, etc.) and reorders or prearranges the information in his own fund of experiences and ideas (interpretation). The pupil abstracts generalizations from a set of particulars and weighs and assesses the relative emphasis to be given the different elements. In these respects, interpretation becomes synonymous with analysis. It also has characteristics in common with evaluation.
LEVEL III: APPLICATION (Questions that lead to an application of past learnings in a new situation) Discussion Teacher: How can electrical energy be used to move this wheel continuously? Pupil: We have learned that electrical energy can be converted into magnetic energy by using an electromagnet. Could we in some way use the electromagnet and a switch to move the wheel...?  	The teacher asks the pupil to use knowledge about the conversion of electrical energy and to apply it to the movement of the wheel. At this level, the pupil shows that he <u>will</u> use his information correctly, given an appropriate situation in which no mode of solution is specified.

LEVELS OF QUESTIONING	RATIONALE RELATED TO QUESTIONING
LEVEL IV: ANALYSIS (Questions that emphasize the critical examination and identification of factors or elements within a given phenomenon) Discussion Teacher: Which of your hypotheses will produce the strongest field in an electromagnet? Pupil: We will need to experiment to determine which of our hypotheses is correct. We can compare the relative strength of the electromagnet in each case by...	The teacher asks the pupil to investigate the separate factors which may contribute to the "magnetic strength" of the electromagnet. He distinguishes fact from hypothesis through experimentation. Analysis in this situation may lead to more thorough comprehension or serve as a prelude to the evaluation of the material.
LEVEL V: SYNTHESIS (Questions that organize separate elements in a new and creative structure) Discussion Teacher: What relationships exist between various forms of energy? Pupil: Our investigations seem to indicate that electrical energy may be converted into magnetic, heat, and mechanical energy. Evidently, energy can be converted from one form to another.	The pupil is guided by the questioning into putting together elements and parts to form a whole and in combining them in such a way as to constitute a pattern or structure not clearly evident previously. This level must clearly provide for creative behavior on the part of the learner. However, this is not completely free, creative expression, since generally the pupil is expected to work within the limits set by particular problems, materials, or by some theoretical or methodological framework.
LEVEL VI: EVALUATION (Questions that produce evaluative judgments about a specific project or activity, such as a series of investigations or a record of data) Discussion Teacher: What suggestions can you make to substantiate better your conclusions concerning the conversion of electrical energy to other forms of energy? Pupil: We could judge the accuracy of our findings by determining if our standards for gathering data were followed. However, differences in findings could lead to further experimentation...	The teacher asks the pupil to judge or evaluate the accuracy of his conclusions. Evaluation involves the use of criteria as well as standards for appraising a given situation for particular purposes (i.e., verifying results by repeating the experiment, working with one variable at a time, using a control, etc.). Judgments may be quantitative or qualitative. This level has a major relationship to values, liking, and enjoying (affective behaviors). (Refer to pages 14-23.)

WHAT IS THE RELATIONSHIP OF INTERESTS, ATTITUDES, AND VALUES TO QUESTIONING AND LEVELS OF LEARNING?

Thus far, the premise that a pupil is able to respond to given stimuli at various levels has received attention. More important, perhaps, is whether the pupil actually does respond and with what degree of commitment he does so. This section is concerned with the pupil's internalization, such as growth in his interests, attitudes, and values, or commitment to levels of learning and the understandings which he gains.

Although motivation and pupil interests long have been a concern to teachers, there is a need to examine these factors more critically in terms of the objectives of teacher-pupil questioning. An analysis of "affective" goals is presented by David Krathwohl in Taxonomy of Educational Objectives: The Classification of Educational Goals. Handbook II: The Affective Domain.[6] A summary of the taxonomy, including a brief description of each of the affective behaviors, is therefore presented. The relationships between the cognitive and affective domains in science questioning also are discussed. It should be emphasized that there is no true separation between the cognitive and affective structures. Behavior may be considered as being interwoven in a cognitive-emotional-motivational relationship in which no true separation is possible. Regardless of how we analyze behavior, the ingredients of motivation-emotion-cognition are present in one order or another.

LEVEL I. RECEIVING: The development of pupil interest is essential to any pursuit. This is clearly the first and crucial step if the learner is to be properly oriented to learn what the teacher intends. Pupil interests may vary from his first awareness that a "communication" or phenomenon exists, in which he is merely receiving stimuli passively, to a degree of commitment in which he responds voluntarily and derives satisfaction from doing so. The category of receiving is represented as a continuum, beginning with an extremely passive position or role on the part of the learner, in which the sole responsibility for "capturing" the pupil's attention rests with the teacher to a point at which the learner directs his attention toward the stimuli. The essence of the motivational aspects of teacher-planning has been directed at this level.

LEVEL II. RESPONDING: This level is concerned with responses which go beyond merely attending to the phenomenon. At the first state in a "learning by doing" process, the pupil commits himself in some small measure to the phenomenon involved. This is a low level of commitment in which the pupil is doing something with or about the phenomenon. This is the level which many teachers will find best describes their "interests" objectives. The term responding is used to indicate the level at which a child becomes sufficiently involved in or committed to a subject, phenomenon, or activity that he will seek it out and gain satisfaction from working with it or engaging in it.

LEVEL III. VALUING: This is the only category headed by a term which is in common use in the expression of objectives by teachers. It is employed in its usual sense: that a thing, phenomenon, or behavior has worth. Behavior at this level is sufficiently consistent to have taken on the characteristics of a belief or an attitude. Objectives related to valuing are the prime factors from which the conscience of the individual is developed into commitment to active control of behavior. Valuing is motivated, not by the desire to comply or obey but by the individual's commitment to the underlying value guiding the behavior.

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[6]David R. Krathwohl, Benjamin S. Bloom, and Bertram B. Masia, Taxonomy of Educational Objectives - The Classification of Educational Goals, Handbook II: Affective Domain. (New York: David McKay, 1964), 196 pp.

LEVEL IV. ORGANIZATION: As the learner successively internalizes values, he encounters situations for which more than one value is relevant. This category includes the proper classification for objectives which describe (1) the organization of the values into a system, (2) the determination of the interrelationships among them, and (3) the establishment of the dominant and pervasive values. The level is subdivided, since a prerequisite to inter-relating is the conceptualization of the value in a form which permits organization. Conceptualization forms the first subdivision in the organization process. Organization of a value system is the second.

LEVEL V. CHARACTERIZATION BY A VALUE OR VALUE COMPLEX: At this level of internalization, (1) the values already have a place in the individual's value hierarchy, (2) are organized into some kind of internally consistent system, and (3) have controlled the behavior of the individual for a sufficient length of time so that he has adapted to behaving in this way. Realistically, the pupil generally cannot reach this level through formal education alone. The maturity and personal integration required at this level are not attained until at least some years after the individual has completed his formal education. Time and experience must interact with affective and cognitive learnings before the individual can answer the crucial question, "Who am I?" and "What do I stand for?"

SUMMARY: The following descriptions indicate relationships between the subcategories of the two domains. Although these have been presented in parallel form, the subcategories do not correspond as closely as the format implies. It can be noted throughout the analysis, however, that there is some tendency for the cognitive counterpart of a low-level objective to come from the lower levels of the affective continuum and for objectives at the upper level of the affective continuum to have upper-level cognitive counterparts. In some instances, it is difficult to determine whether the affective goal is being used as a means to a cognitive goal or vice versa. Perhaps both are being sought simultaneously.

COGNITIVE DOMAIN	AFFECTIVE DOMAIN
1. The cognitive continuum begins with the pupil's recall and recognition of Knowledge.	1. The affective continuum begins with the pupil's merely Receiving stimuli and passively attending to it. It extends through his more actively attending to it.
2. It extends through his Comprehension of the Knowledge.	2. It extends through his Responding to stimuli on request, willingly responding to these stimuli, and taking satisfaction in this responding.
3. It extends through his skill in Application of the Knowledge that he comprehends.	3. It extends through his Valuing the phenomenon or activity so that he voluntarily responds and seeks out ways to respond.
4. It extends through his skill in Analysis of situations involving this Knowledge and his skill in Synthesis of this Knowledge into new organizations.	4. It extends through his Conceptualization of each value responded to.
5. It extends through his skill in Evaluation in that area of Knowledge which involves the judgment of the value of material and methods for given purposes.	5. It extends through his Organization of these values into systems and finally in organizing the value complex into a single whole, a Characterization, of the individual.

LEVELS OF QUESTIONING IN SCIENCE

Primary Grades - Growth and Development of Plants

LEVELS OF QUESTIONING	RELATIONSHIP OF QUESTIONING TO THE COGNITIVE DOMAIN
LEVEL I: KNOWLEDGE (Questions that emphasize memory skills) Discussion Teacher: What are two things that plants need for proper growth? Pupil: I remember that plants need water and sunlight...	The teacher asks the pupil to remember several basic needs of plants. The question calls for a level of thinking involving essentially memory or recall. It does not lead the pupil into investigation or divergent thinking.
LEVEL II: COMPREHENSION (Questions that emphasize skill in developing the meaning and intent of a situation) Discussion Teacher: What does our chart (data) indicate about the needs of plants? Pupil: The chart shows that most growth occurs when the plants receive one cup of water daily...	The teacher asks the pupil to translate the chart information into verbal communication (translation). The pupil comprehends the relationship between its various parts and secures some total view of what the communication contains (interpretation). The emphasis is on the pupil's knowing what is being communicated and on his being able to make some use of the materials or ideas contained in it.
LEVEL III: APPLICATION (Questions that lead to an application of past learnings in a new situation) Discussion Teacher: How deep should we plant these bean seeds in the soil if we expect them to germinate? Pupil: We have learned that other kinds of seeds have to be planted at certain depths depending on the size of the seed. Could we experiment by using this information when we plant the bean seeds...?	The pupil is guided to select from past learnings the soil depth factors which are necessary for seed germination and to apply them to a new situation involving a different type of seed. The teacher asks the pupil to use his information correctly, given an appropriate situation in which no model or solution is specified.

RELATIONSHIP OF QUESTIONING TO THE AFFECTIVE DOMAIN

I. This question, which emphasizes memorization, seems to suggest that receiving the information is the important element. The response requires the pupil to show interest, which may vary from minimal awareness to that of selected attention. To work at this level, the pupil need not have achieved a high affective level of interests, attitudes, or values. It also is questionable whether the level provides opportunities for their continuous growth.

II. This question which emphasizes content, suggests, as does a knowledge question, that the receiving of information is the important element. However, the pupil is involved to a greater degree in that he responds by developing the meaning or intent of a situation. Therefore, he must operate at a higher affective level. The responses may be minimal, in that the pupil simply may obey instructions, or it may extend to his gaining satisfaction from the response and to his recognizing the value of the phenomenon. This level of questioning, then, provides some opportunities for the development of attitudes and values from interests.

III. This question clearly emphasizes what the pupil can and will do with a phenomenon. He must work at a level which exceeds that of interests; which includes attitudes; and which requires that he feel a sense of worth or value in doing so. As a result of the pupil's preliminary experimentation, he becomes interested through the teacher's questioning in other related problems. The pupil's action may be the result of an aroused need or drive. There is real motivation to perform the activity. This level of affective behavior, to a large degree, determines the quality of his response. There are clearly opportunities for growth in his affective behavior.

LEVELS OF QUESTIONING IN SCIENCE

Primary Grades - Growth and Development of Plants

LEVELS OF QUESTIONING	RELATIONSHIP OF QUESTIONING TO THE COGNITIVE DOMAIN
LEVEL IV: ANALYSIS (Questions that emphasize the critical examination and identification of factors or elements within a given phenomenon) <u>Discussion</u> Teacher: How could we discover why plant "A" grew larger than plants "B" and "C"? Pupil: We could study the conditions (environmental) that the plants were exposed to and see if there were any differences...	The pupil is guided to examine each of the factors necessary for plant growth and to decide which caused one plant to grow larger than the others. Analysis may be used to detect the organization and structure of a "communication," to develop more thorough comprehension, or to begin an evaluation.
LEVEL V: SYNTHESIS (Questions that organize separate elements in a new and creative structure) <u>Discussion</u> Teacher: How could we develop a plan to investigate whether conditions other than sunlight and watering affect plant growth? Pupil: We have learned how light and watering affect plant growth. Since plants need food from the soil, perhaps we could plan experiments with different types of soils to see what effect they have...	The teacher asks the pupil to analyze what he understands to be environmental interrelationships and to organize these elements in an original pattern or structure. Generally, this process involves a recombination of parts of previous experiences with new material, reconstructed into a new and more or less well-integrated whole. This is the category which most clearly provides for creative behavior on the part of the learner.
LEVEL VI: EVALUATION (Questions that produce evaluative judgments about a specific project or activity, such as a series of investigations or a record of data) <u>Discussion</u> Teacher: How well did we follow our standards for experimenting when we investigated how plants grow in different soils? Pupil: I think we followed our standards except that we could have kept a record of how the same plant would grow in different kinds of soil...	The teacher asks the pupil to examine his experimental procedures and to make a value judgment about the validity of the conclusion. The judgment may be either quantitative or qualitative. Criteria for evaluation may be determined by the pupil or they may be provided to him. At this point, he is guided in combining elements of all the other levels. Criteria or standards are developed. The pupil's response may lead to divergent thinking.

RELATIONSHIP OF QUESTIONING TO THE AFFECTIVE DOMAIN

IV. This question emphasizes pupil involvement. It is what he does with a phenomenon that is important. The cognitive and affective aspects of learning become as one in that a high degree of achievement in both is required to work effectively at the analysis level. It involves a wide range of interests and attitudes and extends well into a system of values. The pupil must show acceptance of the worth of a phenomenon and may, by showing preference, perform a more effective or superior analysis.

V. This question emphasizes a greater degree of commitment on the part of the pupil than do questions at any other level. The activity, being entirely creative within certain limitations, requires the pupil to have a high degree of interests, attitudes, and values. The quality of the response depends entirely on the affective level at which the pupil is working. The opportunities for growth on the affective level are many.

VI. This question emphasizes the organization of things, such as the pupils' development of criteria for making an evaluation. Affective behavior as it involves interests, attitudes, and values has a role in effective evaluation. The pupil must have internalized the understandings to respond effectively. Practice at this level assures opportunities for growth in all aspects of affective behavior.

SUMMARY: It is evident that the highest cognitive goals must be accompanied by correspondingly high affective goals, or objectives will not be attained. If this is the case, it is understandable why some instruction has been restricted to the lower levels of cognitive behavior. The pupil may not be prepared affectively to respond at the higher levels. This suggests that cognitive objectives may not only have their affective counterpart, but also that each has to be developed simultaneously. Activities that provide opportunities for pupil growth in interests, attitudes, and values need to be pursued as a part of teacher planning.

LEVELS OF QUESTIONING IN SCIENCE
Upper Grades - Growth and Development of Plants

LEVELS OF QUESTIONING	RELATIONSHIP OF QUESTIONING TO THE COGNITIVE DOMAIN
LEVEL I: KNOWLEDGE (Questions that emphasize memory skills) Discussion Teacher: What do you recall is the effect of light on green and non-green plants? Pupil: I remember that green plants need light to manufacture their food while non-green plants depend upon food from other sources...	The teacher asks the pupil to recall their understanding about the effect of light on green and non-green plants and to communicate this information. Here, the pupil need only know the principle or generalization and be able to recognize or recall a correct version.
LEVEL II: COMPREHENSION (Questions that develop skill in developing the meaning and intent of a situation) Discussion Teacher: How did the lack of sunlight affect the growth of these green and non-green plants? Pupil: The green plants did not continue to grow normally without light. Most of the non-green plants did not show any major change in their growth patterns...	The teacher asks the pupil to observe how plant growth was affected by varying the volume of light. The pupil translated his observations into verbal communication (translation). He comprehends the relationship between plant growth and sunlight and has a total view of what the communication contains (interpretation). The emphasis is on the pupil's knowing what is being communicated and on his being able to make some use of the materials or ideas contained in it. The pupil used his knowledge about plant growth but had to go beyond the recall level to apply it.
LEVEL III: APPLICATION (Questions that lead to an application of past learnings in a new situation) Discussion Teacher: Based on our experiments of plant relationships to their environment, what environmental conditions would be ideal for a non-green plant? Pupil: We have learned that different kinds of plants have special needs for growth. Could we experiment to see which of these conditions apply to the growth of non-green plants...?	The pupil is guided to select from past learnings the possible factors which are essential for the growth of non-green plants and to apply them to a new situation. The teacher asks the pupil to use his information in a situation in which no model nor solution is specified.

RELATIONSHIP OF QUESTIONING TO THE AFFECTIVE DOMAIN

I. This question, which emphasizes memorization, seems to suggest that receiving the information is the important element. The response requires the pupil to show interest, which may vary from minimal awareness to that of selected attention. To work at this level, the pupil need not have achieved a high affective level of interests, attitudes, or values. It also is questionable whether the level provides opportunities for their continuous growth.

II. This question, which emphasizes content, suggests, as does a knowledge question, that the receiving of information is the important element. However, the pupil is involved to a greater degree. He is asked to respond by developing the meaning or intent of a situation. Therefore, he must function at a higher affective level. The response may be minimal, in that the pupil simply may obey instructions, or it may extend to his gaining satisfaction from the response and to his recognizing the value in the phenomenon. This level of questioning, then, provides some opportunities for the development of attitudes and values from interests.

III. This question clearly emphasizes what the pupil can and will do with a phenomenon. He must work at a level which exceeds that of interests; which includes attitudes; and which requires that he feel a sense of worth or value in doing so. As a result of the pupil's preliminary experimentation, he becomes interested through the teacher's questioning in other related problems. The pupil's action may be the result of an aroused need or drive. There is real motivation to perform the activity. This level of affective behavior, to a large degree, determines the quality of his response. There are clearly opportunities for growth in his affective behavior.

LEVELS OF QUESTIONING IN SCIENCE

Upper Grades - Growth and Development of Plants

LEVELS OF QUESTIONING	RELATIONSHIP OF QUESTIONING TO THE COGNITIVE DOMAIN
LEVEL IV: ANALYSIS (Questions that emphasize the critical examination and identification of factors or elements within a given phenomenon) Discussion Teacher: How can we determine what effect gravitational attraction has on plant growth? Pupil: We could experiment with several plants by placing them in various positions and observing the gravitational effect on their growth...	The pupil is guided to examine the factor of gravitational attraction (geotropism) on plant growth. The question concerns a situation which is new to the pupil, to "test" his analytical ability. He would have no opportunity for analysis if he were simply asked to recall a previous discussion.
LEVEL V: SYNTHESIS (Questions that organize separate elements in a new and creative structure) Discussion Teacher: How are the environmental conditions of plants and animals inter-related? Pupil: We have investigated how plants and animals interact with their environment. Perhaps we could try to put this information together so we could determine some common relationships ...	The teacher asks the pupil to analyze what he understands to be environmental inter-relationships and to organize these elements in an original pattern or structure. Generally, this process involves a recombination of parts of previous experiences with new material, reconstructed into a new and more or less well-integrated whole. This is the category which most clearly provides for creative behavior on the part of the learner.
LEVEL VI: EVALUATION (Questions that produce evaluative judgments about a specific project or activity, such as a series of investigations or a record of data) Discussion Teacher: How can we determine whether our experimental findings are accurate? Pupil: We could evaluate how we proceeded in the experiment on the basis of our standards for experimentation. We also could repeat the experimental procedure, using a "control" plant to help us identify the changes...	The teacher asks the pupil to examine his experimental procedures and to make a value judgment about the validity of the conclusion. The judgment may be either quantitative or qualitative. Criteria for evaluation may be determined by the pupil, or they may be provided to him.

RELATIONSHIP OF QUESTIONING TO THE AFFECTIVE DOMAIN

IV. This question emphasizes pupil involvement. It is what he does with a phenomenon that is important. The cognitive and affective aspects of learning become as one in that a high degree of achievement in both is required to work effectively at the analysis level. It involves a wide range of interests and attitudes and extends well into a system of values. The pupil must show acceptance of the worth of a phenomenon and may, by showing preference, perform a more effective or superior analysis.

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SUMMARY: It is evident that the highest cognitive goals must be accompanied by correspondingly high affective goals, or objectives will not be attained. If this is the case, it is understandable why some instruction has been restricted to the lower levels of cognitive behavior. The pupil may not be prepared affectively to respond at the higher levels. This suggests that cognitive objectives may not only have their affective counterpart, but also that each has to be developed simultaneously. Activities that provide opportunities for pupil growth in interests, attitudes, and values need to be pursued as a part of teacher planning.

The central part of all learning activities, particularly in problem solving, is the asking of questions by teachers or pupils. According to Dr. R. C. Bradley, there are two concomitant problems facing teachers who seek to improve their "question making" procedures.[7] One involves the failure of most pupils to ask questions about the subject matter which they are studying. The other concerns the lack of training of children in how to ask questions. To eliminate such problems, the teacher must be well grounded in the art of structuring questions. Dr. Bradley states, "In order to move from the usual procedure of 'telling' information for purposes of memorization, one must look toward the cultivation of the child's own decision-making process. This requires that we help him to ask the right questions to get him a step further as he seeks to make the right decisions in accordance with his previous backgrounds of experience. If the pupil is properly grounded in the types of questions asked by teachers, there should be some transfer of training to his own decision-making. His questions become even more 'personalized' and rise to a higher quality. The structure of pupil questions is most important in that they (1) determine the type of cognitive (to know: thinking) skill the child will employ in searching for and attacking answers; (2) involve the thinking skills one may learn; and (3) determine the range or scope of curriculum content one may encounter at a given moment or period of time." Several techniques are suggested that will involve the pupil in formulating questions for himself. He is urged to ask questions when he has a problem so that he can receive information which will help him to reach a solution. The pupil needs to recognize that his questions should emphasize the various kinds of information needed rather than only specific facts. The teacher should:

1. Encourage the pupil to formulate questions for himself and afterward provide an opportunity for him to evaluate them. For example, provide the pupil with materials for investigation, such as different types of magnets or plants that have been exposed to various environmental conditions. Ask the pupil to write questions that he would ask and to evaluate them before seeking answers.

2. Present a problem to the class. Ask the pupils to write the questions which they would ask before deciding whether to investigate. By the nature of their questions, the pupils will recognize the need for seeking answers through various forms of investigation.

3. Demonstrate a science phenomenon to stimulate better questions. The procedure of using a pupil demonstration or experiment to guide the pupil to improve his questioning and other factors were selected for study by J. Richard Suchman (training in the process of inquiry, or more specifically, question-asking). This approach provides the pupil with a plan of operation that will help him to discover casual factors of physical change through his own initiative and control and not to depend on the explanation and interpretations of teachers or other knowledgeable adults. In Suchman's procedure, which supplements those regularly used in the classroom, a pupil performs a demonstration experiment before the class. The class members observe the phenomenon and then seek to arrive at an explanation of it by raising related questions. These are answered by the teacher with a yes or no response. This procedure encourages pupils to listen to all other questions that have been asked by their peer group to categorize, regroup, and assimilate their own ideas concerning the nature of the experiment. For example, in one activity, a small amount of water is poured into a gallon metal can. It is then heated on a hot

[7] R. C. Bradley, "Structuring Questions - A Teacher's Major Teaching Tool: The Art of Questioning," Arizona Teacher, 54 (March, 1966), pp. 14, 29.

plate with the cap removed. When steam is initially generated, the can is removed from the heat source and tightly corked. Cold water is then poured over the top of the can, and its sides collaspse. The pupils raise questions related to the demonstration. This procedure appears to have a decided effect upon the fluency of question-asking. Although it does not follow that pupils who ask more questions also ask better ones, fluency of questioning appears to be a contributing factor to successful inquiry just as ideational fluency is significant in any form of productive thinking.[8] The pupils' questions may be classified according to their apparent function, as follows:

Level 1. Verification of objects: "Was that water she poured on the varnish can?"
Level 2. Verification of events: "Was the water boiling inside the can?"
Level 3. Verification of relationships: "Was the air pressure the same inside and outside of the can when she poured water on it?"
Level 4. Experimental manipulation: "If there had been no water in the can to begin with, would the same thing have happened?"
Level 5. Focussing: "Did it have anything to do with air pressure?"
Level 6. Hypotheses of cause and effect: "Did air pressure on the outside crush the can because it was greater than the inside pressure?"
Level 7. Hypotheses of generalization: "Does the pressure of steam always become less when it is cooled?"

By examining the specific nature of pupil questions, the teacher will note the insights which are reflected in the strategy or techniques. The categories indicate the levels of the pupil's thinking or questioning that may be considered sequential in nature. A study of the structure of the taxonomy also is suggested as a means of identifying levels of pupil questioning. (Refer to pages 7-23.)

SUMMARY: Who asks the questions in the classroom? According to Dr. R. C. Bradley, the teacher asks nearly two-thirds of the questions. It is Dr. Bradley's contention that the pupils should be asking most of them. The teacher who spends considerable time in improving his questions will stimulate pupils to ask questions which are more relevant. Moreover, pupils of different basic ability levels will benefit differentially and will transfer more readily their understandings to the solution of real problems outside the classroom.

"The evidence that good teaching has taken place is reflected more in the kinds of questions pupils ask than in the abundance of pat answers they can produce. Only when teachers and pupils understand and use better techniques of questioning as part of the learning process will each pupil's real potential be achieved." [9]

[8]Richard L. Carner, "Levels of Questioning," Education, 83, (May, 1963), pp. 546-550.
[9]Richard J. Suchman, "Training Children in Scientific Inquiry" (A paper presented at the 1959 meeting of the Society for Research in Child Development at the University of Illinois.)

WHAT ARE SOME SUGGESTED TEACHER GUIDELINES FOR QUESTIONING?[10]

Effective teaching demands complete participation of class members. For this reason, the teacher should develop techniques of questioning that challenge pupils and sustain interest in discussion. It is important for the teacher to identify a purpose for each question, and for each series of questions. Care in planning and evaluation of procedures helps to increase the teacher's skill. The following suggested guidelines are divided into the categories of (1) purpose questions, (2) pupil responses, and (3) teaching techniques:

PURPOSE QUESTIONS

The teacher should:

- Precede questioning with thought and understanding. Questions should reflect a real grasp of purpose and content. A depth approach and clear logic should be evident when questioning is evaluated. Raise questions that are stimulating and not merely memory testing.

- Formulate questions for effective pupil response. Develop thought questions in such a way that pupils are stimulated to think. Questions should permit the pupils to draw answers freely from their experiences rather than to encourage guessing at what might be in the teacher's mind.

- Ask questions for a specific purpose and at an appropriate time. Introduce questions at the point in the lesson when they can best achieve their purpose. Pupils should be ready to answer questions or to investigate problems when they are asked to do so.

- Provide for individual differences. Note that questioning calls for flexibility on the part of the teacher. Design questions to cover segments of material appropriate to the subject matter and to the differing ages and abilities of learners. Questions and lines of questioning need to be adapted to pupil needs which become evident during the lesson. Ask questions about the same subject on various levels of difficulty. Consider length, phrasing, conceptual level, etc., so as to provide for individual differences.

PUPIL RESPONSES

The teacher should:

- Direct questions at all levels. Ask questions of all class members, including those who do not volunteer responses. Guide the pupil who seems unable to answer. Suggest group involvement by inquiring, "How can we help _____?" Try not to interrupt a pupil who is attempting to answer. Do not tolerate ridicule of an honest effort.

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[10]Adapted from Ruth P. Klebaner, "Questions That Teach," Grade Teacher, LXXXI, (March, 1964), pp. 10, 76-77; and Richard L. Loughlin, "On Questioning," The Educational Forum, XXV, (May, 1961), pp. 481-482.

- Provide a proper classroom climate for pupil questions. Guide pupils to understand that their school encourages a questioning attitude and that questioning is an important part of science investigation.

- Encourage pupil responses in depth. Raise questions that require a sustained answer. If a yes-no question is directed toward pupils, then add "Explain your answer."

- Stimulate critical thinking. Use key words and phrases to stimulate thinking, such as "Why?", "How?", "Compare (or contrast) with _____," "To what extent?", "Under what circumstances?"

- Provide sufficient time for pupils to consider the question and formulate answers. Remember that pupils need an opportunity to consider answers carefully. Handle both correct and incorrect answers in such a way as to stimulate learning. Ask questions one at a time so that pupils can work out a specific answer in response to a specific question. Use the procedure of (1) directing the question to the class, (2) allowing adequate time for comprehension, and then (3) requesting a response from the class or an individual.

- Encourage pupils to listen to the speaker. Keep in mind that repeating a pupil's statement (question or answer) may cause the class to be inattentive to the speaker. Encourage pupils to be alert and attentive.

- Encourage pupils to comment on the answers of classmates. Allow pupils to ask questions of each other and to make comments about what is said. Begin the discussion by asking, "What is your opinion of that answer...?" Build on promising statements. Curb tactfully pupils who are overly aggressive so that no single pupil nor the teacher dominates the discussion.

- Encourage individual responses. Note that choral responses and mass handwaving do not create a climate for discussion. Allow pupils to participate in the discussion, but as individuals.

TEACHING TECHNIQUES

The teacher should:

- State questions clearly. Be a model of correct phrasing and coherent thinking. Be sure that pupils readily grasp the intent of the question. Formulate questions clearly the first time so they do not need immediate rephrasing. Make each question specific, short, and provocative.

- Reflect energy and vitality in questioning procedures. Note that class attention and a more dynamic atmosphere is created when the teacher changes position and moves around the room during a discussion.

- Encourage pupils to request clarification when necessary. Permit pupils to ask for clarification of questions stated by either pupils or the teacher. This technique can often lead to greater understanding and further investigation.

- <u>Raise questions that can not be answered immediately</u>. Use questions to encourage investigation and discovery. Remember that the use of procedures of scientific exploration by pupils is an important objective of science teaching.

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