The purpose of this study was to assess the effectiveness of a training program designed to assist Thai junior high school science teachers in asking a larger number of higher cognitive level questions, extending wait-time following a question, and decreasing the amount of teacher talk during classroom instruction.

Sixty-two junior high school science teachers in Bangkok were randomly assigned to one of two equivalent groups (experimental and control). The teachers taped two 50-minute lesson sessions, one set each for pretest and posttest. The researcher transcribed and categorized the teacher questions on the tapes, using Blosser's Question Category System for Science. Wait-time and length of teacher talk in each class session were measured with a stopwatch.
Only the experimental group participated in the training program. The training program utilized an instructional pamphlet based on Blosser's (1973) *Handbook of Effective Questioning Techniques*. A discussion of wait-time was included. Teachers in the experimental group were asked to read and discuss question strategies, learn to categorize and use a variety of cognitive questions, and analyze their own questions and wait-time behavior.

One-way analysis of covariance was used to analyze data. Data from tapes made prior to the study served as the covariates.

The conclusion drawn from the study was that the training program was effective in training teachers to decrease the number of cognitive-memory questions and increase the number of divergent thinking and evaluative thinking questions they asked, extending teacher wait-time, and reducing the amount of teacher talk during instruction in the science class. No significant change occurred in the number of convergent thinking questions or the total number of all cognitive-level questions asked by the teachers.
The Effects of a Training Program on Wait-Time and the Questions Asked by Junior High School Science Teachers in Thailand

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CHAPTER 1
INTRODUCTION

At all levels of schooling, curricular sameness characterizes topical organization, factual orientation, textbook content, and the things tested. In an article on the study of schooling in the United States, John I. Goodlad remarked that the emphasis was on recall, not problem solving or inquiry. He also mentioned that teachers varied in the quality of their teaching strategy but that "teacher talk" was by far the dominant classroom activity. Teachers rarely encouraged students to talk or to ask or respond to questions. Talking requires an organization of thought and can be an important avenue to learning. Teachers, then, were doing most of the learning (Goodlad, 1983).

Many new science programs emphasize the ability of teachers to ask thought-provoking and inquiry-type questions in order to encourage students to develop thinking skills and to become independent problem solvers. Learning to inquire is learning how to learn what one needs to know. Students must be able to decide for themselves which inquiry processes might be useful and effective when confronted with a problem. The role of teachers in the inquiry approach is to provide an appropriate environment that facilitates students to inquire more (Bruner, 1962; Gagne, 1965; Schwab, 1962; Suchman, 1965; Schlenker, 1970; Wittmer, 1974). Such an environment involves many factors but one factor is the type of questioning strategy used by the teacher.
The functions of questions, their use as a teaching strategy, and their effect on student behaviors and learning have been the focus of many studies for many years (Stevens, 1912; Lancelot, 1929; Houston, 1938; Dewey, 1939; Austin, 1963; Gall, 1970; Hunkins, 1970; Balzer, Evans, and Blosser, 1973; Blosser, 1973; Rowe, 1977; McGlathery, 1978; Andre, 1979; Winne, 1979). Questions are potential instructional tools that can be manipulated by a teacher or instructional designer in order to produce certain learning outcomes, and asking questions remains one of the most common teaching methods employed (Andre, 1979; Orlich et al., 1980).

It has been recognized that the levels of cognitive questions teachers ask during classroom dialogue play an important role in the science learning process (Lowery and Leonard, 1978) and that the levels of questions are closely related to the levels of student thinking (Taba, 1966). The results from several studies revealed that science teachers asked questions which primarily emphasized the lower cognitive levels. For example, they asked for recall of factual information (Stevens, 1912; Bellack, 1966; Gall, 1970; King, 1975). Teachers asked too many questions while giving instructions (Moyer, 1965). Not only that, teachers asked few higher level questions, and they did not allow enough time for students to think before answering their questions. In this regard, Rowe (1974) concluded that factors other than the level of knowledge possessed by the teacher must be involved in the failure of students to learn science. One of these factors she characterized as a rapid question-answer sequence in the teaching strategy. This situation generally holds true for Thai
Science teachers (Chewprecha, 1980). It is suggested that in order to improve science instruction and give students an opportunity to participate in the science class, it is important that teachers increase the cognitive level of the questions they ask (Rice, 1977).

Research efforts on questioning have resulted in the development of a number of classification systems which classify teachers' and students' questions as to type and cognitive level (Crump, 1970; Gall, 1970; McGlathery, 1978). One classification system is the Questions Category System for Science, developed and described by Blosser (1973) for use in science classrooms and for categorizing science-related questions. The system allows for the categorization of all cognitive-level questions.

Training programs aimed at the development of question-asking strategies have been developed, mainly to increase the number of higher cognitive-level questions and decrease the number of lower cognitive-level questions (Clegg, 1967; Galloway and Mickkelson, 1973; Arnold, Atwood, and Rogers, 1974; Winne, 1979). Studies associated with such training programs found that trained groups asked more higher cognitive-level questions. However, Arnold, Atwood, and Rogers (1974) reported that whether teachers asked lower or higher cognitive questions, their wait-time did not change. It would seem that teacher training programs aimed at developing better question-asking strategies should also be concerned with developing strategies which would allow students time to think, particularly when higher cognitive-level questions were asked.
Mary Budd Rowe (1974) did an extensive study of the questioning behavior of teachers. In her analysis of science lesson tapes, she found that teachers, on the average, waited less than one second for students to answer questions. An analysis of student responses revealed that teachers with longer wait-time (average of three seconds) obtained greater speculation, conversation, and argument than did those with shorter wait-times. It appeared to Rowe that when teachers were trained to wait an average of three seconds for students to respond, the expectancy levels of students were more likely to change positively. For example, students gave longer and more complete answers, instead of short phrases. There was an increase in speculation and creative thinking and in the number of questions and experiments suggested by students. Students who were rated by the teachers as relatively slow participated more. Teachers became more flexible in their responses to students and asked fewer questions, because the ones they asked required more reflection. Students gave a greater number of qualified inferences. It seemed that teacher expectations for student performances changed. They were less likely to expect only the brighter students to reply. For inquiry teaching to occur, it seems reasonable that teachers should increase the cognitive level of the questions they ask and increase their wait-time so that students may have more opportunities to think and to create answers.

In summary, the research literature reveals that: Teacher talk dominates classroom activity; the new science programs emphasize the ability of the teacher to ask thought-provoking and inquiry-type
questions; questions are considered the most commonly used teaching strategy; classification systems have been developed for categorizing questions; Blosser's Category System for Science was developed for use in science classrooms for categorizing science-related questions; and training programs have been developed and implemented to increase the number of higher cognitive-level questions teachers ask. It can be inferred that teacher training programs aimed at developing better question asking should also be concerned with developing strategies which allow students time to think, wait-time. Mary Budd Rowe found that wait-time of teachers is short in duration but that the length of wait-time can be increased. Conditions suggest that more attention should be given to a training program and teaching strategies which emphasize questioning strategies and increased wait-time.

Background of Science Curricula in Thailand

In Thailand, educators generally agree that science plays an important role in general education. The scientific and technological revolution has resulted in tremendous change. Although Thai students live in a scientifically oriented culture, they often have limited backgrounds in science and technology. The problem is how to prepare young people to cope with an intellectual environment characterized by this rapid change. It seems reasonable to say that science instruction assists individuals in recognizing their need to understand science and technology, motivates them to satisfy
their need for better understanding, and assures that they develop into a citizenry of critical, scientific thinkers.

A study by Sloan and Pate (1966) indicated that curriculum has much to do with teacher questioning. In respect to this position, the Institute for the Promotion of Science Teaching and Technology (IPST), a semiautonomous unit of the Ministry of Education of Thailand, was established in 1970 and charged with the responsibility to develop inquiry-oriented school science curricula. The new science courses that were developed are very different from the traditional ones. The science content of the new courses has been updated and made relevant to the Thai culture, and the role of inquiry in learning is emphasized. To properly implement the new science courses requires teachers to ask more higher cognitive-level questions.

There is no doubt that current instructional strategies have to emphasize inquiry and that the widespread commitment to inquiry science teaching is largely responsible for the current interest in improving questioning techniques (Atwood and Stevens, 1976).

In order for teachers' questions to be effective stimulators of thought, teachers must first have "an awareness of various purposes that questions may serve and an awareness of the different types of questions for achieving these purposes" (Pate and Bremer, 1967).

**Need for the Study**

A number of studies in the United States have attempted to determine the effect of training in higher cognitive-level questions
and extended wait-time on teacher-student interaction in science classrooms. However, few such studies have been conducted in Thailand, especially at the junior high school level.

Many science educators have advocated the processes of inquiry as effective means through which students may learn science. Most of the new science curriculum at both the elementary and the secondary level was designed to include some variation of the inquiry method with the teacher leading students to form conclusions by asking them questions. So, efforts have been made to develop teachers' ability to ask higher level, inquiry-provoking questions. In spite of these efforts, the cognitive level of questions asked by teachers has not changed. Emphasis has continued to be placed on asking low cognitive-level questions. A possible explanation for this situation is that teachers may not be aware of the level of cognitive questions which elicit answers in students (Gall, 1970).

Rogers (1972) claimed that teachers not only lack necessary skills for asking effective questions but also receive little or no guidance in terms of clear strategies set out by either research or training programs related to how effective questioning techniques are developed. This suggests that there is a need for training programs which utilize available research to assist teachers in developing teaching strategies that emphasize questioning techniques.

Skill in asking higher level questions has been considered by many educators to be one of the most important competencies which teachers can possess. The development of such question-asking skills should be of primary concern. In training teachers to ask higher
cognitive-level questions, it is necessary for teachers to identify the levels of the questions they ask. Blosser's (1973) Question Category System has been shown to be a valid and reliable instrument for categorizing the level of questions that science teachers ask during classroom instruction.

Furthermore, teacher training programs aimed at developing question-asking strategies should be concerned with developing strategies which allow students time to think, particularly when higher cognitive-level questions were asked. Studies had revealed that when teachers used increased wait-time, the desired inquiry behavior occurred and improved various teacher-student classroom interactions (Rowe, 1974; McGlathery, 1978).

In summary, the needs for this study are as follows:

1. Few studies have been conducted in Thailand to determine the effect of training science teachers to ask higher cognitive-level questions and extend wait-time.

2. Most of the new science curriculum emphasizes inquiry learning with the teacher leading students to form conclusions, by asking questions.

3. Research literature reveals that teachers continue to ask low cognitive-level questions.

4. Teachers lack the necessary skills for asking effective questions and receive little guidance or training on effective questioning techniques.
5. Teachers need a training program concerned with developing strategies which give students more time to think (extend wait-time), particularly when higher cognitive-level questions are asked.

Statement of Problems

The problems studied in this research are associated with the examination of the effectiveness of training Thai junior high school science teachers to modify their science teaching behavior in using the IPST curriculum. The IPST curriculum emphasizes teacher behaviors such as asking higher cognitive-level questions and waiting longer for students to respond, which have been associated with improvement in the quality of student responses to inquiry activities. The basis for this study was the finding by other researchers that teachers can be trained to increase the number of higher cognitive-level questions asked and the length of time a teacher waits for students to respond (Rowe, 1974; Rice, 1977; McGlathery, 1978). Specifically, the problems investigated are to determine if a training program emphasizing questioning strategies will result in Thai junior high school science teachers asking higher cognitive-level questions and increasing the length of their wait-time following questioning and to determine if this training affects the length of time teachers talk during a classroom session.

The three dependent variables of this study are:

1. the cognitive levels and number of questions teachers ask;
2. the length of wait-time after each question; and
3. The amount of teacher's talk in each class session.

The independent variable is the training which is provided to science teachers in the experimental group.

**Research Hypotheses**

The null hypotheses of this study are as follows:

H1: There is no significant difference between the control group and the experimental group in the number of all cognitive level questions asked by teachers.

H21: There is no significant difference between the control group and the experimental group in the number of cognitive memory level questions asked by teachers.

H22: There is no significant difference between the control group and the experimental group in the number of convergent thinking level questions asked by teachers.

H23: There is no significant difference between the control group and the experimental group in the number of closed questions (cognitive memory and convergent thinking questions) asked by teachers.

H24: There is no significant difference between the control group and the experimental group in the number of divergent thinking questions asked by teachers.

H25: There is no significant difference between the control group and the experimental group in the number of evaluative thinking level questions asked by teachers.
\textbf{H}_26: There is no significant difference between the control group and the experimental group in the number of open questions (divergent thinking and evaluative thinking questions) asked by teachers.

\textbf{H}_3: There is no significant difference between the control group and the experimental group in the length of teacher wait-time.

\textbf{H}_{31}: There is no significant difference between the control and experimental groups in the length of wait-time following teacher's closed questions.

\textbf{H}_{32}: There is no significant difference between the control and experimental groups in the length of wait-time following teacher's open questions.

\textbf{H}_4: There is no significant difference between the control and experimental groups in the amount of teacher's talk.

\section*{Definition of Terms}

The following terms are used in this study. Other terms used but not defined here are considered to be self-explanatory.

\textbf{Cognitive-level questions:} Questions identified by Level III of Blosser's Question Category System for Science (Blosser, 1973:9-10; see Appendix D) and categorized by Level II as follows:

1. "\textit{Cognitive memory questions} are defined as those which require the simple reproduction of facts, formulas, and other items of remembered content analysis through the use of such processes as recognition, rote memory, or selective recall."
2. "Convergent thinking questions involve the analysis and integration of given or remembered data. These questions are designed to stimulate such mental activities as translation, association, explanation, and drawing conclusions. They focus thinking toward a possible answer."

3. "Divergent thinking questions are those in which the individuals questioned are free to generate their own data within a "data-poor" situation. These questions are designed to cause students to invent, to synthesize, to elaborate, to point out implications, or to make open predictions for which the data are insufficient to limit the response expected."

4. "Evaluative thinking questions deal with matter of value rather than matter of fact. They contain the implication that the individual responding may be called upon to justify his response. The questions asked cause students to evaluate methods and procedures in the formulation of an experimental design, to judge matters of value, to criticize, or to give an opinion."

5. "Closed questions are subdivided into cognitive memory questions and convergent thinking questions. They have a limited range of acceptable responses."

6. "Open questions are subdivided into divergent-thinking questions and evaluative thinking questions. They have a wide range of acceptable responses."

7. Low cognitive-level questions require only recall and memorization, as defined by cognitive memory questions in Blosser's Question Category System for Science.
8. **High cognitive-level questions** require either convergent thinking, divergent thinking, or evaluative thinking, according to Blosser's Question Category System for Science.

**Wait-time:** The interval between the end of a teacher's utterance in posing a question and the beginning of an oral response by a student, or, if no student responds, continuation by the teacher.

**Mattayom 1 (M1):** Class level in Thai schools equivalent to seventh grade in the United States.

**Mattayom 2 (M2):** Class level in Thai schools equivalent to eighth grade in the United States.

**Mattayom 3 (M3):** Class level in Thai schools equivalent to ninth grade in the United States.

**Science teachers:** Teachers in Bangkok, Thailand, assigned to teach M1, M2, and M3 science lessons in the 1983 academic year.

**Experimental group (E):** A randomly selected group of Thai junior high school science teachers who are assigned to teach an IPST science class, which participates in a training program, the purpose of which is to increase the number of higher cognitive-level questions the teachers ask, extend teacher's wait-time, and reduce the amount of teacher's talk.

**Control group (C):** A randomly selected group of Thai junior high school science teachers who are assigned to teach an IPST science class.

**IPST curriculum specialists:** Specialists in question-asking and teacher behavior, from IPST and from Chulalongkorn University in Bangkok, Thailand.
Limitations of the Study

1. The study is limited to M1, M2, and M3 of the IPST science lessons taught by Thai junior high school science teachers.

2. The science lessons are limited to only science units from the IPST curriculum.

3. The science lessons are limited to teacher-student verbal classroom interactions and not those lessons involving correction of homework, lesson summaries, or tests.

4. Measurements are limited by the technical parameters of the equipment used and observer perception.

Delimitations of the Study

1. This study will consider the wait-time that occurs between the teacher's question and the student's response. A pause after a teacher's statement that is other than a question and the wait-time that occurs between a student response and the next comment will not be considered.

2. No attempt will be made to study nonverbal classroom behavior interaction.

3. No attempt will be made to evaluate the verbal behavior of the individual teachers.
Methodology

Design of Study

The experimental design for the study will be the Pretest-Posttest Control Group Design (Campbell and Stanley, 1963). Table 1 pictorially represents this design.

Table 1
Pretest-Posttest Control Group Design

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<th>O2</th>
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<tbody>
<tr>
<td>R2O1</td>
<td></td>
<td>O2</td>
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R1 = randomly selected experimental group
R2 = randomly selected control group
O1 = pretest
O2 = posttest
X = experimental treatment

Population and Sampling

Science teachers. Sixty-six science teachers at junior high school level (Mattayom 1, 2, 3) in Bangkok, Thailand, will be randomly assigned to an experimental group and a control group. Teachers' names will be written on slips of paper placed in a box and then drawn alternately for assignment to one of the groups: that is, the first name drawn is placed in the experimental group and the second name
drawn is placed in the control group, and so on, until 33 teachers are assigned to each group.

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<th>Experimental</th>
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The projected sample size of 33 subjects per cell provided for a power level of .80 and an effect size of .35; the alpha-level is set at .05. This assures that the hypothesis results reflect a Type II error not more that 20% of the time (Cohen, 1977).

**Students.** The study involves students in junior high school (M1, M2, M3) classes of 1983 in Bangkok, Thailand. The students will be randomly assigned to the experimental and control groups.

**Instrumentation**

Cassette-tape recorders will be used to record verbal instruction of science lessons.

From each audiotape, the number of each cognitive level of teachers' questions asked will be determined by using Blosser's Question Category System for Science. Teacher wait-times will be obtained from the tapes by using a stopwatch to measure the pause between teachers' question and subsequent student response or teacher response. In addition, the amount of time each teacher talked during each class session will be measured and recorded.

**Procedure**

The study will take place over 12 weeks of the first semester of the 1983 academic year (June 16-November 12). The training program will be developed by using an instructional pamphlet which will be
prepared in Thai language by the researcher. The materials covered in this pamphlet will be developed from Blosser's Handbook of Effective Questioning Techniques (1973) and from ideas gained from a survey of literature related to question and questioning. The pamphlet will contain a discussion of certain characteristics of effective questions, functions which questions can serve in a lesson, and the use of a question as a teaching strategy. The importance of wait-time will be discussed. The pamphlet will also discuss how a training program related to effective questioning can help teachers improve their teaching strategies. Teachers in the experimental group will learn the category system and practice categorizing their own questions as self-analysis.

All science teachers will be taped during two 50-minute science lesson periods during the first week. As a pretest, each session taped will be analyzed by the researcher to classify cognitive level of the teacher's questions used, teacher wait-time, and amount of teacher's talk.

Posttesting will occur five to six weeks after pretesting. All science teachers will be taped again during two 50-minute science lesson periods. As with the pretest, each posttest audiotape will be analyzed by the researcher to classify the cognitive level of teacher's questions used and measure teacher's wait time and the amount of teacher's talk.

Advice and suggestions will be sought from experts in the field of questioning behavior from IPST and from Chulalongkorn University in Bangkok, Thailand.
mathematical model for an analysis of variance (Snedecor and Cochran, 1980) is as follows:

\[ Y_{ij} = \alpha_j + \beta(X_{ij} - \bar{X}) + \epsilon_{ij} \]

where, \( \alpha_j \) represents the population means of the class \( j \);
\( \beta \) is the regression coefficient of \( Y \) on \( X \);
\( X_{ij} \) is the covariate corresponding to observation \( i \) in class \( j \);
\( \epsilon_{ij} \) is a residual, NID \((\phi, \sigma^2)\).

Transformation of some scores will be necessary.

**Organization of the Remainder of This Dissertation**

The remainder of this dissertation is presented in four chapters. Chapter 2 presents a summary of published literature and research relevant to this study. Chapter 3 details the methodology. Chapter 4 reports the results and data analyses, and Chapter 5 presents the summary, conclusions, and recommendations for further research and practice.
CHAPTER 2
REVIEW OF RELEVANT LITERATURE

This chapter presents a summary of published literature and research that is relevant to this study. It begins with a review of literature on the use of questions as a teaching strategy. The next section deals with questioning and inquiry process, followed by a discussion of the level of questions and then the various systems for classifying questions, with particular reference to Blosser's Question Category System for Science (1973). The findings of research studies involving classroom questioning practices, particularly questioning in science classrooms, are considered next. Finally, the discussion concerning the effect of teacher wait-times, which prescribes training teachers in the use of particular questioning patterns, is considered. The main aspects of this literature on questioning as it relates to this study are briefly summarized.

Questioning as a Teaching Strategy

Questioning has been recognized as one of the major strategies of teachers for many years. General methods of teaching textbooks usually contain descriptions of the use of questions in teaching, in order to help teachers improve their questioning techniques (White, 1886; Strayer, 1912; Odell, 1924; Douglas, 1926; Burton, 1929; Lancelot, 1929). Ruddell (1974) identified the question as "a basic and commonly accepted tool used to stimulate thinking and enhance the cognitive process and comprehension ability." Taba (1965) viewed
questions as the act of asking that plays a crucial role in focusing, expanding, and directing thinking in a teaching strategy.

Considering the value of questioning in teaching, it is not surprising that questioning in the classroom continues to be the focus of much research in education. Over half a century ago, Stevens (1912) disclosed that questioning comprised a large portion of the teacher's daily verbal output. In observation of a number of high school teachers, she found that a mean of 395 questions was asked daily, and estimated that four-fifths of instructional time were occupied with question-and-answer recitation. Some fifty years later, Flanders (1963) supported this statistic. He reported that the asking of questions and the giving of information accounted for 70 to 90 percent of teacher talk. More recent reviews have verified the ongoing practice of extensive and high frequency question asking by teachers (Gall, 1970; Godbold, 1970; King, 1975; Hyman, 1976; Riley, 1978). Gall (1970) cited several studies in elementary classrooms in which large numbers of questions were used, ranging from 64 to 180 in one class period to an average of 348 questions during the school day. Godbold (1970) claimed that secondary school teachers asked more questions than elementary school teachers asked. King (1975), while analyzing a tape of her own reading lesson, found that she had asked 59 questions in 30 minutes. Hyman (1976) reported that a third of all classroom discourse consists of questions.

It would appear then that questioning is a significant procedure within the classroom in terms of the time spent in questioning activities, but what effect do these questions have on student thinking?
Burton (1962) listed and supported various functions of questions as follows:

1. Stimulate reflective thought by requiring analysis, comparison, definition, interpretation, or the use of judgment;
2. Develop appreciation and attitudes;
3. Develop the power and habit of evaluation;
4. Determine the informational background, interests, and maturity of individuals or clan groups; and
5. Create interest, arouse purpose, or develop mind set.

Likewise, Austin (1963) suggested that teachers use questions for various purposes from developing and maintaining a good emotional and intellectual atmosphere in the classroom to developing the "act of thinking." Educators agreed that questions can serve various educationally desirable functions. But what kinds of questions should teachers ask? How do those questions affect students in the classroom?

**Questioning and Inquiry Process**

Inquiry teaching is a process that requires situations where learning is meaningful to the learner, voluntary, self-initiated, self-evaluated, and feeling-oriented (Wittmer, 1974). Bruner (1962) proposed that an approach to learning which involved the development of problem solving, discovery, and concept-building techniques is "necessary for 'real' possession of knowledge. This approach has certain unique motivational advantages, promotes the organization of
knowledge for more effective later use, and promotes long term retention."

Gagne (1965) described several types of learning and conditions necessary for each type of learning to occur. Gagne's problem solving seems the most related to what is called "inquiry." It involved combining learned principles into a great variety of new higher order principles. As Ober (1970) mentioned in his article, the learner learned to solve problems and create new solutions by using behavior principles. According to Gagne, the essential conditions for problem solving includes the learner's ability to identify the essential feature of the problem solutions and to recall relevant principles, and enough time for the learner to combine principles.

Schwab (1962) indicated that the understanding of the products of science cannot be attained unless the process is also understood and the process is inquiry. The learner must be provided with some information and questions asked. Suchman (1965) proposed an inquiry approach in which the learners are actively involved in the entire process. Especially, student motivation to inquiry can be stimulated by teacher's questions. The learners are trained to think, to seek for answers.

Schlenker (1970) reported a study in which middle-grade students having both inquiry-oriented teachers and lecture/demonstration teachers were tested on their understanding of science. He concluded that students receiving inquiry training developed a significantly greater understanding of science, as well as a greater fluency in inquiry and critical thinking.
In this study, the investigator's purpose in examining the inquiry process was to determine the teacher behaviors that had the most effect on student learning, that is, to determine the cognitive level of thought demanded by the teacher's questions.

Levels of Questions

Some teachers think that asking questions is the same as inquiry teaching. Nevertheless, few investigators would classify a teacher as an inquiry teacher if the questions the person asked students did not require significant thought. Evidence supporting the cognitive level of the teacher's question as important has been provided by many researchers (i.e., Bruner, 1960; Taba 1964; Schreiber, 1967; Straasser, 1967; Gallagher and Aschner, 1968; Ladd and Anderson, 1970; Tyson and Carol, 1970; Wright and Nuthall, 1970; Cunningham, 1971; Hunkins, 1972; Scott, 1973; Riley, 1978). Gallagher and Aschner (1968) provided strong arguments for attempting to increase teacher questioning levels, by pointing out that the kind of thinking in which students engaged depended upon the kinds of questions teachers asked.

Question Classification Systems

Questions are classified according to the level of thought required to answer them, the different types of answers that would be acceptable, or the way that basic knowledge appears to have been used in arriving at the answer. A number of reports and studies were concerned with the development of systems for use in classifying questions. Several systems (Carner, 1963; Fraenkel, 1966; Simon and Boyer, 1967; Gallagher and Aschner, 1968; Amidon, 1969; Shrable and Minnis, 1969) are content free and may be used with any subjects. The
primary intent of the developers appears to have been to provide a category system for teachers to use in analyzing their questioning habits and to improve their techniques regardless of the content area.

The category system defined in Bloom's Taxonomy of Educational Objectives (1956) was utilized to classify the cognitive levels of questions and responses. "Memory" referred to Bloom's level one, which he called "knowledge," and "above memory" referred to level two to six in Bloom's Taxonomy. These six levels of thinking formed the basis for several question classification systems (Sanders, 1966; Clegg, 1967; Davis and Tinsley, 1967; Farley, 1968). Some category systems (Amidon, 1969; Hunter, 1969) were concerned with student responses as well as teacher questions. Others were concerned not only with the types of thinking demanded by the teacher's questions but also with the flow of classroom interaction (Clements, 1966; Fraenkel, 1966; Minor, 1966; Douglass, 1967). Amidon's system (1969) used an expression of Flander's Interaction Analysis system for analysis of the verbal interaction and also used the four levels of cognitive production contained in the Gallagher-Aschner (1964) system for question classification (cognitive memory, convergent thinking, divergent thinking, and evaluative thinking questions) which has been modified from Guilford (1956). Hunter (1969) modified the revised Verbal Interaction Category System and combined it with the four categories of the Gallagher-Aschner (1964) system.

Blosser (1973) designed a system for use in analyzing questions asked in the context of science lessons. It can be adapted to apply
to other contents as well. Blosser's question category system may be used in combination with other systems of categorizing classroom interaction or in conjunction with other systems for analyzing questioning behavior.

In reviewing the literature on the various systems for classifying questions, it was decided that Blosser's Question Category System for Science (1973) would be most appropriate for use in this study because it was developed with particular reference to questions used for science classes. The handbook prepared by Blosser (1973) describes the Question Category System for Science. It is useful for training teachers in classifying questions and preparing questions. It was designed to help teachers become more aware of the questions they ask, the levels of thinking which these questions are intended to stimulate, and ways in which questioning techniques may be modified.

Blosser's Question Category System for Science is a relatively simple system, consisting of three levels of question classifications (see Appendix A). At the first level, questions are classified as either "closed questions," which seek a limited number of acceptable responses, or "open questions," for which there is a wide range of acceptable responses. The second level of classification further divides the closed and open questions into four subdivisions. The closed questions are divided into cognitive-memory and convergent thinking questions. Cognitive-memory questions are questions for which answers are directly available (textbook, previous lesson or discussion, film, filmstrip, chart, experiment, field trip, etc.). Convergent thinking questions seeks answers for which the information
is directly available but not in the form called for by the questions. Open questions are divided into divergent thinking and evaluative thinking questions. Divergent thinking questions seek answers for which the information is not directly available. Evaluative thinking questions seek answers for which the information may or may not be directly available and imply that students may be called upon to provide a defense their responses.

The third level of the Question Category System for Science divides the level two subdivisions into the types of thinking operation the questions call for. Cognitive memory questions are subdivided into recall and identify (name or observe). Convergent thinking questions are subdivided into associate and/or discriminate; classify, reformulate, apply, synthesize, close prediction, and make critical judgment. Divergent thinking questions are subdivided into give opinion, open prediction, infer, and imply. Evaluative thinking questions are subdivided into justify, design, judge according to the value linked with affective and the judge linked with cognitive behaviors.

Teachers learn, through experience, the kind of questions to use in different situations. Level three descriptions can serve to guide teachers in preplanning questions. The third level of the Question System Category for Science is based on the type of thinking operation that the questions require of respondents. However, as Blosser indicated, there is no guarantee that the thinking operation which the questions are designed to stimulate will produce a particular response in any of the students hearing the questions. The questions are
classified on the basis of their intent as perceived by the listener and not on the basis of the students' response. This is probably the weakness of most question classification systems. For example, a question designed to produce convergent thinking may only be a cognitive-memory question for a student who has read widely, has studied more than the assigned material, or has previously encountered the same question or one similar to it.

Nevertheless, Blosser's Question Category System for Science lends itself to various levels of classifying teachers' questions where the classifications are not based on detailed analyses of the intents of the questions. For example, questions can readily be classified at level one (open versus closed questions). At level two, questions require more analysis during classification into one of the four subdivisions.

Question classification systems are commonly based upon the cognitive demand made on the student in responding to a question. Questions soliciting memorized facts are categorized lower in this hierarchy than are questions requiring synthesis or evaluation. In this system, those questions that require only recall and memorization as defined by cognitive memory questions are low cognitive-level questions, and those questions which require either convergent thinking, divergent thinking, or evaluative thinking questions are high cognitive-level questions.

The general categories of questions are managerial questions, those which a teacher uses to facilitate classroom operation and
discussion, and rhetorical questions, which teachers use to reinforce a point but for which they do not expect any response.

Studies of Classroom Questioning Practices

Classroom observations of questioning have consistently revealed that teachers asked questions which primarily emphasized the recall of factual information and also asked too many questions while giving instruction (Stevens, 1912; Haynes, 1935; Corey, 1940; Floyd, 1961; Moyer, 1965; Guszak, 1967; Gall, 1970; Galloway and Mickelson, 1973).

In one of the earliest studies of classroom questioning, Stevens (1912) found that the number of questions teachers asked ranged from 0 to 122 in one period in one class; that is, teachers asked from two to four questions per minute. She inferred that if so many questions were asked so rapidly, there was little opportunity for students to think or make any judgment about questions, or do more than recall information. She also estimated that of the total 2000 questions asked, approximately only 200 to 300 (10 to 15 percent) of the questions were designed to elicit reflective thought.

Haynes (1935) analyzed questions asked in sixth-grade history classes and found that 77 percent called for factual answers. Gall (1970) reviewed both high school and elementary school teachers' questioning strategies and reported that at least two-thirds of the questions asked for factual information and one-third required the students to think. Galloway and Mickelson (1973) reported that 70 to
80 percent of the questions asked by elementary school teachers were of the memory variety.

Corey (1940) also studied classroom questioning practices and reported that about 38 percent of teachers' questions were not answered by students. Either there was no response or the teacher proceeded to answer the questions. The questions usually involved recitation of factual information, and only one out of four questions teachers asked appeared to require a thoughtful answer.

Floyd (1961) analyzed oral questioning activity in primary level classrooms in Colorado elementary schools. He concluded that teachers dominated classroom activity by asking memory questions.

Guszak (1967) studied transcriptions of teachers' questions and students' responses in elementary school classrooms over a three-day period and revealed that although 15.3 percent of the questions asked were rated as evaluation, there was serious doubt as to the thinking depth they required, since nearly all required "yes-no" responses.

Davis and Tinsley (1967), working with students in secondary school social studies classes, found that both student teachers and their students asked more memory questions than all other questions combined. They concluded that more attention needed to be given to different objectives in social studies and that preservice and inservice programs needed to emphasize the skill of classroom questioning.

Pate and Bremer (1967) contacted 190 teachers in grade one through six to investigate why teachers asked questions. They found that 68 percent of the respondents to their questionnaire asked
questions to check on the effectiveness of their teaching and 47 percent asked questions to check students' ability to recall facts. Pate and Bremer concluded that teachers used questions for a number of purposes. Some teachers apparently had not given much thought to the purposes questions can serve. Most teachers asked questions requiring short answers and did not give their students practice in using the skills of generalizing and inferring.

Clegg, Farley, and Curran (1967) designed a procedure for training teachers to recognize the different levels of cognitive behavior and to develop classroom learning procedures which included all levels of cognitive behavior. Six student teachers of grade one through six and their cooperating teachers were involved in the study. Clegg and his co-workers found that student teachers asked a wide range of questions, with only 26.77 percent of the total being at the knowledge level.

Farley (1969) worked with student teachers in grade one through three to improve the level of questions they asked. The student teachers were divided into two groups. The experimental group received instruction in applying Sander's modification of Bloom's taxonomy to their teaching procedures. Farley found that teachers in the experimental group asked a larger percentage of above-memory questions. The level of questioning seldom went above the "interpretation" category. An additional paper issued by Farley and Clegg (1969) contained a report that training in the use of the taxonomy did make a difference in the cognitive level of the
questions the student teachers asked but that the level of the questions seldom rose above that of "interpretation."

Wickless (1971) reported a study on the effectiveness of an inservice program for teachers, which centered on student questions. Analyses showed that a significant increase in the number of questions asked by students, as well as a greater variety of teacher questions, occurred after the teacher training. Arnold, Atwood, and Rogers (1974) and Winne (1979) reported their studies associated with training program and found that trained teachers asked more higher cognitive-level questions.

Other studies by Houston (1938), Parsons and Shaftel (1967), and Schreiber (1967) involved efforts to improve questioning techniques of inservice social studies teachers. The investigators suggested that teachers were able to exhibit some improvement in their questioning patterns through self-analysis. Schreiber found that training in questioning did make a difference in teachers' classroom performances: the percentage of factual recall questions decreased. Schreiber also found that the type of lesson being taught influenced the types of questions the teachers asked.

In 1969 personnel at the Far West Laboratory for Educational Research and Development were developing a series of mini-courses, each emphasizing different teaching skills, designed to help teachers improve questioning behavior. Minicourse one, "Effective Questioning in a Classroom Discussion," was designed for use by inservice elementary teachers. It was field tested, however, with preservice elementary school teachers at three different colleges (Kallenbach,
1969). Students on three different campuses were involved in student teaching when they participated in the field-testing program. When the three groups of students were compared, the differences favored the student teachers who had completed the minicourse. These individuals made significantly greater improvement in two scores: repeating student answers (goal: not to do this) and percentage of teacher talk (goal: to decrease this). Information obtained revealed that student teachers had too many demands on their time to allow for adequate use of the minicourse. They were unable to complete some of the required activities. Kallenbach (1969) suggested that, in a preservice setting, the minicourse should be offered on a two or three days per week basis rather than as a daily assignment. He urged that the work to develop minicourses be continued, because, despite the problems that arose, significant changes did occur in the methods of questioning and conducting discussion lessons that were used by the participating student teachers.

Bedwell (1975) reported a study which indicated that elementary teachers can be trained to classify, write, and ask questions according to cognitive level, and thereby raise the cognitive level of class discussions.

Kleinman (1965) conducted the study of questioning practices to ascertain the kinds of questions general science teachers asked. She investigated to see what relationship, if any, existed between the kinds of questions they asked and student and teacher behaviors. She also sought to determine whether the kinds of questions general science teachers asked influenced students' understanding of science.
According to Kleinman's category system, the "high" group consisted of teachers who asked more critical thinking questions during the lesson and the "low" group was composed of teachers who asked no critical thinking questions. Kleinman found that teachers in the "high" group asked significantly fewer rhetorical and factual questions and twice as many neutral questions as did those in the "low" group. She also found teachers in the "high" group tended to give directions or implied commands in questioning form. Kleinman grouped questions as higher type and lower type. Higher type questions were defined as those calling for comparisons, inferences, and support for conclusions. Lower type questions required simple recall and memorization, limiting responses. Kleinman classified neutral, rhetorical, and factual questions as "lower type" questions, and clarifying, associative, and critical thinking questions as "higher type" questions. She inferred from her study that teachers in the "low" group were limiting student responses rather than stimulating thinking. She summarized her findings that the kinds of questions teachers asked were fairly stable for each teacher and that teachers who asked more critical thinking questions tended to ask fewer questions per minute and to ask more neutral, clarifying, and associative questions rather than rhetorical or factual questions. Only one value question was asked during all observations.

Kleinman's study gave a clear picture of how science teachers ask questions. A survey of many studies resulted in additional information about questioning practices in sciences classes and indicated that the curriculum influenced the question types used by
teachers. A study by Sloan and Pate (1966) confirmed that the curriculum has much to do with teacher questioning behavior. They found that School Mathematics Study Group (SMSG) teachers asked significantly more higher level questions than traditional teachers.

In many other studies, carried out at different institutions, the concern was with inservice elementary school teachers who teach by using a new elementary school science program, Science Curriculum and Improvement Study (SCIS) Materials. These studies were conducted by Bruce (1971), Kondo (1968), Moon (1969), and Wilson (1969). SCIS teaching strategies call for at least three different teaching styles. The exploratory lesson requires little teacher intervention, and is designed to give students an opportunity to manipulate materials. The invention lesson requires that the teacher "invent" concepts and labels out of the exploratory phase. The discovery lesson gives students an opportunity to apply new concepts and to transfer them to new context areas. It would seem that invention lessons would call for memory and for generally lower-level questioning while the discovery lesson would require higher level questions (McGlathery, 1978:18).

Wilson (1969) analyzed the teaching procedures of 30 elementary teachers, 15 of whom were using the SCIS materials. When Wilson categorized the questions asked, he found that recognition and recall questions were asked a significantly greater number of times by teachers using the more traditional elementary school science materials. In contrast, the SCIS teachers asked a significantly greater number of analysis and synthesis questions, as well as more
skill-type questions. In addition, SCIS teachers asked more questions than did teachers using the traditional materials.

Bruce (1971) examined the extent of the relationship among selected teacher personality factors, science process skills, attitude toward teacher-student relationship, and the verbal characteristics of question asking in elementary school science classes. Using Bloom's (1956) taxonomy, Bruce found a significant difference in the level of questions asked before and during formal involvement in the SCIS program. The number of high level questions increased, with a significantly greater number of analysis questions being asked. Bruce noted that curriculum may determine types of questions asked by teachers. He suggested, for example, that the use of Science Curriculum Improvement Study (SCIS) Materials may cause the teacher to ask higher level questions.

Moon (1969) also worked with elementary school teachers and analyzed selected examples of verbal behavior patterns in science class activities. Moon's analysis involved the use of Flanders' Interaction Analysis System, the Science Teaching Observational Instrument, and the Science Process Test for Elementary School Teachers. Moon found that after the SCIS teachers had participated in a workshop designed to involve them in the use of SCIS materials, their question preferences changed from low-level questions to high-level questions.

Kondo (1968) analyzed the questioning behavior of teachers using the SCIS program to determine the effect that the curriculum and content had on the questions and question techniques used. He found
that teachers who use complex questioning strategies and patterns tended to use them regardless of the type of lesson.

Hunter (1969) analyzed the verbal behavior of elementary school science teachers. She inferred that if a broad question was not immediately answered by students, a teacher would delimit it until it became one of the cognitive memory type questions. According to Hunter's study, when verbal behaviors were compared between groups, teachers in the experimental group, who participated in the inservice program, talked significantly less than those in the control group, but their verbal patterns were not different. The question-asking behavior of most science teachers appeared to be functioning at the level of cognitive-memory thinking operations. This would appear to be true at both the elementary and secondary school levels.

Arguments on the proper mixture of higher and lower level questions came about from the results of many studies.

Konya (1972) reported a study in which teachers controlled the percentages of higher level questions. He concluded that the best balance of student response seems to be when teachers ask higher and lower level questions in equal amount. Tisher (1971) found that students exposed to an equal mixture of higher and lower level questions achieved better than students exposed to mainly lower level or higher level questions. Lamb (1976) suggested that to enhance student achievement in science, teachers should concentrate on developing a balance between higher and lower level questions.

Attempts have been made to help science teachers improve their questioning techniques (Cunningham, 1968; Masla, 1969; Johnson, 1969;
Konetski, 1969; Koran, 1969; Blosser, 1970; Riley, 1980). Both preservice and inservice teachers were included in these studies.

Cunningham (1971) attempted to change the question-phrasing practices of elementary school science teachers so that they would ask a greater number of divergent thinking questions (as defined by Gallagher and Aschner, 1964). He worked with 40 students enrolled in two science education methods courses. Students were pretested and then posttested after seven periods of instruction on question phrasing. Cunningham found a significant decrease in the number of cognitive memory questions from pre- to post-test, as well as a significant increase in the number of divergent thinking questions. There were no significant changes in the number of convergent thinking questions asked nor any change in the number of evaluative thinking questions asked.

Masla (1969) studied what effect instruction in an interaction analysis system had on the inquiry patterns of elementary school science teachers. Seventy-six preservice elementary school teachers were pretested with the Elementary Teacher's Science Inventory (ETSI) to determine their competency in science processes. They were divided into high and low competency groups on the basis of their ranked scores and were then randomly assigned by rank to either an experimental or a control group. The experimental group received intensive instruction in interaction analysis. After instruction was completed, 40 students from the total group were randomly selected to teach science lessons to elementary school children. Masla recorded and analyzed verbal interaction. The means of question ratios
indicated a significantly greater number of open-ended questions were asked by teachers in the experimental group. The level of competency in science processes did not appear to be a factor affecting the verbal inquiry patterns of the preservice teachers.

Koran (1969) worked with preservice elementary school science teachers. He compared the results of three groups: no treatment, specific instruction only, specific instruction plus presentation of a videotaped model of a teaching behavior to be acquired. The "specific instruction" portion of the study consisted of a four-hour session in which the students worked with materials from "Science: A Process Approach," while discussing the objectives of lessons, lesson format, and teaching strategies used. The model consisted of a 14-minute videotape of a teacher conducting a science lesson with four elementary school students. In the model, the teacher's observations and classification of questions were highlighted. Koran analyzed the data obtained and found that the students who had received instruction and viewed the videotape, scored significantly higher on both within group and between group differences than did the two control groups (specific instruction only; no treatment).

Johnson (1969) worked with inservice elementary school teachers in a summer program designed for teachers of students from disadvantaged areas. Five teachers participated in a follow-up study in which Johnson attempted to develop a model program for improving questioning behavior in science instruction. The study used the perform-analyze-perform approach. The teachers were videotaped during three 20-minute science lessons. Johnson found evidence to
suggest important gains in both quality and quantity of productive thinking questions asked.

Konetski (1969) worked with preservice secondary school science teachers. He attempted to change the number of divergent thinking and evaluative thinking questions, as well as the total number of questions, they asked. Student teachers were pretested and grouped on the basis of the number of divergent thinking and evaluative thinking questions they asked while teaching a short science lesson. An equal number of high-ranking and low-ranking students were then randomly assigned to experimental and control groups. Those in the experimental group were provided with a programmed instructional booklet designed to help them improve their questioning. Students in the control group received only informal instruction on questioning. The experimental group worked on two instructional strategies. One aimed at developing skill in classifying questions; the other was designed to develop ability in constructing questions for inquiry-oriented science lessons. In individual conferences with their laboratory instructor, students in the experimental and control groups discussed their questioning practices in relation to the use of divergent thinking and evaluative thinking questions. Students taught two more short science lessons which were recorded and analyzed. Konetski classified questions as (1) cognitive memory and convergent or (2) divergent thinking and evaluative thinking. After classifying and analyzing the questions from the tape recordings, Konetski concluded that the instruction given the experimental group (1) significantly and positively affected the number and proportion
of divergent thinking and evaluative thinking questions asked and (2) significantly and negatively affected the total number of questions asked. The conferences of preservice teacher and instructor were more effective in producing desired changes in questioning behavior when used in conjunction with a programmed instruction on questioning.

Blosser (1970) designed a study (1) to assess the effectiveness of an instructional procedure designed to develop the skill in questioning, (2) to determine if skill developed during the instructional sequence would transfer to the student teaching experiment, and (3) to determine possible relationships of selected personality factors to the development of questioning skill. The study extended over three quarters and involved a total of 42 preservice secondary school science teachers. She found that questioning appeared to be a skill that can be developed through instruction and practice. The development of questioning skill did not appear to be limited by intelligence, sex, personality type, or educational set, insofar as her study concerned.

**Effects of Wait-Time and Teacher Questions**

Teachers tend to ask questions far too rapidly and do not allow enough time for students to think before answering questions. Many studies related to teaching strategies are concerned with an extended wait-time, providing students with additional time to engage in the activity by thinking of a response.

Rowe (1969) investigated the verbal behavior pattern of inservice elementary school teachers as they taught science. One questioning
strategy that she considered was the extension of teacher question wait-time. Bellack (1966) had identified a common questioning cycle within classrooms, composed of three components: the teacher's question, the student's response, and the teacher's reaction to the response. Rowe (1969) expanded this questioning cycle by identifying two pauses (or wait-times). The first pause, wait-time I, was the period of time between the end of the teacher's question and the beginning of a student response or further teacher talk. The second pause, wait-time II, was the period of time that a teacher waited before replying to a student response. Rowe stated that factors other than the level of knowledge possessed by the teacher were involved in the failure of students to learn science. One factor was characterized by a rapid question-answer sequence in teaching strategy. In studying wait-time aspects of the questioning cycle, Rowe found that experienced teachers allowed an average of one second for a student to start an answer before they either repeated, or rephrased, the question or called on another student. After a student response, teachers generally waited slightly less than one second before repeating the student's answer, rephrasing it, or asking another question.

Rowe and her colleagues (1974a) experimented to test the effect of increasing the length of time a teacher waited for a student response, increasing the length of time a teacher waited before responding to a student, and decreasing the pattern of reward and punishment delivered to students. Rowe found that when teachers increased the average wait-time five seconds or more after asking a question, the length of student responses to questions increased
and that as teachers increased their wait-time, they began to exhibit more flexibility in the kinds of questions they asked. In Rowe's study, analysis of more than 900 tapes showed that when mean wait-times of three to five seconds were achieved through training, values on ten student outcome variables changed as follows:

1. the length of student responses increased;
2. the number of unsolicited, but appropriate, responses increased;
3. the incidence of failure to respond decreased;
4. confidence, as reflected by a decrease in the number of inflected responses, increased;
5. the incidence of speculative responses increased;
6. the incidence of child-child comparisons of data increased;
7. the incidence of evidence-influence statements increased;
8. the frequency of student questions increased;
9. there was an increase in the incidence of responses from students rated by teachers as relatively slow learners; and
10. the variety in type of verbal behaviors of students increased.

In addition to these changed student behaviors, Rowe noted that at least three teacher behaviors changed when wait-time increased, as follows:

1. the teacher demonstrated a greater response flexibility;
2. the number and type of questions asked by the teacher changed;
3. there was some indication that teacher expectations improved for performance of students rated as relatively low.
Moriber (1971) suggested that one problem which impeded wait-time research and training teachers to extend wait-time was in not having an effective method to train teachers to control their wait-time. Subsequently, researchers studying the wait-time principle have used various methods to train teachers to increase their wait-time.

Although there is evidence from many studies that wait-time is an important classroom variable, teachers continue to have difficulty in maintaining an average wait-time greater than three seconds (Garigliano, 1972; Arnold, Atwood, and Roger, 1973; Lake, 1973; Rowe, 1974a; De Ture, 1979; Tobin, 1980).

Rowe (1969) reported that the elementary teachers she worked with achieve the criterion wait-time of three seconds by employing audiotape teach-reteach cycles accompanied by specific feedback.

Garigliano (1972) and Arnold, Atwood, and Roger (1973) conducted a study similar to those reported by Rowe, but the participating teachers were unable to attain mean wait-time of three seconds.

Teachers do not control wait-time I, which can be terminated with either teacher or student talk. De Ture (1979) reported on a training study in which no teacher attained an average wait-time I above 1.8 seconds. Effective training programs for extending wait-time are considered important. Teachers are confronted with difficulty in training in extended wait-time because teachers do not have absolute control over the length of relevant pause. Student talk can reduce the length of wait-time I. Lake (1973) suggested that wait-time should be redefined in terms of the period of silence that precedes teacher's talk. His suggestion was made as an attempt to overcome an
extended wait-time (see Figure 1). This conceptualization offered by Lake has been supported in a study by Fowler (1975). Fowler partitioned wait-time into four species: teacher reaction wait-time, student reaction wait-time, teacher initiated wait-time, and student initiated wait time. By partitioning wait-time in this way, Fowler suggested that a broad range of hypotheses can be tested. Tobin and Capie's 1981 article indicated that teacher wait-time is a valuable variable in understanding classroom processes. Tobin (1980) suggested that a decision to use the definition of wait-time in the study for the interpretation of experimental implies the results for different hypotheses to be tested.

**Effects of Wait-Time and Cognitive-Level Questions**

Boeck and Hillenmeyer (1973) investigated the relationship between cognitive level of questioning and wait-time I. They reported that wait-time was no longer after high-level questions than after low-level questions.

Arnold, Atwood, and Rogers (1973) reported that teachers had a short wait-time regardless as to whether a question was simple or complex. In subsequent studies, Arnold, Atwood, and Rogers (1974) mentioned that students took more time to come up with responses at the analysis level than at the knowledge, comprehension, application, synthesis, or evaluative level. The results reported from the study suggested that longer pauses preceded analysis and synthesis questions.
Rowe's Definitions of Wait-Time

Wait-Time I: Teacher question --> Pause --> Teacher or student talk
Wait-Time II: Student response --> Pause --> Teacher comment or question

Lake's Definitions of Wait-Time

Teacher Wait-Time

Example 1: Student talk --> Pause --> Teacher talk
Example 2: Teacher talk --> Pause --> Teacher talk

Student Wait-Time

Example 1: Teacher talk --> Pause --> Student talk
Example 2: Student talk --> Pause --> Student talk

Fowler's Definitions of Wait-Time

Teacher Reaction Wait-Time

Example: Student talk --> Pause --> Teacher talk

Student Reaction Wait-Time

Example: Teacher talk --> Pause --> Student talk

Teacher Initiated Wait-Time

Example: Student talk --> Pause --> Student talk

Student Initiated Wait-Time

Example: Teacher talk --> Pause --> Teacher talk

Figure 1. Schematic representative of different definitions of wait-time. (Source: Kenneth G. Tobin and William Capie, Wait-Time and Learning in Science, 1981, p.4.)
Lake (1973) demonstrated that the use of extended wait-time led to an increase in higher cognitive-level student responses and that the incidence of conversational sequence and alternative explanation responses in student talk increased.

Fowler (1975) reported that the use of an increased wait-time according to his definition (see Figure 1) led to an increase in student-to-student interactions, significant increase in the frequency of student initiated statements, and decreases in student interruptions. Winterton (1976) obtained similar results in his study of effects of extended wait-time on verbal response characteristics of Pueblo Indian students.

The extensive study by Rice (1977) to investigate whether wait-time, the number of questions asked, and the cognitive level of those questions would improve if preservice elementary teachers were given instruction dealing with various question-asking strategies. Ten elementary education majors were assigned at random to experimental and control groups. The experimental manipulation consisted of viewing films on questioning strategy, reading an article on the importance of wait-time, and analyzing one's own micro taught lessons. In spite of the small sample, significant results were obtained for the three hypotheses.

Hassler, Fagan, and Szabo (1980) replicated some of Rowe's research in language arts classes. They reported that teachers trained in wait-time techniques asked fewer questions, asked more higher level questions, and had longer student responses.
Effects of Wait-Time on Student's Science Achievement and Other Variables

Anderson (1978) reported his study on students in a physics lesson class. He found that longer student responses were associated with the use of extended wait-time, and physics content was perceived to be less difficult in extended wait-time classes. In addition, the short wait-time treatment was more effective than the long wait-time treatment for teaching physics facts and concepts to low ability students. He stated that the study on long wait-time or short wait-time must be regarded with caution to achieve the desirable outcome.

Tobin and Capie (1981:7) cited a nonschool situation studied by Marsh (1978) in which museum guides were able to increase the number of questions they received by using an extended wait-time of five to six seconds. Marsh did not provide a definition of wait-time in the report of the research.

Anshutz (1975), Riley (1980), Tobin (1980), Tobin and Capie (1981), and Samiroden (1982) studied the effects of wait-time on student science achievement. Anshutz (1975) reported no science achievement differences between short and long wait-time I groups for students in grade 3 and 4. Riley (1980) reported an interaction between wait-time I and the cognitive level of questioning on science achievement for students in grade 1 through 5. He remarked that a decrease in achievement occurred when wait-time was extended from medium to long for low-level questions and that achievement was increased when wait-time was extended for high and mixed cognitive
questioning. Riley suggested that the optional wait-time to be used
may be dependent on the cognitive level of questioning and the
cognitive level of the outcomes to be achieved. The study by Tobin
(1980) showed a significant relationship between teacher's extended
wait-time and science achievement for students in grades 5, 6, and 7.
It indicated that extended teacher wait-time was beneficial for
students' thinking operation.

Tobin and Capie (1981) made an extensive review of studies which
had investigated the effects of an increased teacher wait-time on
student engagement rates and integrated process skill achievement for
students in grades 6, 7, and 8. They suggested that a wait-time
average of three seconds was favored over short and long wait-time
values.

Samiroden (1982) studied the use of two different higher
cognitive-level question wait-time ranges by biology student teachers.
He examined the relationship between the biology student teachers'
higher cognitive-level question wait-time range and student
achievement and determined whether 11th grade biology students
perceived student teachres who used longer, higher cognitive-level
question wait-time range as being more or less effective than student
teachers who use shorter, higher cognitive-level question wait-time
range. He reported that 11th grade biology students given a longer
wait-time (4-7 seconds) demonstrated higher levels of achievement than
short wait-time range (1-4 seconds) groups and the students perceived
student teachers who used a 4-7 second higher cognitive level
wait-time range as being less effective than student teachers who used
a 1-4 second higher cognitive-level question wait-time range. He concluded that neither mean wait-times nor wait-time ranges are adequate descriptors of teachers question wait-time when used separately.

Most research has been primarily directed toward training teachers to implement an extended wait time.

Chewprecha, Gardner, and Sapianchai (1980) compared three training methods to modify questioning and wait-time behaviors of 77 experienced Thai secondary school chemistry teachers. Group I teachers studied from three instructional pamphlets that were mailed to them, one per month for three consecutive months. Group II teachers were mailed three audiotapes with directions to listen to and comment on the types of questions the teacher used in the model lesson. Group III teachers were mailed the same three audiotapes as Group II, with instructions to listen to and classify the teacher's questions by the category system in which they had been trained.

The use of instructional pamphlets was found to be more effective than qualitative or quantitative analysis of audiotapes in training Thai teachers. De Ture (1979) investigated the effects of feedback on the ability of teachers to implement an extended wait-time. Two methods of training were used, video and audio, with and without a feedback component. She reported that the use of a video technique with feedback, enables teachers to attain a mean wait-time II of 3.7 seconds, significantly higher than the mean wait-time attained by groups using other training techniques. She also stated that no teachers in the study were able to attain an average wait-time I above 1.8 seconds.
From the studies that described training methods used to assist teachers in increasing their wait-time, it appears that when teachers were provided with a question-asking strategy and information as to what to expect when question wait-time increased, their wait-time usually increased. However, the emphasis must be on the training program provided for the improvement of teachers' questioning strategy. As Rogers (1972) claimed, teachers need training skills for asking effective questions.

**Summary**

Educators agree that questioning and questions are among the most commonly used teaching strategies. Within the past decade researchers have attempted to develop and design training programs to help teachers to improve their questioning skills in order to enhance inquiry science teaching. The various question classifications system that have been developed to identify questions are based on the intention of the questions. Blosser's Category System for Science is the system that covers a variety of questions asked by science teachers and aids teachers in self-analysis. The studies cited, in science and in other content areas, revealed that teachers tend to ask low cognitive-level questions and ask too many questions.

Many studies on wait-time indicated that, regardless of whether teachers asked high or low cognitive-level questions, they expected students to answer within a short period of time. They did not allow enough time for students to think before answering their questions.
Research studies attempting to improve teacher's ability to ask higher cognitive questions, extend wait-time, and talk less in class have been few and inconclusive. Studies in these areas are highly dependent on effective training procedures to assist teachers improve their questioning strategies.
CHAPTER 3  
METHODOLOGY

This chapter consists of a discussion of the design of the study, the population involved, data-gathering, and treatment procedures. It also includes a description of the development of an instructional pamphlet, procedures for determining reliability (interobserver agreement) and recording. Finally, the statistical technique used in analyzing data is discussed.

Design of the Study

The experimental design for the study was the Pretest-Posttest Control Group Design (Campbell and Stanley, 1966). The Pretest-Posttest Control Group Design was as follows:

\[ R_{101} \quad X \quad 0_2 \]
\[ R_{201} \quad 0_2 \]

In this diagram, X designates a treatment, and 0, an observation or measurement.

Population and Sampling

Science Teachers

Science teachers at the junior high school level (Mattayom 1, 2, 3) in Bangkok, Thailand, were selected in the following manner: Seven schools in Bangkok were randomly selected. The researcher visited the
principals of the schools, bearing a letter of introduction from the Education Department, Kasetsart University, which asked the school principals' permission to conduct the study in their schools. The letter described the study in general and requested the principals to ask teachers in Mattayom 1, 2, 3 to participate in the study.

Sixty-eight teachers were willing to participate in the study. The teachers were randomly assigned to an experimental group and a control group. The teachers' names were written on slips of paper which were placed into a box and alternately drawn for assignment to one of the groups. That is, the first name drawn was assigned to the experimental group, and the second name drawn was assigned to the control group, and so on, until 34 teachers were assigned to each group.

Data on the characteristics of the teachers are shown in Table 2. While both groups were predominately female, the control group had the larger percentage of women: 82% to 68%. For degree held, most teachers in both groups held bachelor's in education (control, 85%; experimental, 82%). Likewise in teaching experience, the groups were similar, with most teachers having 4-10 years (control 65%; experimental, 71%). The groups differed somewhat on age. The percentage of teachers 36 or older in the control group was 18%, compared to 45% for the experimental group. Half (50%) of the control group was 31 to 35; while in the experimental group less than one-third (29%) were 31 to 35.

The initial sample size had 34 subjects per cell. Unfortunately, five subjects for various reasons could not complete
Table 2

Subjects Classified by Sex, Age, University Degree Held, and Total Teaching Experience

<table>
<thead>
<tr>
<th></th>
<th>Experimental</th>
<th></th>
<th>Control</th>
<th></th>
<th>Total</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F&lt;sup&gt;a&lt;/sup&gt;</td>
<td>p&lt;sup&gt;b&lt;/sup&gt;</td>
<td>F</td>
<td>P</td>
<td>F</td>
<td>P</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>11</td>
<td>.32</td>
<td>6</td>
<td>.18</td>
<td>17</td>
<td>.25</td>
</tr>
<tr>
<td>Female</td>
<td>23</td>
<td>.68</td>
<td>28</td>
<td>.82</td>
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<td>.75</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 or under</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>.03</td>
<td>1</td>
<td>.02</td>
</tr>
<tr>
<td>26-30</td>
<td>9</td>
<td>.26</td>
<td>10</td>
<td>.29</td>
<td>19</td>
<td>.27</td>
</tr>
<tr>
<td>31-35</td>
<td>10</td>
<td>.29</td>
<td>17</td>
<td>.5</td>
<td>27</td>
<td>.40</td>
</tr>
<tr>
<td>36-40</td>
<td>9</td>
<td>.26</td>
<td>4</td>
<td>.12</td>
<td>13</td>
<td>.19</td>
</tr>
<tr>
<td>41 or over</td>
<td>6</td>
<td>.19</td>
<td>2</td>
<td>.06</td>
<td>8</td>
<td>.12</td>
</tr>
<tr>
<td><strong>University degree:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.Ed.</td>
<td>28</td>
<td>.82</td>
<td>29</td>
<td>.85</td>
<td>57</td>
<td>.84</td>
</tr>
<tr>
<td>B.Sc.</td>
<td>3</td>
<td>.09</td>
<td>2</td>
<td>.06</td>
<td>5</td>
<td>.07</td>
</tr>
<tr>
<td>M.Ed.</td>
<td>3</td>
<td>.09</td>
<td>3</td>
<td>.09</td>
<td>6</td>
<td>.09</td>
</tr>
<tr>
<td><strong>Teaching Experience:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 4 years</td>
<td>3</td>
<td>.09</td>
<td>2</td>
<td>.06</td>
<td>5</td>
<td>.07</td>
</tr>
<tr>
<td>4-10 years</td>
<td>24</td>
<td>.71</td>
<td>23</td>
<td>.65</td>
<td>46</td>
<td>.68</td>
</tr>
<tr>
<td>Over 10 years</td>
<td>7</td>
<td>.20</td>
<td>10</td>
<td>.29</td>
<td>17</td>
<td>.25</td>
</tr>
</tbody>
</table>

Note: Total n = 68; 34 each group.

<sup>a</sup>F = frequency

<sup>b</sup>p = proportion
their responsibility in the study. In the experimental group, one moved to another school, and one was about to give birth and did not complete training. Another one in the experimental group and two teachers in the control group failed to record their lesson and the research was unable to collect the posttest tapes. Since the research was designed for samples of equal cell size, the researcher adjusted both experimental and control groups by discarding the pretest tapes recorded for subjects for which there were no posttests. This reduced the sample size to 31 teachers of junior high school (M₁, M₂, M₃) in each group, experimental and control.

The proposed sample size of 31 subjects per cell provided for a power level of .80 and an effects size of .35; the alpha level was set at .05. This provided that hypotheses results would reflect a Type II error not more than 20% of the time (Cohen, 1977:384). There were 31 subjects per cell, satisfied the criteria.

Data Gathering and Treatment Procedures

All subjects met with the researcher, who explained the study and how the study might contribute to their professional growth. They were told the following:

1. The study was designed to study teacher verbal behavior in the classroom.
2. It would not evaluate individual teachers.
3. Others would not be allowed to see or use the tapes without teacher's permission.
4. The researcher requested teachers not to discuss the research with other teachers.

After meeting with the researcher, the teachers were told of their assignment to either one of two groups (experimental or control) without knowing which group they were in. A date was set for the next meeting with each group.

The teachers assigned by random selection to the control group participated only in the pretest and posttest measures. Teachers assigned by random selection to the experimental group participated all through the study, meeting four times during the training periods, as well as for the pretest and posttest. The activities of experimental and control groups are summarized in Table 3. The study took place over 12 weeks of the first semester (June 16-November 12) of the 1983 Thai school academic year.

Pretest

All science teachers involved in the study were asked to tape two 50-minute science lesson periods, using a topic chosen from the content involved in their teaching schedules, in the first week. The researcher provided each teacher in both groups with blank cassette and tape recorder, in order to make it convenient for the teachers to record their own lessons. These tapes were used as a pretest. Teachers completed taping before the experimental group received the treatment. Each pretest tape was analyzed by the researcher. Blosser’s Category System for Science was used to classify the cognitive-level questions asked by each teacher. A stopwatch was
Table 3
Summary of Activities of Experimental and Control Groups

<table>
<thead>
<tr>
<th></th>
<th>Experimental Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>Taped and analyzed for the number of each cognitive-level of teacher's question asked, teacher wait-time, and length of time teacher talked in each class session</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>Trained to increase number of high-level questions and prolong wait-time (average of 3 seconds)</td>
<td>Received no treatment</td>
</tr>
<tr>
<td>Posttest</td>
<td>Taped and analyzed for the number of each cognitive-level of teachers' question asked, teacher's wait-time, and length of time teacher talked in each class session</td>
<td></td>
</tr>
</tbody>
</table>
used to measure the teacher's wait-time and to determine the length of time of teacher talk.

Treatment for the Experimental Group

First meeting. The researcher met with teachers in the experimental group and explained their part in the study. The following items were covered in the first meeting.

1. Each teacher received a pamphlet designed to improve teacher questioning behaviors. The pamphlet defined and categorized cognitive-level questions, using Blosser's Question Category System for Science, and indicated the way to improve teacher's wait-time. (See Appendix A.)

2. The researcher openly discussed use of materials with the teachers in order that they become familiar with the general format of the Question Category System. Teachers were asked to study and use the pamphlet for self-training.

3. The researcher instructed teachers in how to categorize and/or measure (a) questions and (b) wait-time, during self-analysis. Emphasis was placed on studying the pamphlet and using the category system to improve their teaching performance.

4. Teachers were supplied with blank tape for later use in training in both categorizing questions and measuring wait-time.

5. Teachers were asked to set dates for the next meeting with the researcher, who preferred one teacher or small groups (two or three teachers) at a time. Each meeting took about 50 minutes.

Second meeting. Teachers, singly or in groups of two or three, met with the researcher as scheduled ahead, to discuss the category system, question strategy and wait-time training described in the
The teacher was asked to make a tape of their actual teaching behavior and to make a self-analysis of the tape. They were asked to use Blosser's Category System to categorize their questions. The teachers found that they had asked very few or no high cognitive-level questions. They were encouraged by the researcher to read the pamphlet and do the exercises provided in the pamphlet in order to get familiar with all types of cognitive questions and make use of the questions properly in their lesson plans. The teachers were also asked to practice waiting longer for student to respond to their questions and to measure wait-time to see how they improved.

**Third meeting.** Again singly or in small groups, teachers met for about 50 minutes with the researcher as scheduled ahead. The self-analysis of the tape made by each teacher was discussed. Teachers were asked to make a second training tape and self-analysis. Emphasis was placed on their asking cognitive questions as categorized questions using Blosser's system. The discussion was on the teacher asking more higher cognitive-level questions and waiting longer (approximately 3 seconds) for students to respond to their questions.

**Fourth meeting.** The researcher met with the teachers to go over self-analysis on categorized questions and wait-time of the second training tape. If improvement was still needed, the teacher was asked to make another tape in order to improve skills as suggested in the pamphlet. Some teachers offered to do so because they felt they needed more time to work on the training procedures.

**Posttest**

Posttesting occurred five to six weeks after pretesting. All science teachers in the experimental and control groups were asked to
tape two 50-minute science lesson periods. These tapes were analyzed by the researcher using Blosser's Category System and a stopwatch. Questions that the teachers asked were categorized into cognitive memory questions, convergent thinking questions, divergent thinking questions, evaluative thinking questions, as well as closed and open questions, and tabulated in order to determine the number of each cognitive-level questions teachers asked. The stopwatch was used to measure teacher wait-time, the pause between teacher's question and subsequent student response or teacher response, and the length of time each teacher talked in each class session. The resulting data were used as posttest data in the statistical analysis.

The Research Instrument

Development of Instructional Pamphlet

From experience, the researcher knew that Thai teachers always have full teaching loads. In addition they have to participate in a variety of other school activities, such as guiding the science club, helping slow learners, and managing class routines, etc. This causes many teachers to develop a view of teaching as a day-by-day activity. The researcher concluded that it would be difficult to add anything to their routine schedule such as a long series of workshops. As a result, it was decided that the training program should include something the teachers could read in their spare time, such as an instructional pamphlet on questioning behavior and wait time.

An instructional pamphlet was prepared in the Thai language by the researcher (see Appendix A). The materials covered in this
pamphlet were developed from Blosser's (1973) handbook and from ideas gained from a survey of literature related to questions and questioning. The pamphlet contained a discussion of certain characteristics of effective questions (those which elicit the type of student response the teacher hoped to stimulate), functions which questions could serve in a lesson, and the use of a question as a teaching strategy. Wait-time was discussed. The pamphlet also discussed how a training program related to effective questioning could help teachers improve their teaching strategies. (See Appendix A).

The instructional pamphlet was critically reviewed, discussed, and evaluated by experienced teachers at Kasetsart University Laboratory School. It was edited and approved by Thai teachers (two science teachers, one Thai language teacher, and one social science teacher).

The pamphlet was developed to serve these purposes:

1. To present a general knowledge of classroom questioning technique that enhances teaching science by inquiry.

2. To present the Question Category System for Science developed by Blosser as an effective system for classifying teacher's questions.

3. To present the wait-time strategy that would improve student's learning science.

4. To provide suggestions to improve teacher classroom questioning and increase wait time.

5. To present a training program which would result in less teacher talk in each class session.
Blosser's Question Category System for Science was chosen because the system could be used to train teachers, to cover a variety of questions asked by science teachers, and to aid teachers in self-analysis. Blosser (1973) had tested the system by observing classrooms of experienced teachers and of student teachers to determine whether the categories were inclusive enough for the purposes of questioning training. Blosser's Question Category System is a relatively simple system that is used by many researchers. It is not difficult for teachers to learn and use in categorizing their questions and practicing to increase the number of higher cognitive-level questions they ask. Blosser's system is shown to be reliable and valid for use by science teachers in questioning training.

The pamphlet contained a translation, as well as explanation, of parts of Blosser's category system. Basically, the researcher followed the presentation of Blosser's handbook of Question Category System for Sciences, but it was presented in a way to make easier for Thai teachers to use and follow. Some examples were changed to make them relevant to the knowledge level of science for Mattayom 1, 2, and 3 and Thai culture.

Determining Reliability (Interobserver Agreement)

Six Thai science teachers who were engaged in teaching science at Mattayom 1, 2, and 3 at Kasetsart University Laboratory schools were asked to train in asking questions categorized according to Blosser's Category System for Science. They were given the pamphlet to study
and asked to discuss the category system and to use the system to categorize their questions in their lessons. After three weeks' training the six teachers were asked to tape two 50-minute-period science lessons. The researcher then randomly selected four of the six sets of tapes. The four tapes were transcribed and provided for the curriculum specialists to categorize the teachers' questions.

Five curriculum specialists who specialize in questioning strategies, from the IPST and Chulalongkorn University, were also invited to participate in the study. The researcher asked each curriculum specialist to use Blosser's Question Category System for Science to analyze, categorize, and rate the questions in the four sets of transcribed taped lessons. The intention of using the transcripts of these four sets was to provide for consistency among the observants.

The curriculum specialists were asked to independently analyze and categorize teachers' questions in the four sets of transcripts, into four categories according to Blosser's system. They were asked to indicate any remarks they had. General discussion as to why they categorized questions as they did followed. The researcher also analyzed and categorized teachers' questions in the four sets of transcripts, following the same instructions as given the curriculum specialists.

The researcher was advised by a specialist from Chulalongkorn Research Center in Bangkok, regarding the procedure to use in determining reliability or interobserver agreement. Data were obtained in the following manner:
First, the researcher recorded how each observant (five curriculum specialists and the researcher) categorized teachers' questions for each set of the four transcripts. Table 4 shows how data from these analyses were recorded. For example, on questions 1, 3, 4, and 5, the observer agreement was "yes" because the ratio of questions categorized by observants was 5/6 and 6/6. On question 2 the observer agreement was "no" because ratio of question categorized by observants was lower than agreement.

Secondly, for each set of transcripts the researcher asked the observants for their reasons in categorizing the questions as they did when the observants disagreed on categories. In some cases, reasons given were very good and agreement was reached by the raters on the category for a question. The criterion for agreement among observants on each set of questions was set at 95% (95 out of 100 questions) in agreement with recommendation by the curriculum specialist from Chulalongkorn Research Center. If this criterion was met for a set, the categorization of questions by the observants was considered reliable. Reliability data are shown in Table 5. The total number of questions in each set was 67, 133, 115, and 98 questions, respectively. The observants were in agreement upon 65, 128, 110, and 95 questions but were in disagreement on 2, 5, 5, 3 questions for each set, respectively. The percentage of agreement was 97.0, 96.24, 95.65, and 96.94, respectively. The criterion of 95% was exceeded for each set. The researcher concluded, therefore, that reliability and consistancy of the instrument were shown.
### Table 4

**Sample of Data**

**Question Categorized by Observants**

<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>Ratio</th>
<th>Observer Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(Question detail asked)</td>
<td>D</td>
<td>D</td>
<td>M</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>5/6</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>D</td>
<td>E</td>
<td>M</td>
<td>D</td>
<td>E</td>
<td>E</td>
<td>-</td>
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</tr>
<tr>
<td>3</td>
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<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
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<td>C</td>
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<tr>
<td>4</td>
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<td>C</td>
<td>C</td>
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<td>D</td>
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<td>C</td>
<td>5/6</td>
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<tr>
<td>5</td>
<td></td>
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<td>D</td>
<td>D</td>
<td>D</td>
<td>C</td>
<td>D</td>
<td>5/6</td>
<td>Yes</td>
</tr>
</tbody>
</table>

n

M = cognitive memory question  
C = convergent thinking question  
D = divergent thinking question  
E = evaluative thinking question

### Table 5

**Set of Questions**

<table>
<thead>
<tr>
<th></th>
<th>Set I</th>
<th>Set II</th>
<th>Set III</th>
<th>Set IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of questions</td>
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<td>133</td>
<td>115</td>
<td>98</td>
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<tr>
<td>Agreed upon questions</td>
<td>65</td>
<td>128</td>
<td>110</td>
<td>95</td>
</tr>
<tr>
<td>Disputed questions</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Percentage of agreement</td>
<td>97.0</td>
<td>96.24</td>
<td>95.65</td>
<td>96.94</td>
</tr>
</tbody>
</table>
Recording Procedure

The researcher transcribed the pretest and posttest tapes for both the experimental and the control group and categorized teachers' questions into four categories, according to Blosser's Question Category System for Science (see Appendix B).

Each tape was played twice. A stopwatch was used to measure wait-time after each teacher's question. The two measures for each teacher's question were averaged to determine wait-time for each question. Total wait-time accumulated was recorded for each subject. In addition, the researcher tabulated and recorded wait-time for both closed questions and open questions. The total time a teacher talked in each class session was also recorded. These data were coded for analysis.

Statistical Analysis

In some experimental situations it is not possible to design the experiment so as to control for differences in the experimental units. However, in such experimental situations it may still be possible to control certain sources of variation by taking additional observations. The analysis of covariance is a technique for adjusting the observations according to the value of the covariate and then analyzing the adjusted experimental data.

In this study, analysis of covariance was used to test the null hypotheses. The pretest measures were used as the covariate in all analyses.
Model and Assumptions

Covariance analysis is designed for the following type of experiment. Suppose that a total of nt individuals are selected at random from a population. A measurement X is made on each individual. Then n individuals are assigned at random to each of t treatments. After the treatment has been applied, a criterion measurement is made for each individual. Thus, we have two scores, \( X_{ij} \) and \( Y_{ij} \), for the \( i \)th individual in the \( j \)th treatment.

The research questions are: Are the average criterion scores significantly different for the \( t \) treatments? What are good estimates of the average criterion scores in each treatment?

The covariance procedure would reduce possible bias in treatment comparisons due to differences in the covariate \( X \) (premeasurement) and increase precision in the treatment comparisons by reducing variability in criterion scores due to variability in the covariate \( X \).

The statistical model for analysis of covariance is composed of four independent terms.

\[
Y_{ij} = \mu + \alpha_j + B(X_{ij} - \bar{X}) + \epsilon_{ij}
\]

where,

- \( \mu \) is the mean of the criterion variable \( Y \) across individuals and treatments;
- \( \alpha_j \) is the differential effect on the mean due to treatment \( j \) (\( j = 1 \), control; \( j = 2 \), experiment).

The null hypothesis to be tested is that \( \alpha_j = 0 \) for all \( j \), that is, there is no difference among treatments after adjusting for differences in the covariate. Thus, the analysis of covariance is a
valid technique for testing for differences in average criterion scores among treatments if it can assumed that:

1. random assignment of individuals to treatments;

2. within each treatment, criterion scores have a linear regression on X scores;

3. the slope of the regression line is the same for each treatment (there is no slope treatment interaction);

4. for individuals with the same score, X, in the same treatment, criterion scores, Y, have a normal distribution;

5. the variance of the distribution of Y scores for all subjects with the same X score in a particular treatment is the same for all treatments and for all X scores; and

6. criterion scores are a linear combination of independent components: an overall mean (μ), a treatment effect (αj), a covariate X, and an error term (εij).

The validity of the analysis of covariance depends on how closely the data satisfy the necessary assumptions. It was appropriate to this study because all of the assumptions were met through this design.

Effects of Assumption

Randomization. The analysis of covariance is based on the assumption that individuals are randomly assigned to treatment groups and that all groups are treated exactly the same except for treatments.

Covariate independent of treatment. A basic postulate underlying the use of analysis of covariance to adjust treatment means for the
effects of covariate X is that the X variable is stochastically independent of the treatment effect. To achieve this stochastical independence, the X variable should be measured prior to the administration of treatments and treatments should be assigned to groups at random.

**Linearity.** There are many ways in which the criterion variable, Y, and the covariate, X, could be related. This relationship must be known or estimated in order to "adjust" Y scores for the effects of the X scores. It is often argued that a linear model may provide an adequate fit for other relationships between X and Y and is simple to use and interpret.

**Homogeneity of regression.** The covariance analysis procedure rests on the assumption that the regression of Y on X is linear, and that the slope is the same for all treatment groups (there is no treatment-slope interaction). The treatment which is best on the average (has the largest $\alpha_j$), therefore, is also best at each level of X by the same amount. No treatment-slope interaction is necessary for covariance technique to be logically meaningful.

**Normality.** Covariance analysis is based on the assumption that within each group at each ability level the criterion variable, Y, has a normal distribution. That is, the residuals $\varepsilon_{ij}$ are normally distributed.

**Homogeneity of variances.** Covariance analysis relies on the assumption that the variance of Y scores for a given X is the same for each treatment group and independent of X, that is, $\sigma$ is constant (Elashoff, 1969).
Transformations of the data may be useful for making the data satisfy these assumptions.

The effect of training method to modify questioning technique of teachers was the independent variable of this study. Dependent variables were: the number of all cognitive-level questions teachers asked (cognitive memory, convergent thinking, divergent thinking, evaluative thinking, closed, open questions); teacher's wait time, in seconds, for all cognitive-level questions, for closed questions and open questions; and length of time teacher's talk.

Square root transformation. Transformations were made in testing hypotheses 24 and 25 to make the data satisfy the assumption of analysis of covariance. The significant level for all hypothesis testing was set at .05. Statistical procedures for each hypothesis will be presented and described in Chapter 4, along with the interpretation of the results.

Summary

This chapter has described the choice of the research design and the research methodology. Population and sampling, data gathering and treatment procedures have also been described. The development of the research instrument included the description of the development of instructional pamphlet and procedures for determining reliability (interobserver agreement) were outlined in detail. Finally, the method for statistical analysis of the experimental data was outlined and discussed.
CHAPTER 4
ANALYSIS OF RESULTS

This chapter consists of three parts. The first part describes the one-way analysis of covariance programs used to test the hypotheses in this study. The second, and major part, consists of a presentation of hypotheses testing of the study, the data used in determining whether each hypothesis was rejected or not rejected, and interpretation of these data. The last part is a summary of the findings for each hypothesis.

One-Way Analysis of Covariance Programs

The one-way analysis of covariance programs used to test the hypotheses in this study was designed by the Department of Biomathematics, University of California at Los Angeles, in June 1981. This version of BMDP has been converted for use on CDC 6000 and Cyber series computers by BMDP Project, Vogelback Computing Center, Northwestern University, Evanston, Illinois.

The statistical model for analysis of covariance is:

\[ Y_{ij} = \mu + \alpha_j + \beta (X_{ij} - \bar{X}) + \epsilon_{ij} \]

where,

\( \mu \) is the mean of the criterion variable \( Y \) across individuals and treatment;

\( \alpha_j \) is a treatment effect (\( j = 1 \) for control; \( j = 2 \) for treatment);
$\beta$ is regression coefficient of covariant and fixed for all $i$ and $j$;

$X_{ij}$ is an $i$th covariate of $j$th group;

$\bar{X}$ is $1/n \sum_i \sum_j X_{ij}$ ($j = 1, 2; i = 1, \ldots, 31$); and

$\epsilon_{ij}$ is an error term.

The covariate measure was the pretest of the experimental and control groups. In the analysis of covariance, the group means were adjusted for both control and experimental groups to make them comparable with respect to the covariate since the mean values usually will not be the same for all treatments. The adjusted group means were determined by the equation (Neter and Wasserman, 1974:711)

$$\bar{Y}_j(\text{adj}) = \bar{Y}_j + G_w(\bar{X}_j - \bar{X})$$

where,

$\bar{Y}_j(\text{adj})$ is an adjusted group mean. It is simply the ordinate of its regression line at $X = \bar{X}$;

$\bar{Y}_j$ is an estimate of the mean response with the $j$th treatment (group);

$\bar{X}_j$ is the covariate for group $j$; and

$G_w$ is the regression estimate for effect of covariate.

For the analysis of covariance to be a valid technique, each hypothesis should be tested for equality of the slopes and for the covariate. The results of this study are interpreted through the testing for the identity of group means for each hypothesis.
Hypotheses Testing

The analysis of covariance assumes that the slopes of the regression line (coefficient of covariate, $\beta$) are the same for each treatment. In other words, there is no interaction between effect of experimental group and of control group. To test this kind of hypothesis, the F statistic is used at equals .05 level of significance. Note that if the calculated F is greater than the appropriate F from the table of F distribution, the hypothesis is rejected. The hypotheses are that

$H_0$: Slopes are equal.

$H_a$: Slopes are not all equal.

In this situation, if F is smaller than the F from the table of F distribution, or p value is larger than .05, then $H_0$ is not rejected, that is, the slopes are determined to be equal. There is homogeneity of slopes of experimental and control group regression line.

Otherwise, if F is larger than the F from the table of F distribution, or p value is smaller than .05, then the $H_0$ is rejected, which means there is an interaction effect between the experimental group and the control group; hence, the model

$$y_{ij} = \mu + \alpha_j + \beta(X_{ij} - \bar{X}) + \epsilon_{ij}$$

is not appropriate for this study.

The hypothesis for testing significance of the covariate is:

$H_0$: The slope of the regression line, $\beta$, is zero.

$H_a$: The slope of the regression line, $\beta$, is not zero.
To test this hypothesis the F statistic is used at \( .05 \) level of significance. \( H_0 \) is rejected if the calculated F is greater than the appropriate F value from table of F distribution, or the p value is smaller than \( .05 \). Otherwise, when the F ratio is smaller than the appropriate value from the table of F distribution, or the p value is larger than \( .05 \) level of significance, the hypothesis is not rejected.

If the slope of the regression line is significant (i.e., \( \beta \neq 0 \)), then the covariate term, \( X_{ij} - \bar{X} \), is significant and, hence, the postmeasure, \( Y_{ij} \), is linearly dependent on the premeasure, \( X_{ij} \). Otherwise, they are not linearly dependent.

The hypothesis for testing identity of group means is:

\[ H_0: \mu_1 = \mu_2. \]
\[ H_a: \mu_1 \text{ does not equal } \mu_2. \]

where,

\( \mu_1 \) is the adjusted group means of the control group; and
\( \mu_2 \) is the adjusted group means of the experimental group.

There are two group means, namely, means of the experimental group and means of the control group. In analysis of covariance, the groups means are adjusted for experimental and control groups to make them comparable with respect to the covariate as earlier mentioned. The estimates of adjusted group means are used to test each hypothesis by means of the F statistic. \( H_0 \) is rejected if the calculated F is greater than the tabulated F, or if the p value is smaller than \( .05 \) level of significance. Otherwise, if calculated F is smaller than tabulated F, of the p value is larger than \( .05 \) level of significance,
$H_0$ is not rejected. If $H_0$ is not rejected, it can be concluded that there is significant difference in effect between the experimental and the control group.

Each hypothesis in this study was tested for these three effects.

Hypothesis 1

$H_1$: There is no significant difference between the control group and the experimental group on the number of all cognitive-level questions asked by teachers.

Table 6 presents data for testing the equality of slopes (homogeneity of regression line), significance of covariate, and identity of group means for the number of all cognitive-level questions asked by the teachers.

Table 6

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>Sum of SR</th>
<th>Mean SR</th>
<th>F Ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>1</td>
<td>488.37</td>
<td>488.37</td>
<td>2.7943</td>
<td>.0999</td>
</tr>
<tr>
<td>Covariate</td>
<td>1</td>
<td>1859.52</td>
<td>1859.52</td>
<td>10.6395</td>
<td>.0018</td>
</tr>
<tr>
<td>Error</td>
<td>59</td>
<td>10311.71</td>
<td>174.77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equality of slopes</td>
<td>1</td>
<td>133.93</td>
<td>133.93</td>
<td>.7633</td>
<td>.3859</td>
</tr>
<tr>
<td>Error</td>
<td>58</td>
<td>10177.77</td>
<td>175.48</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Equality of slopes. As Table 6 shows, the F ratio was .7633 and the p value was .3859. Since the calculated F was smaller than the tabulated F, and the p value was larger than .05, $H_0$ was not rejected. The slopes of the experimental and control groups were determined
to be equal. There was homogeneity of the slopes of the experimental and control group regression line.

**Significance of the covariate.** As Table 6 shows, the F ratio was 10.6395 and the p value was .0018. Since the calculated F was larger than the tabulated F, and the p value was smaller than .05, \( H_0 \) was rejected, was not equal to zero. The covariate was effective for the analysis of covariance, and the groups means needed to be adjusted for the experimental and control groups on all cognitive-level questions (see Table 7).

<table>
<thead>
<tr>
<th>Table 7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group Means and Adjusted Means for All Cognitive-Level Questions</strong></td>
</tr>
<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>Group</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>Control</td>
</tr>
<tr>
<td>Experimental</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><em>Covariate = TOTPRE; Reg. Coeff. = .41807; Std. Error = .12817; T Value = 3.26183.</em></td>
</tr>
</tbody>
</table>

**Identity of Group Means.** Table 6 shows that the F ratio was 2.7943 and the p value was .0999. Since the calculated F was smaller than the tabulated F, and the p value was larger than .05, \( H_0 \) was not rejected. The adjusted group means of the control and experimental groups for all cognitive-level questions were not significantly different. That is, the teachers in the experimental group asked relatively the same number of cognitive-level questions after treatment as asked by the teachers in the control group.
Hypothesis 2

H₂: There is no significant difference between the control group and the experimental group on the number of cognitive memory level questions asked by teachers.

Table 8 presents data for testing the equality of slopes (homogeneity of regression line), significance of covariate, and identity of group means for the number of all cognitive-memory questions asked by teachers.

Table 8
Analysis of Covariance Table for Testing Equality of Slopes, Significance of Covariate, and Identity of Group Means of Cognitive-Memory Questions

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>Sum of SR</th>
<th>Mean SR</th>
<th>F Ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>1</td>
<td>4748.99</td>
<td>4748.99</td>
<td>32.4090</td>
<td>.0000</td>
</tr>
<tr>
<td>Covariate</td>
<td>1</td>
<td>3468.60</td>
<td>3468.60</td>
<td>23.6710</td>
<td>.0000</td>
</tr>
<tr>
<td>Error</td>
<td>59</td>
<td>8645.47</td>
<td>146.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equality of slopes</td>
<td>1</td>
<td>5.55</td>
<td>5.55</td>
<td>.0373</td>
<td>.8476</td>
</tr>
<tr>
<td>Error</td>
<td>58</td>
<td>8639.92</td>
<td>148.96</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Equality of slopes. As Table 8 shows, the F ratio was .0373 and the p value was .8476. Since the calculated F was smaller than the tabulated F, and the p value was larger than .05, H₀ was not rejected. The slopes of the experimental and control groups were determined to be equal. There was homogeneity of the slope of the experimental and control group regression line.

Significance of the covariate. As Table 8 shows, the F ratio was 23.6710 and the p value was .0000. Since the calculated F was larger than the tabulated F, and the p value was smaller than .05, H₀ was rejected, was not equal to zero. The covariate was
effective for the analysis of covariance, and the groups means needed to be adjusted for the experimental and control groups on all cognitive-memory questions (see Table 9).

Table 9

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Group Mean</th>
<th>Adjusted Group Mean</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>31</td>
<td>46.10</td>
<td>46.11</td>
<td>2.17414</td>
</tr>
<tr>
<td>Experimental</td>
<td>31</td>
<td>28.61</td>
<td>28.60</td>
<td>2.17414</td>
</tr>
</tbody>
</table>

*Covariate = MPRE; Reg. Coeff. = .62154; Std. Error = .12775; T Value = 4.86529.*

Identity of Group Means. Table 8 shows that the F ratio was 32.4090 and the p value was .0000. Since the calculated F was larger than the tabulated F, and the p value was smaller than .05, Ho was rejected. The adjusted group means of the control and experimental groups for the number of cognitive-memory questions were significantly different. That is, the teachers in the experimental group asked a significantly different number of cognitive-memory questions after treatment than asked by teachers in the control group.

H22: There is no significant difference between the control group and the experimental group on the number of convergent thinking level questions asked by teachers.

Table 10 presents data for testing the equality of slopes (homogeneity of regression line), significance of covariate, and identity of group means for the number of convergent questions asked by the teachers.
Table 10

Analysis of Covariance Table for Testing Equality of Slopes, Significance of Covariate, and Identity of Group Means for Convergent Thinking Questions

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>Sum of SR</th>
<th>Mean SR</th>
<th>F Ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>1</td>
<td>24.15</td>
<td>24.15</td>
<td>.4507</td>
<td>.5046</td>
</tr>
<tr>
<td>Covariate</td>
<td>1</td>
<td>522.24</td>
<td>522.24</td>
<td>9.7450</td>
<td>.0028</td>
</tr>
<tr>
<td>Error</td>
<td>59</td>
<td>3161.83</td>
<td>53.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equality of slopes</td>
<td>1</td>
<td>12.17</td>
<td>12.17</td>
<td>.2241</td>
<td>.6377</td>
</tr>
<tr>
<td>Error</td>
<td>58</td>
<td>3149.66</td>
<td>54.30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Equality of slopes. As Table 10 shows, the F ratio was .2241 and the p value was .6377. Since the calculated F was smaller than the tabulated F, and the p value was larger than .05, H₀ was not rejected. The slopes of the experimental and control groups were determined to be equal. There was homogeneity of the slope of the experimental and control group regression line.

Significance of the covariate. As Table 10 shows, the F ratio was 9.7450 and the p value was .0028. Since the calculated F was larger than the tabulated F, and the p value was smaller than .05, H₀ was rejected, was not equal to zero. The covariate was effective for the analysis of covariance and the groups means were adjusted for the experimental and control groups on convergent thinking questions (see Table 11).

Identity of Group Means. Table 11 shows that the F ratio was .4507 and the p value was .5046. Since the calculated F was smaller than the tabulated F, and the p value was larger than .05, H₀ was not rejected. The adjusted group means of the control and experimental
groups for convergent thinking questions were not significantly different. That is, the teachers in the experimental group asked relatively the same number of convergent thinking questions after treatment as asked by the teachers in the control group.

Table 11
Group Means and Adjusted Group Means for Convergent Thinking Questions

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Group Mean</th>
<th>Adjusted Group Mean</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>31</td>
<td>21.39</td>
<td>21.37</td>
<td>1.31482</td>
</tr>
<tr>
<td>Experimental</td>
<td>31</td>
<td>20.10</td>
<td>20.12</td>
<td>1.31482</td>
</tr>
</tbody>
</table>

*Covariate = CPRE; Reg. Coeff. = .32551; Std. Error = .10427; T Value = 3.12170.

\( H_{23} \): There is no significant difference between the control group and the experimental group on the number of closed questions (cognitive memory and convergent thinking questions) asked by teachers.

Table 12 presents data for testing the equality of slopes (homogeneity of regression line), significance of covariate, and identity of group means for closed questions asked by the teachers.

Table 12
Analysis of Covariance Table for Testing Equality of Slopes, Significance of Covariate, and Identity of Group Means for Closed Questions

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>Sum of SR</th>
<th>Mean SR</th>
<th>F Ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>1</td>
<td>5439.66</td>
<td>5439.66</td>
<td>36.8920</td>
<td>.0000</td>
</tr>
<tr>
<td>Covariate</td>
<td>1</td>
<td>1948.92</td>
<td>1948.92</td>
<td>13.2180</td>
<td>.0006</td>
</tr>
<tr>
<td>Error</td>
<td>59</td>
<td>8699.21</td>
<td>147.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equality of slopes</td>
<td>1</td>
<td>54.80</td>
<td>54.80</td>
<td>.3677</td>
<td>.5466</td>
</tr>
<tr>
<td>Error</td>
<td>58</td>
<td>8644.41</td>
<td>149.04</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Equality of slopes. As Table 12 shows, the F ratio was .3677 and the p value was .5466. Since the calculated F was smaller than the tabulated F, and the p value was larger than .05, $H_0$ was not rejected. The slopes of the experimental and control groups were determined to be equal. There was homogeneity of the slope of the experimental and control group regression line.

Significance of the covariate. As Table 12 shows, the F ratio was 13.2180 and the p value was .0006. Since the calculated F was larger than the tabulated F, and the p value was smaller than .05, $H_0$ was rejected, was not equal to zero. The covariate was effective for the analysis of covariance and the groups means were adjusted for the experimental and control groups on closed questions (see Table 13).

Table 13

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Group Mean</th>
<th>Adjusted Group Mean</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>31</td>
<td>67.48</td>
<td>67.46</td>
<td>2.18089</td>
</tr>
<tr>
<td>Experimental</td>
<td>31</td>
<td>48.71</td>
<td>48.73</td>
<td>2.18089</td>
</tr>
</tbody>
</table>

*Covariate = MCPRE; Reg. Coeff. = .41882; Std. Error = .11520; T Value = 3.63566.

Identity of Group Means. Table 12 shows that the F ratio was 36.8920 and the p value was .0000. Since the calculated F was larger that the tabulated F, and the p value was smaller than .05, $H_0$ was rejected. The adjusted group means of the control and experimental groups for closed thinking questions were significantly different.
That is, teachers in the experimental group asked a significantly different number of closed questions after treatment than were asked by teachers in the control group.

H24: There is no significant difference between the control group and the experimental group on the number of divergent thinking questions asked by teachers.

Table 14 presents data for testing the equality of slopes (homogeneity of regression line), significance of covariate, and identity of group means for divergent thinking questions asked by the teachers.

Table 14
Analysis of Covariance Table for Testing Equality of Slopes, Significance of Covariate, and Identity of Group Means for Divergent Thinking Questions

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>Sum of SR</th>
<th>Mean SR</th>
<th>F Ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>1</td>
<td>56.84</td>
<td>56.84</td>
<td>107.3055</td>
<td>.0000</td>
</tr>
<tr>
<td>Covariate</td>
<td>1</td>
<td>.19</td>
<td>.19</td>
<td>.3590</td>
<td>.5513</td>
</tr>
<tr>
<td>Error</td>
<td>59</td>
<td>31.25</td>
<td>.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equality of slopes</td>
<td>1</td>
<td>.04</td>
<td>.04</td>
<td>.0736</td>
<td>.7871</td>
</tr>
<tr>
<td>Error</td>
<td>58</td>
<td>31.21</td>
<td>.54</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Equality of the Slopes. Square root transformations were applied for this test in order to correct for lack of normality. As Table 14 shows, the F ratio was .0736 and the p value was .7871. Since the calculated F was smaller than the tabulated F, and the p value was larger than .05, H0 was not rejected. The slopes of the experimental and control groups were determined to be equal. There was homogeneity of the slope of the experimental and control group regression line.
Significance of the covariate. As Table 14 shows, the F ratio was .3590 and the p value was .5513. Since the calculated F was smaller than the tabulated F, and the p value was larger than .05, $H_0$ was not rejected; as equals zero, the postmeasure was not linearly dependent on the premeasure. The adjusted group means were only slightly different on divergent thinking questions (see Table 15).

Table 15
Group Means and Adjusted Group Means for Divergent Thinking Questions

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Group Mean</th>
<th>Adjusted Group Mean</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>31</td>
<td>1.72</td>
<td>1.72</td>
<td>.13094</td>
</tr>
<tr>
<td>Experimental</td>
<td>31</td>
<td>3.63</td>
<td>3.64</td>
<td>.13094</td>
</tr>
</tbody>
</table>

*Covariate = DPRE; Reg. Coeff. = .09406; Std. Error = .15698; T Value = .59919.

Identity of Group Means. Table 14 shows that the F ratio was 39.5680 and the p value was .0000. Since the calculated F was larger that the tabulated F, and the p value was smaller than .05, $H_0$ was rejected. The adjusted group means for divergent thinking questions were significantly different. That is, the teachers in the experimental group asked a significantly different number of divergent thinking questions after treatment than were asked by the teachers in the control group.
$H_{25}$: There is no significant difference between the control group and the experimental group on the number of evaluative thinking questions asked by teachers.

Table 16 presents data for testing the equality of slopes (homogeneity of regression line), significance of covariate, and identity of group means for evaluative thinking questions asked by the teachers.

Table 16

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>Sum of SR</th>
<th>Mean SR</th>
<th>F Ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>1</td>
<td>6.12</td>
<td>6.12</td>
<td>39.5680</td>
<td>.0000</td>
</tr>
<tr>
<td>Covariate</td>
<td>1</td>
<td>.11</td>
<td>.11</td>
<td>.6888</td>
<td>.4099</td>
</tr>
<tr>
<td>Error</td>
<td>59</td>
<td>9.13</td>
<td>.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>58</td>
<td>8.98</td>
<td>.15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Equality of Slopes. Square root transformations are applied for this test in order to correct for lack of normality. As Table 16 shows, the F ratio was .7633 and the p value was .3859. Since the calculated F was smaller than the tabulated F, and the p value was larger than .05, $H_0$ was not rejected. The slopes of the experimental and control groups were determined to be equal. There was homogeneity of the slope of the experimental and control group regression line.

Significance of the covariate. As Table 16 shows, the F ratio was .6888 and the p value was .4099. Since the calculated F was smaller than the tabulated F, and the p value was larger than .05, $H_0$ was not rejected; as $\sigma$ was equal to zero, the postmeasure was not
linearly dependent on the premeasure. The adjusted group means for evaluative thinking questions were only slightly different (see Table 17).

**Identity of Group Means.** Table 16 shows, the F ratio was 39.5680 and the p value was .0000. Since the calculated F was larger than the tabulated F, and the p value was smaller than .05, \( H_0 \) was rejected. The adjusted group means of the control and experimental groups for evaluative thinking questions were significantly different.

**Table 17**

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Group Mean</th>
<th>Adjusted Group Mean</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>31</td>
<td>1.29</td>
<td>1.29</td>
<td>.07072</td>
</tr>
<tr>
<td>Experimental</td>
<td>31</td>
<td>1.92</td>
<td>1.92</td>
<td>.07072</td>
</tr>
</tbody>
</table>

*Covariate = EPRE; Reg. Coeff. = -.15802; Std. Error = .19039; T Value = -.82995.*

\( H_{26} \): There is no significant difference between the control group and the experimental group on the number of open questions (divergent thinking and evaluative thinking questions) asked by teachers.

Table 18 presents data for testing the equality of slopes (homogeneity of regression line), significance of covariate, and identity of group means for all cognitive-level questions asked by the teachers.

**Equality of slopes.** As Table 18 shows, the F ratio was .0017 and the p value was .9668. Since the calculated F was smaller than the tabulated F, and the p value was larger than .05, \( H_0 \) was not
rejection. The slopes of the experimental and control groups were determined to be equal. There was homogeneity of the slope of the experimental and control group regression line.

Table 18

Analysis of Covariance Table for Testing Equality of Slopes, Significance of Covariate, and Identity of Group Means for Open Questions

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>Sum of SR</th>
<th>Mean SR</th>
<th>F Ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>1</td>
<td>69.45</td>
<td>69.45</td>
<td>117.2097</td>
<td>.0000</td>
</tr>
<tr>
<td>Covariate</td>
<td>1</td>
<td>.44</td>
<td>.44</td>
<td>.7485</td>
<td>.3905</td>
</tr>
<tr>
<td>Error</td>
<td>59</td>
<td>34.96</td>
<td>.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equality of slopes</td>
<td>1</td>
<td>.00</td>
<td>.00</td>
<td>.0017</td>
<td>.9668</td>
</tr>
<tr>
<td>Error</td>
<td>58</td>
<td>34.96</td>
<td>.60</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Significance of the covariate. As Table 18 shows, the F ratio was .7485 and the p value was .3905. Since the calculated F was smaller than the tabulated F, and the p value was larger than .05, H0 was not rejected; as was equal to zero, the postmeasure was not linearly dependent on premeasure. The adjusted group means for closed questions were only slightly different (see Table 19).

Table 19

Group Means and Adjusted Group Means for Open Questions

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Group Mean</th>
<th>Adjusted Group Mean</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>31</td>
<td>1.90</td>
<td>1.90</td>
<td>.13830</td>
</tr>
<tr>
<td>Experimental</td>
<td>31</td>
<td>4.01</td>
<td>4.01</td>
<td>.13830</td>
</tr>
</tbody>
</table>

*Covariate = DEPRE; Reg. Coeff. = -.12701; Std. Error = .14680; T Value = .86516.
Identity of Group Means. Table 18 shows that the F ratio was 117.2097 and the p value was .0000. Since the calculated F was larger than the tabulated F, and the p value was smaller than .05, Ho was rejected. The adjusted group means of the control and experimental groups for all open questions were significantly different. That is, the experimental group after treatment asked a significantly different number of open questions than were asked by the control group.

Hypothesis 3

H3: There is no significant difference between the control group and the experimental group on teacher wait-time.

Table 20 presents data for testing the equality of slopes (homogeneity of regression line), significance of covariate, and identity of group means for length of teacher wait-time.

Table 20

Analysis of Covariance Table for Testing Equality of Slopes, Significance of Covariate, and Identity of Group Means for Teacher Wait-Time

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>Sum of SR</th>
<th>Mean SR</th>
<th>F Ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>1</td>
<td>33611.88</td>
<td>33611.88</td>
<td>28.0897</td>
<td>.0000</td>
</tr>
<tr>
<td>Covariate</td>
<td>1</td>
<td>1082.27</td>
<td>1082.27</td>
<td>.9045</td>
<td>.3455</td>
</tr>
<tr>
<td>Error</td>
<td>59</td>
<td>70599.00</td>
<td>1196.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equality of slopes</td>
<td>1</td>
<td>1263.17</td>
<td>1263.17</td>
<td>1.0567</td>
<td>.3082</td>
</tr>
<tr>
<td>Error</td>
<td>58</td>
<td>69335.80</td>
<td>1195.44</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Equality of slopes. As Table 20 shows, the F ratio was 1.0567 and the p value was .3082. Since the calculated F was smaller than the tabulated F, and the p value was larger than .05, Ho was not rejected. The slopes of the experimental and control groups were
determined to be equal. There was homogeneity of the slope of the experimental and control group regression line.

Significance of the covariate. As Table 20 shows, the F ratio was .9045 and the p value was .3455. Since the calculated F was smaller than the tabulated F, and the p value was larger than .05, $H_0$ was not rejected; as $\text{covariate}$ equaled zero, the postmeasure was not linearly dependent on the premeasure. The adjusted group means for teacher wait-time were only slightly different (see Table 21).

Table 21

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Group Mean</th>
<th>Adjusted Group Mean</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>31</td>
<td>65.46</td>
<td>65.49</td>
<td>6.21297</td>
</tr>
<tr>
<td>Experimental</td>
<td>31</td>
<td>112.10</td>
<td>112.06</td>
<td>6.21297</td>
</tr>
</tbody>
</table>

*Covariate = WTOTPRE; Reg. Coeff. = .19212; Std. Error = .20201; T Value = .95103.

Identity of Group Means. As Table 20 shows, the F ratio was 28.0897 and the p value was .0000. Since the calculated F was smaller that the tabulated F, and the p value was larger than .05, $H_0$ was rejected. The adjusted group means of the control and experimental groups for teacher wait-time significantly different. That is, teachers in the experiment group had a significantly different wait-time after treatment than teachers in the control group did.
H₃: There is no significant difference between the control and experimental groups on wait-time of teacher's closed questions.

Table 22 presents data for testing the equality of slopes (homogeneity of regression line), significance of covariate, and identity of group means for wait-time of closed questions asked by the teachers.

Table 22

Analysis of Covariance Table for Testing Equality of Slopes, Significance of Covariate, and Identity of Group Means for Wait-Time for Closed Questions

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>Sum of SR</th>
<th>Mean SR</th>
<th>F Ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>1</td>
<td>4116.83</td>
<td>4116.83</td>
<td>9.5814</td>
<td>.0030</td>
</tr>
<tr>
<td>Covariate</td>
<td>1</td>
<td>660.09</td>
<td>660.09</td>
<td>1.5363</td>
<td>.2201</td>
</tr>
<tr>
<td>Error</td>
<td>59</td>
<td>25350.54</td>
<td>429.67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equality of slopes</td>
<td>1</td>
<td>1406.31</td>
<td>1406.31</td>
<td>3.4065</td>
<td>.0700</td>
</tr>
<tr>
<td>Error</td>
<td>58</td>
<td>23944.23</td>
<td>412.83</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Equality of slopes. As Table 22 shows, the F ratio was 3.4065 and the p value was .0700. Since the calculated F was smaller than the tabulated F, and the p value was larger than .05, H₀ was not rejected. The slopes of the experimental and control groups were determined to be equal. There was homogeneity of the slope of the experimental and control group regression line.

Significance of the covariate. As Table 22 shows, the F ratio was 1.5363 and the p value was .2201. Since the calculated F was smaller than the tabulated F, and the p value was larger than .05, H₀ was not rejected; as equal to zero, the postmeasure was not linearly dependent on the premeasure. The adjusted groups means for
wait time on closed questions were only slightly different (see Table 23).

Identity of Group Means. As Table 22 shows, the F ratio was 9.5814 and the p value was .0030. Since the calculated F was larger that the tabulated F, and the p value was smaller than .05, H₀ was rejected. The adjusted group means of the control and experimental groups for wait-time on closed questions were significantly different. That is, teachers in the experiment group had significantly different wait-times for closed questions after treatment than did the teachers in the control.

Table 23

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Group Mean</th>
<th>Adjusted Group Mean</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>31</td>
<td>55.93</td>
<td>55.99</td>
<td>3.72320</td>
</tr>
<tr>
<td>Experimental</td>
<td>31</td>
<td>39.74</td>
<td>39.69</td>
<td>3.72320</td>
</tr>
</tbody>
</table>

*Covariate = WMCPRE; Reg. Coeff. = .14981; Std. Error = .12087; T Value = 1.23946.

H₃₂: There is no significant difference between the control and experimental groups on wait-time of teacher's open questions.

Table 24 presents data for testing the equality of slopes (homogeneity of regression line), significance of covariate, and identity of group means for wait-time on open questions asked by the teachers.
Equality of slopes. As Table 24 shows, the F ratio was .0003 and the p value was .9873. Since the calculated F was smaller than the tabulated F, and the p value was larger than .05, $H_0$ was not rejected. The slopes of the experimental and control groups were determined to be equal. There was homogeneity of the slope of the experimental and control group regression line.

Table 24

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>Sum of SR</th>
<th>Mean SR</th>
<th>F Ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>1</td>
<td>436.97</td>
<td>436.97</td>
<td>104.0261</td>
<td>.0000</td>
</tr>
<tr>
<td>Covariate</td>
<td>1</td>
<td>.20</td>
<td>.20</td>
<td>.0468</td>
<td>.8294</td>
</tr>
<tr>
<td>Error</td>
<td>59</td>
<td>247.83</td>
<td>4.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equality of slopes</td>
<td>1</td>
<td>.00</td>
<td>.00</td>
<td>.0003</td>
<td>.9873</td>
</tr>
<tr>
<td>Error</td>
<td>58</td>
<td>247.83</td>
<td>4.27</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Significance of the covariate. As Table 24 shows, the F ratio was .0468 and the p value was .8294. Since the calculated F was smaller than the tabulated F, and the p value was larger than .05, $H_0$ was not rejected; as $\alpha$ was equal to zero, the postmeasure was not linearly dependent on the premeasure. The group means were only slightly adjusted (see Table 25).

Identity of Group Means. Table 24 shows that the F ratio was 104.0261 and the p value was .0000. Since the calculated F was larger that the tabulated F, and the p value was smaller than .05, $H_0$ was rejected. The adjusted group means of the control and experimental groups for wait-time on open questions were significantly different.
That is, the teachers in the experimental group had significantly different wait-times on open questions after treatment than did the teachers in the control group.

Table 25

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Group Mean</th>
<th>Adjusted Group Mean</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>31</td>
<td>2.91</td>
<td>2.92</td>
<td>.36829</td>
</tr>
<tr>
<td>Experimental</td>
<td>31</td>
<td>8.23</td>
<td>8.23</td>
<td>.36829</td>
</tr>
</tbody>
</table>

*Covariate = WDEPRE; Reg. Coeff. = .04140; Std. Error = .19134; T Value = .21637.

Hypothesis 4

H4: There is no significant difference between the control and experimental groups on time length of teacher's talk.

Table 26 presents data for testing the equality of slopes (homogeneity of regression line), significance of covariate, and identity of group means for time length of teacher's talk.

Table 26

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>Sum of SR</th>
<th>Mean SR</th>
<th>F Ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>1</td>
<td>1990.64</td>
<td>1990.64</td>
<td>14.1165</td>
<td>.0004</td>
</tr>
<tr>
<td>Covariate</td>
<td>1</td>
<td>1053.25</td>
<td>1053.25</td>
<td>7.4690</td>
<td>.0083</td>
</tr>
<tr>
<td>Error</td>
<td>59</td>
<td>8319.93</td>
<td>141.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equality of slopes</td>
<td>1</td>
<td>18.63</td>
<td>18.63</td>
<td>.1302</td>
<td>.7195</td>
</tr>
<tr>
<td>Error</td>
<td>58</td>
<td>8301.30</td>
<td>143.13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Equality of slopes. As Table 26 shows, the F ratio was .1302 and the p value was .7195. Since the calculated F was smaller than the tabulated F, and the p value was larger than .05, $H_0$ was not rejected. The slopes of the experimental and control groups were determined to be equal. There was homogeneity of the slope of the experimental and control group regression line.

Significance of the covariate. As Table 26 shows, the F ratio was 7.4690 and the p value was .0083. Since the calculated F was larger than the tabulated F, and the p value was smaller than .05, $H_0$ was rejected, was not equal to zero. The covariate was effective for the analysis of covariance and the groups means were adjusted for the experimental and control groups on time length of teacher's talk (see Table 27).

Table 27

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Group Mean</th>
<th>Adjusted Group Mean</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>31</td>
<td>59.42</td>
<td>59.08</td>
<td>2.13644</td>
</tr>
<tr>
<td>Experimental</td>
<td>31</td>
<td>47.37</td>
<td>47.71</td>
<td>2.13644</td>
</tr>
</tbody>
</table>

*Covariate = TIMEPRE; Reg. Coeff. = .31696; Std. Error = .11598; T Value = 2.73295.

Identity of Group Means. As Table 26 shows, the F ratio was 14.1165 and the p value was .0004. Since the calculated F was larger than the tabulated F, and the p value was smaller than .05, $H_0$ was rejected. The adjusted group means of the control and experimental
groups for time length of teacher's talk were significantly different. That is, the teachers in the experimental group after treatment spent a different length of time talking during the class session than did the teachers in the control group.

**Summary of the Findings**

The findings of each hypothesis are shown in tables 28 and 29. As presented in Table 28, testing for all hypotheses for equality of slopes was significance at the .05 level. There was homogeneity of slope of experimental and control group regression line for each hypothesis. Testing for significance of the covariate for all cognitive-level questions, the hypothesis was not rejected for cognitive-memory questions, convergent thinking questions, closed questions, or length of teacher's talk showed. However, there was no concern with whether the regression coefficient, $G_w$, was significant, that is, whether there was any bias in the results of the covariance analysis (Neter and Wasserman, 1976:696).

As shown in Table 29, for the cases where slopes were not significant, equals zero, group means and corresponding adjusted group means were only slightly different.

Square-root transformation was applied for divergent thinking and evaluative thinking questions because the numbers of observations in these cases were so small. Recall that observations are discrete types. Normality assumption might not be met, and, hence, some transformation is needed. It was found that square root transformation satisfactorily fit into this analysis.
Table 28
Summary of Group Means and Adjusted Group Means

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Covariate</th>
<th>Group Means</th>
<th>Adjusted Group Means</th>
<th>Standard Error S(adj ( \bar{Y}_j ))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Control</td>
<td>Experiment</td>
<td>Control</td>
</tr>
<tr>
<td>H^{1}</td>
<td>All cognitive questions</td>
<td>70.45</td>
<td>64.58</td>
<td>70.32</td>
</tr>
<tr>
<td>H_{21}</td>
<td>Cognitive-memory questions</td>
<td>46.10</td>
<td>28.61</td>
<td>56.21</td>
</tr>
<tr>
<td>H_{22}</td>
<td>Convergent thinking questions</td>
<td>21.39</td>
<td>20.10</td>
<td>21.37</td>
</tr>
<tr>
<td>H_{23}</td>
<td>Closed questions</td>
<td>67.48</td>
<td>48.71</td>
<td>67.46</td>
</tr>
<tr>
<td>H_{24}</td>
<td>Divergent thinking questions</td>
<td>1.72</td>
<td>3.63</td>
<td>1.72</td>
</tr>
<tr>
<td>H_{25}</td>
<td>Evaluative thinking questions</td>
<td>1.29</td>
<td>1.92</td>
<td>1.29</td>
</tr>
<tr>
<td>H_{26}</td>
<td>Open questions</td>
<td>1.90</td>
<td>4.01</td>
<td>1.90</td>
</tr>
<tr>
<td>H_{3}</td>
<td>Total wait-time (sec)</td>
<td>65.46</td>
<td>112.10</td>
<td>65.50</td>
</tr>
<tr>
<td>H_{31}</td>
<td>Wait-time/Closed questions (sec)</td>
<td>55.93</td>
<td>39.74</td>
<td>55.99</td>
</tr>
<tr>
<td>H_{32}</td>
<td>Wait-time/Open questions (sec)</td>
<td>2.91</td>
<td>8.23</td>
<td>2.92</td>
</tr>
<tr>
<td>H_{4}</td>
<td>Length of teacher's talk (sec)</td>
<td>59.42</td>
<td>47.37</td>
<td>59.08</td>
</tr>
</tbody>
</table>
Table 29
Summary of the Findings for Each Hypothesis

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Covariate</th>
<th>F Ratio</th>
<th>p</th>
<th>Rejected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ho:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H1</td>
<td>All cognitive questions</td>
<td>.7633</td>
<td>.3859</td>
<td>No</td>
</tr>
<tr>
<td>H21</td>
<td>Cognitive-memory questions</td>
<td>.0373</td>
<td>.8476</td>
<td>No</td>
</tr>
<tr>
<td>H22</td>
<td>Convergent thinking questions</td>
<td>.2241</td>
<td>.6377</td>
<td>No</td>
</tr>
<tr>
<td>H23</td>
<td>Closed questions</td>
<td>.3677</td>
<td>.5466</td>
<td>No</td>
</tr>
<tr>
<td>H24</td>
<td>Divergent thinking questions</td>
<td>.0736</td>
<td>.7871</td>
<td>No</td>
</tr>
<tr>
<td>H25</td>
<td>Evaluation thinking questions</td>
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<td>.3434</td>
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<td>H26</td>
<td>Open questions</td>
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<td>.9668</td>
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Table 29 continued

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<th>Covariate</th>
<th>F Ratio</th>
<th>p</th>
<th>Rejected</th>
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Testing for the identity of group means showed significant difference for most hypotheses, except for all cognitive-level and convergent thinking questions. The teachers in the experimental group after treatment asked relatively the same number of cognitive-level and convergent thinking questions as asked by the teachers in the control group. (See Appendix C for data.)
CHAPTER 5
SUMMARY, CONCLUSIONS, DISCUSSION, AND RECOMMENDATIONS

This chapter consists of four parts: a summary of the study, conclusions, discussion of the findings as they related to the hypotheses involved in the study, and recommendations.

Summary

The purpose of the study was to assess the effectiveness of a training program designed to assist Thai junior high school science teachers in asking a larger number of higher cognitive-level questions, extending wait-time following questions, and decreasing the amount of teacher talk during classroom instruction. The training program utilized an instructional pamphlet based on Blosser's (1973) Handbook of Effective Questioning Techniques and from ideas gained from a survey of literature related to questions and questioning. A discussion of wait-time was included.

Teachers in the experimental group were asked to read and discuss question strategies, learn to categorize and use a variety of cognitive questions, and then analyze their own questions and wait-time behavior.

The experimental design for the study was the Pretest-Posttest Group Design in which equivalent groups as achieved by randomization are employed. Sixty-two science teachers at junior high school level (Mattayom 1, 2, 3) in Bangkok, Thailand, were randomly assigned to experimental and control groups.
The study took place over 12 weeks of the first semester of the 1983 academic year (June 16-November 12) of Thai school. Cassette-tape recorders were used to record verbal instructions of science lessons as pretest and posttest measures. Teachers in both the experimental group and the control group participated in the pretest and posttest. In the pretest, the teachers were taped during two 50-minute science lesson periods, using a topic chosen from content involved in their teaching schedules, in the first week. For the posttest, the teachers were asked to tape two 50-minute science lesson periods five to six weeks after pretesting.

Only the teachers in the experimental group received treatment and participated all through the study. The teachers in the experimental group were given materials and instruction for training them to increase the number of higher cognitive-level questions they asked and prolong wait-time (average three seconds).

From each audiotape, both pretest and posttest, the researcher categorized questions teachers asked into cognitive memory questions, convergent thinking, divergent thinking questions, evaluative thinking questions, as well as closed questions and open questions, and then tabulated them in order to determine the number of each cognitive level question teachers asked, as categorized by Blosser's Question Category System for Science. A stopwatch was used to measure teacher wait-time, the pause between teacher's question and subsequent student response or teacher response, and the length of time each teacher talked in each class session. All data were coded for analysis.
Analysis of covariance was used to test the null hypotheses of this study. The pretest measures were used as the covariate in all analyses.

The major objective of this study was to assess the effectiveness of an instructional training sequence designed to develop skill in questioning and wait-time as a teaching technique by Thai junior high school science teachers.

In drawing conclusions from this study, it must be noted that there are some major limitations associated with this research. First, the researcher had little control over numerous potentially contaminating classroom-related variables. Secondly, the sample of junior high school science teachers from Bangkok may not be representative of all Thai junior high school teachers. Thirdly, recording teacher talk may alter a teacher's classroom behavior. Fourthly, the posttest was made during the final week of the study. This coincided with the approaching end of the school term. Fifthly, flooding forced schools to close for a few days, thereby forcing teachers to rush their teaching plans in order to cover all the content needed before the school term ended.

Conclusions

Findings for hypotheses showed that the experimental group was affected by the training procedure on asking higher cognitive-level questions. The teachers in the experimental group asked less cognitive memory questions but asked more divergent thinking and
evaluative questions. The hypothesis for all cognitive-level questions teachers asked could not be rejected. It could be explained that when teachers decreased the number of lower cognitive-level questions asked, they increased asking higher cognitive-level questions. The overall number of questions in each cognitive-level category was not changed.

Only hypothesis 22 could not be rejected on the basis of available evidence: the experimental group did not significantly improve on convergent thinking questions.

Level two of the Question Categories System, the category of closed questions is subdivided into cognitive memory questions and convergent thinking questions. The researcher found that when the hypothesis on closed questions was tested, the results showed that teachers in the experimental group significantly improved in using close questions in their classrooms. Likewise, the category of open questions is subdivided into divergent thinking questions and evaluative questions. When open questions were examined, the results showed that teachers in the experimental group were also significantly improved in using open questions in their classrooms.

Findings for hypothesis 3 revealed that the teachers in the experimental group increased the length of wait-time after asking a question. It can be inferred from this that students had more opportunity to think about the questions.

Findings for hypothesis 4 can be interpreted to mean that teachers in the experimental group decreased the amount of talking time in each class session. In handling time in this manner, the
teachers gave students more time to think before answering the question and more opportunity to answer the question as a result.

The conclusion drawn from the study was that the training program was effective in training teachers to decrease the number of cognitive-memory questions and increase the number of divergent thinking and evaluative thinking questions they asked, extending teacher wait-time, and reducing the amount of teacher talk during instruction in the science class. No significant change occurred in the number of convergent thinking questions or the total number of all cognitive-level questions asked by the teachers.

Discussion of the Findings

This study found that a training program was effective in changing teacher questioning and wait-time behaviors, which by supported many previous studies (Davis and Tinsley, 1967; Clegg, Farley, and Curran, 1967). (See Appendix C for summaries of pretest and posttest results for experimental group.) Studies by Wickless (1974), Arnold, Atwood, and Rogers (1974), and Winne (1979) were supported by the findings in this study that trained teachers asked more higher cognitive questions after treatment. The findings also indicated that the self-analysis procedure utilized in the training program was effective. This agreed with Schreiber (1967) who suggested that teachers were able to improve their questioning patterns through self-analysis; in particular, teachers asked fewer factual recall questions after analyzing their own questions. This
study had similar findings as in Cunningham's (1971) study. There was a significant decrease in the number of cognitive-memory questions and an increase in the number of divergent thinking questions but no significant change in the number of convergent thinking questions. However, contrary to several studies, this study reported an increase in evaluative thinking questions asked (Cunningham, 1968; Kleinman, 1969; Bedwell, 1975).

The effects of wait-time has been considered by many researchers. Rowe (1973) and Arnold, Atwood, and Rogers (1973) suggested that extended wait-time makes teachers ask more higher cognitive-level questions. Hassler, Fagan, and Szabo (1980) repeated some of Rowe's research. They reported that teachers trained in extended wait-time asked fewer questions overall but more higher level questions.

This study was concerned with the teacher's training program to improve questioning strategies. Konetski (1969) said that teachers' training affects the preparation of questions teachers asked. Chewprecha (1980) suggested the use of instructional pamphlet was more effective than other methods. As far as this study was concerned, Blosser's Handbook of Effective Questioning Techniques was found to be a valid and reliable instrument for use in the training program.

Recommendations

The conclusions of this study clearly shows that Thai teachers should be provided more training and practice in the use of question strategies and extended wait-time, which result in increasing the
number of thought-provoking and inquiry-types questions that the teachers ask in science classes. Science educators should become aware that they can help teachers develop teaching skills by giving sufficient guidance and providing opportunities to practice the skill of questioning. This needs to be carried on in such a manner that the teachers are encouraged to be critical in their self-analysis without feeling threatened or insecure. It is possible that some teachers possess some degree of skill in questioning; however, their level of proficiency in that skill can be increased through conscious attention to the development of the skill.

Classroom teachers need to become aware of the types of questions they customarily ask. They need to analyze and critically evaluate their teaching behavior after each class. They need to preplan for the questions to be used and how to use them.

The teachers should be provided with training programs in question strategies. As the findings of this study indicate, teachers can be trained to improve their question asking, increase the length of their wait-time after asking a question, and reduce the number of questions asked. To change teachers' questioning behavior and wait-time, training programs need to be established to assist in this changes.

The cooperating teachers expressed a need for extending training periods and following conference with the teachers in the experimental group. They suggested that this was a desirable way to increase their competencies. It is important to remember the fact that skill development is not an activity that reaches a high degree of mastery
in a limited period. It appears that skill in questioning requires an extended amount of practice before a significant degree of mastery is attained.

The teacher needs time to read and discuss materials on teacher questions and wait-time and to practice asking higher cognitive-level questions and increasing their wait-time.

A recommendation for further research would be to consider the influence of time length on the instructional training sequence. As mentioned previously, teachers in the experimental group felt they would have benefited from more practice. How much time is sufficient for skill development?

A study might be conducted to determine what changes might result if the instruction training sequence was a series of microteaching sessions. The number of times devoted to microteaching sessions might be varied for different teachers to determine at which point in the training an experience would result in maximum benefits for teachers of varying characteristics.

If this study were replicated, the instructional sequence might be modified to include more emphasis upon choosing lesson topics and activities that promote the asking of more convergent thinking, divergent thinking, and evaluative thinking questions, in order to determine if such a change would result in teachers asking higher cognitive-level questions.

Studies might be conducted to determine the effect of the IPST curriculum content on the opportunity to use higher cognitive-level questions in science classes.
In the process of research on extended teacher question wait-time, the description of the research appears to require further consideration. For instance, for this study treatments associated with teacher question wait-time were described in terms of mean wait-times. While teachers had different wait-time ranges for different questions types, on the basis of the evidence being presented as mean wait-time, some teachers had the same wait-time range for all question types. Two teachers who had the same mean wait-time may have had different wait-time ranges for each type of question. Further study could investigate what length of wait-time would be appropriate for each type of question if the teacher expects quality or adequacy of student response.

Studies on question strategies and wait-time related to Thai student achievement, problem solving activity, attitude and level of response to varying types of questions are needed and have not been conducted in Thailand. Effects on Thai teacher classroom behavior, expectation of students, and attitude toward teaching and students also need further study. Such investigations should be conducted to determine how well the students respond to teacher questions in Thai junior high school science classes.

Furthermore, it was beyond the scope of this study to examine the relationship between development of questioning skills and instructional factors, such as teaching experience, educational set, sex, personality type, and intelligence. This should be explored in future investigations.
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APPENDIX A

ENGLISH TRANSLATION OF THE THAI PAMPHLET

The following is an English translation of pamphlet material written in Thai used in training Thai junior high school science teachers. It is not a word for word translation because Thai differs considerably from English in sentence construction, especially in imperative, case, and word order. Since the researcher had translated parts of Blosser's Question Category System for Science directly into Thai for use in the pamphlet, those parts have been herewith reprinted from the original.
The purpose of this pamphlet is to provide guidance in improving questioning techniques for use in science class. The pamphlet is organized into five parts as follow: The first part is concerned with the role of the question in the science classroom: the purpose of the question and inquiry teaching. The second part is concerned with the classification of questions: Question Category System for Science and exercises. The third part is a discussion of wait-time and question strategies. The fourth part suggests procedures for improving questioning techniques. The final part includes examples of questions. The pamphlet was designed following Blosser’s direction in Handbook of Effective Questioning Techniques and from the previous research studies and books (see bibliography).

The Role of the Question in the Classroom

Questioning is a commonly used and important teaching technique. In the classroom, teacher can lead students into all kinds of thinking through careful use of questions. Teacher’s questions can serve these purposes:

1. stimulating reflective thought by requiring analysis, comparison, definition, interpretation, or the use of judgement;
2. developing appreciation and attitudes;
3. developing the power and habit of evaluation;
4. determining the informational background, interests and maturity of individuals or class groups; and
5. creating interest, arousing purpose, or developing a mind set. (Burton, 1962)

Many science educators have advocated the process of inquiry as effective means through which students may learn science. Most of the new science curriculum at both the elementary and secondary level was designed to be taught by some variation of the inquiry method with the teacher leading students to form conclusions by asking questions.

A good inquiry oriented teacher seems to be an excellent conversationalist. He listens well and asks appropriate questions assisting students in organizing their thought and gaining insights. An inquiry oriented teacher seldom tells but often questions. This is so because by asking questions, the teacher assists the student in using his mind. Proper questioning is a sophisticated art. To practice it, a teacher must perceive well where the thought of a student is. Teachers should realize that higher level questions affords opportunities for higher level thinking.
Teaching by inquiry, then, emphasizes the ability of the teacher to ask thought-provoking questions in order to encourage students to develop thinking skills and become more independent learners.

It is reasonable to infer that a teacher's questions elicit students' thinking abilities. Some teachers intuitively ask questions of high quality, but far too many overemphasize those that require students only to remember, and practically no teachers make full use of all worthwhile kinds of questions.

A different approach to improving questioning is that of training programs to make teachers more conscious of their own questioning behavior and of the methods designed to help them improve their questioning skills as self-analysis.

The Classification of Questions

Questions may be classified in a variety of ways. Sometimes the division is that of fact questions, requiring low-level cognitive ability to answer, and thought questions, requiring the use of some of the higher-level cognitive processes such as inferring, judging generalizing, hypothesizing, etc.

The general categories are Managerial Questions, which serve the teacher in promoting the usual class routine, and Rhetorical Questions, which reinforce points or are used for emphasis. The teacher really does not expect to receive an answer to a rhetorical question.

Teachers need to understand the question category system which was suggested as a useful tool. However, questions teachers ask affect both student and teacher. For example:

1. Student who have more practice in answering the question will develop intellectual skills to a greater degree than those who have less practice.

2. After a teacher studies the category system, he/she is likely to offer his/her students a greater variety of intellectual experiences than he/she did before.

3. A greater emphasis on the teaching of intellectual skills, other than the cognitive memory level, will not decrease the amount of knowledge the student gains.
Question Category System for Science

The question category system contained in this pamphlet is designed by Blosser (1973) for use in analyzing questions asked in the context of science lessons. It can, however, be adapted to apply to other content areas.

The Question Category System for Science (QCSS) consists of three levels of classification.

**Level I**

Questions are initially divided into (1) Closed Questions, those for which there is a limited number of acceptable responses or "right" answers, and (2) Open Questions, those for which there is a wide range of acceptable responses and not just one or two "right" answers.

![Figure 1](level1.png)

**Level II**

The second level of classification divides the questions into four types of thinking: Cognitive-Memory, Convergent Thinking, Divergent Thinking, and Evaluative Thinking.

![Figure 2](level2.png)

1. Cognitive-Memory questions are defined as those which require the simple reproduction of facts, formulas, and other items of remembered content through the use of such process as recognition, rote, memory, or selection recall.
These are considered to belong to the larger category of "Closed Questions." Examples of Cognitive-Memory questions would be such as:

What is the chemical formula of water?

What is the boiling point of water, at normal atmospheric pressure, on the centigrade scale?

What are the names of the three classes of rocks?

Who is credited with formulating the germ theory of disease?

Cognitive-Memory questions frequently begin with "Who," "What," "Where," and sometimes "How" and "Why." These words are not always signs of the level of questioning. Solicitations such as "Name two examples of minerals" or "Give me the formula for glucose" also fit into this category.

When a teacher operates on the level of cognitive-memory thinking, he usually asks students to repeat something they have already said or heard, to recall some fact or idea, or to classify, with the basis for the classification being provided for the students. (See Examples of Questions).

2. Convergent Thinking questions are also considered to belong to the larger category of "Closed Questions." These questions may involve the analysis and integration of given or remembered data. There questions are designed to stimulate such mental activities as translation (of information in a slightly different context), association, explanation, and drawing conclusions.

Some examples of Convergent Thinking questions might be:

Why will water boil at a lower temperature at a high altitude than it will at sea level?

When you change the microscope magnification from low to high power, what frequently appears to happen to the object you are viewing? Why does this happen?

From the data we now have about the planet Venus, what characteristics would "life" have to possess to survive there?

When you find an area in which fossilized coral predominates in the rock, what can you infer about past geologic conditions when the rock containing the coral was formed?

A question which a teacher thinks is designed to produced convergent thinking may only be a Cognitive-Memory question for a student who has read widely, studied more than the assigned material, or who have encountered the question or one similar to it before.
Teachers use Convergent Thinking questions when they use questions designed to get students to associate facts or see relationships, to discriminate, reformulate, illustrate, explain something using previously acquired data, make a prediction within the limitations imposed by the conditions or evidence, or make critical judgments using arbitrarily imposed standards or criteria.

3. Divergent Thinking questions are those in which the individuals questioned are free to generate their own data within a "data-poor" situation. The situation may be "data-poor" in that the teacher, the materials, or the assignment has not provided enough information to restrict thinking to certain pathways or to limit the types of answers which may be given. Divergent Thinking questions may stimulate such thinking operations as elaborating, divergent association, implication, or synthesis. When a teacher asks a Divergent Thinking question, he is not certain of the answer it may produce. Such questions as the following may be place in the divergent thinking category:

If the average temperature of Bangkok were to be twenty degrees higher than it now is, what changes would this possibly bring about in the ecology of this area?

What inferences can you make on the basis of the data you collected?

What do you suppose might happen if we ran out of natural gas?

How would the results of the experiment differ if you used a different method?

Divergent Thinking questions are designed to cause students to invert, to synthesize, to elaborate, to point out implication, or to make open predictions for which the data are insufficient to limit the response expected.

4. Evaluative Thinking questions deal with matter of value rather than matter of fact. They contain the implication that the individual responding may be called upon to justify his response. The standards or criteria involved in making the judgement may be explicit--set down by the teacher, by scientific evidence, by consensus, etc.--or they may be implicit--internal criteria by which the student operates in his thinking.

Examples of Evaluative Thinking questions are:

How can you indicate that you have good judgment?

If you were going to repeat the experiment, how would you do it better?

Which set of arguments best supports the conclusion?
What one idea did you get out of this problem that you think is the most significant?

What do you think is the most important problem in our community?

Students may be involved in evaluative thinking when the questions asked cause them to evaluate methods and procedures in the formulation of an experimental design, to judge matters of value, to criticize, or to give an opinion.

Teachers should learn and get familiar with these four types of questions: Cognitive-Memory, Convergent Thinking, Divergent Thinking, Evaluative Thinking. All serve different purposes. (See Figure 3.)

<table>
<thead>
<tr>
<th>LEVEL I</th>
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<tr>
<td>CLOSED QUESTIONS</td>
<td>1. COGNITIVE-MEMORY QUESTIONS</td>
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<td>(limited number of acceptable responses)</td>
<td>—stimulate memory, factual recall</td>
</tr>
<tr>
<td></td>
<td>—involve recognition</td>
</tr>
<tr>
<td></td>
<td>2. CONVERGENT THINKING QUESTIONS</td>
</tr>
<tr>
<td></td>
<td>—involve analysis or integration of given or remembered data</td>
</tr>
<tr>
<td></td>
<td>—focus thinking toward a possible answer</td>
</tr>
<tr>
<td>OPEN QUESTIONS</td>
<td>3. DIVERGENT THINKING QUESTIONS</td>
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<tr>
<td>(wide range of acceptable responses)</td>
<td>—many possible responses</td>
</tr>
<tr>
<td></td>
<td>—stimulate original thought</td>
</tr>
<tr>
<td></td>
<td>4. EVALUATIVE THINKING QUESTIONS</td>
</tr>
<tr>
<td></td>
<td>—involve use of standards or criteria</td>
</tr>
<tr>
<td></td>
<td>—deal with matters of value, cognitive and/or affective</td>
</tr>
</tbody>
</table>

“Open Questions” (Divergent Thinking, Evaluative Thinking) may be used to stimulate interest, to provide motivation for further study, or to develop insights, appreciations or attitudes. “Open Questions” may be used to introduce a new idea or topic or may come into use when the teacher thinks the class has acquired enough knowledge and understanding of the topic to go beyond the prescribed information and to use it to do other types of thinking, classified as Divergent and Evaluative.
Cognitive-Memory and Convergent Thinking questions are considered as "Closed Questions" in that the teacher usually can determine the answers they will produce.

Divergent and Evaluative Thinking questions are considered to be "Open Questions" because the teacher usually cannot be certain what the student who is responding is going to say.

Level III

The third level of the Question Category System of Science is the type of thinking operation called for, as detailed in the chart (Figure 4) on the next page.

There is no guarantee that the thinking operation which the question is designed to stimulate will produce that particular response in any or all of the students hearing the questions. Questions are classified on the basis of their intent as perceived by the listener and not on the basis of the response which the student makes.

The chart serves as a reference to be used in learning the category system. It can serve as a guide when the teacher is preplanning questions. Or, the teacher can preplan the questions and then analyze them to determine the question types and perhaps modify the questions if this analysis shows that there are too many memory questions of one type and too few of another to fit the lesson objectives. (See Figure 5.)

Good questions recognize the wide possibilities of thought and are built around varying forms of thinking.

Good questions are also directed toward learning and evaluative thinking, rather than determining what has been learned.

Some examples of the various kinds of questions that might be classified under the different thinking operations listed in the Blosser's Question Category System for Science are given in Examples of Questions.
### Figure 4

#### Question Category System for Science

<table>
<thead>
<tr>
<th>Level I</th>
<th>Level II</th>
<th>Level III</th>
</tr>
</thead>
</table>
| **I. CLOSED QUESTIONS**  
(limited number of acceptable responses) | **A. COGNITIVE MEMORY**  
1. **RECALL**: includes repeat, duplicate, memorized definitions  
2. **IDENTIFY** or **NAME** or **OBSERVE** | **1. ASSOCIATE** and/or **DISCRIMINATE**; **CLASSIFY**  
2. **REFORMULATE**  
3. **APPLY**: previously acquired information to solution of new and/or different problem  
4. **SYNTHESIZE**  
5. **CLOSED PREDICTION**: limitations imposed by conditions or evidence  
6. **MAKE “CRITICAL” JUDGMENT**: using standards commonly known by class |
| **B. CONVERGENT THINKING**  
| | **D. EVALUATIVE THINKING**  
| **C. DIVERGENT THINKING**  
(greater number of acceptable responses) | **1. GIVE OPINION**  
2. **OPEN PREDICTION**: data insufficient to limit response  
3. **INFER** or **IMPLY** | **1. JUSTIFY**: behavior, plan of action, position taken  
2. **DESIGN**: new method(s), formulate hypotheses, conclusion(s)  
3. **JUDGE A**: matters of value, linked with affective behaviors  
4. **JUDGE B**: linked with cognitive behaviors |
| **III. MANAGERIAL** Teacher uses to facilitate classroom operations, discussion | **IV. RHETORICAL** Teacher uses to reinforce a point; does not expect (or want) a response |

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*1. **Cognitive-Memory**: evidence understood to be directly available (textbook, previous lesson, or discussion, film, filmstrip, chart, experiment, field trip, etc.)
2. **Convergent Thinking**: evidence directly available but not in the form called for by question
3. **Divergent Thinking**: evidence for response not directly available
4. **Evaluative Thinking**: evidence may or may not be directly available; criteria for responding available, directly or indirectly. Implication that student may be called upon to provide a defense for his response.
### Figure 5

Observation Form for Determining Teacher's Questioning Behavior

<table>
<thead>
<tr>
<th>Level I</th>
<th>Level II</th>
<th>Level III</th>
<th>Tallies</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLOSED QUESTIONS</td>
<td>COGNITIVE-MEMORY</td>
<td>1. RECALL</td>
<td></td>
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<td></td>
<td></td>
<td>2. IDENTIFY or NAME or OBSERVE</td>
<td></td>
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<tr>
<td></td>
<td>CONVERGENT THINKING</td>
<td>1. ASSOCIATE and/or DISCRIMINATE, CLASSIFY</td>
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<td></td>
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<td>2. REFORMULATE</td>
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<td>3. APPLY</td>
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<td>4. SYNTHESIZE</td>
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<td>5. CLOSED PREDICTION</td>
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<td>6. MAKE &quot;CRITICAL&quot; JUDGMENT</td>
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<tr>
<td>OPEN QUESTIONS</td>
<td>DIVERGENT THINKING</td>
<td>1. GIVE OPINION</td>
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<td>2. OPEN PREDICTION</td>
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<td>EVALUATIVE THINKING</td>
<td>1. JUSTIFY</td>
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<td>4. JUDGE B</td>
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<td>MANAGERIAL QUESTIONS</td>
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<tr>
<td>RHETORICAL QUESTIONS</td>
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Exercises*

The exercises are designed so that the teacher can be used by working alone on a self-improvement project. Teachers learn, through experience, the kind of questions to use in different situations. Answers to the exercise follow on the next page.

Exercise I-A: Distinguishing Between Closed and Open Questions

Although it is sometimes difficult to classify a question when it is taken out of the context of the class discussion, try to identify each of the following questions as being either Open (OQ) or Closed (CQ). Remember that Closed Questions have a limited number of acceptable responses whereas Open Questions allow for a wide variety of answers.

1. Is this a cylinder or a sphere?
2. How could we classify these animals?
3. Who was Louis Pasteur?
4. What does "semipermeable" mean?
5. If you could design an ideal nature study center, what would it be like?
6. What are plant cell walls made of?
7. If you wanted to set up a science lab at home, what things would you include in it?
8. How can you tell a male frog from a female frog if you have a photography rather than live specimens?

*Researcher Note: Exercises were translated directly from Blosser, with only slight modification. Changes to Blosser's text are indicated here by enclosure in brackets [ ].
Answers to Exercise I-A

CQ 1. This is a Closed Question. It calls for the pupil to identify an object, making the identification on the basis of remembered characteristics of cylinders and spheres.

OQ 2. This is an Open Question. No teacher-imposed restrictions are given for setting up classification categories.

CQ 3. This is a Closed Question, requiring factual recall. It also is not a very good question in that the wording of it does not define the limitations of the question. A pupil could answer it by saying "A man" or "A famous scientist" as well as "He invented a treatment for rabies," or by giving several other responses. Even though different responses are possible, the level of thinking required makes it Closed Question.

CQ 4. This is also a Closed Question in that it requires a previously learned definition.

OQ 5. This is an Open Question. Students are requested to hypothesize in their designs and are free to set their own limitations.

CQ 6. Another Closed Question demanding recall of previously learned information.

OQ 7. This is an Open Question. Although there are some pieces of equipment that most science labs contain or are used more in science laboratories than elsewhere, the students are free to stock the imaginary lab according to their individual interests in science.

CQ 8. Closed Question requiring recall type thinking.
Exercise I-B: Distinguishing Between Closed and Open Questions

Again, try your hand at classifying the following questions. In addition to Closed Questions and Open Questions, the following series also contain some questions that can be classified as Managerial or Rhetorical. Designate these questions with the abbreviation NT (non-thinking) because they do not require the students to think about formulating a response that directly relates to that specific question.

1. What would life be like if the gravity here on earth was only one-third as strong as it is?
2. [Suda], did you want to say something?
3. What do you need to do to balance your hamster's diet?
4. Would you call that a plant or an animal?
5. So that's an acid, right?
6. [Why should the Thai government spend money on building more dams in the northern part of our country?]
7. Is this an igneous rock?
8. Who can think of anything to add to the list?
Answers to Exercise I-B

OQ 1. This is an Open Question requiring students to speculate, operating on the basis of previously acquired information, but not limiting them to a narrow list of possible responses.

NT 2. Such a question as this allows a student to participate (making it Managerial) in the discussion but does not require a thinking operation for the response.

CQ 3. This is a Closed Question calling for the analysis of previously learned information about balanced diets for hamsters as well as a comparison between such a balanced diet and what the hamster is presently being fed.

CQ 4. A Closed Question requiring discrimination in order to categorize or classify.

NT 5. This is a Rhetorical Question thrown in to reinforce a point.

OQ 6. An Open Question implying a value judgment as students decide upon their responses.

CQ 7. Another identification or classification question, making it Closed.

NT 8. Another teacher question of the Managerial variety, used to continue the discussion of a particular topic.
Exercise II-A: Recognizing Divergent Thinking Questions

In the two previous exercises, you have had practice in distinguishing between Closed Questions and Open Questions. This was functioning at Level I of the Question Category System for Science. In this exercise you will attempt to work at Level II and classify questions as Cognitive-Memory (CM) or Convergent Thinking (CT) Questions rather than as Closed Questions. In addition, try to identify Open Questions of the Divergent Thinking (DT) variety.

1. How can we modify this cage to make it a suitable home for a hamster?

2. What is the function of a barometer?

3. What mineral is used in the manufacturing of iron products?

4. What might we do if all water supplies were polluted?

5. If you were an explorer on the Moon and you encountered what appeared to be a living creature, how would you communicate with him to show you were friendly?

6. How does running water wear away rocks?

7. How soon do you think we might send a manned space probe to Venus?

8. What do you think might happen if we increased the mass of the two objects?
Answers to Exercise II-A

DT 1. This calls for Divergent Thinking, asking for an opinion.

CM 2. Answering this requires recalling previously memorized definition.

CM 3. Another recall-type question.

DT 4. This is a question of the "Open Prediction" variety for which there is insufficient data for responses to be limited by the already existing information.

DT 5. Again, this is another Open Question with a wide variety of responses, calling for originality in answering.

CT/CM 6. The exact category for classification would depend on the context and what had preceded the lesson. If students were asked to use knowledge they possessed and apply it to the problem, the question is of the Convergent Thinking type. If they had already arrived at, or been told, the explanation, the question would be called Cognitive Memory. Either way, it falls in the Closed Question category at Level I.

DT 7. Such a question solicits student opinions.

DT 8. Students are asked to infer a possible consequence, based on what they already know, but insufficient data are given to impose limitations on their responses.

Exercise II-B: Recognizing Divergent Thinking and Evaluative Thinking Questions

Identify the following questions as:
CM = cognitive-memory question
CT = convergent thinking question
DT = divergent thinking question
ET = evaluative thinking question

1. Is this a Florence flask or an Erlenmeyer?

2. Is abortion wrong?

3. What might happen if we could control the weather?

4. What do you think would happen if we were to discover that there was life on Mars?

5. Should families be limited to two children?

6. How do osmosis and diffusion differ?

7. What is the most efficient way to get this job done?

8. Should we continue to promote [monorail transportation] when we have not yet solved [the flooding problems in Bangkok]?
Answers to Exercise II-B

CM 1. This requires identification, based on recalling the shapes of these two types of flasks.

ET 2. This calls for a value judgment, based probably both on cognitive and affective standards.

DT 3. This calls for an inference.

DT 4. So does this one.

ET 5. Again, personal as well as social values influence students' responses.

CT 6. This requires the analysis of previously learned information, as well as discrimination of differences.

CT 7. Stipulating "most efficient" way imposes the criterion to be used in responding, making it "critical" judgment type of question.

ET 8. Again, personal and social values influence the response.

Exercise III: Recognizing Types of Questions

In exercises one and two, you have had experiences in recognizing the different question types of Levels I and II of the Question Category System for Science. In this exercise you will classify questions as Cognitive-Memory (CM), Convergent Thinking (CT), Divergent Thinking (DT), Evaluative Thinking (ET), or as Non-Thinking (NT) if they are of either the Managerial or Rhetorical variety.

___ 1. Which one feels heavier now?
___ 2. What are some of your reasons for calling them plants?
___ 3. How many uses did you list?
___ 4. What do you predict will happen if I let go of the board?
___ 5. Why is it important that the thermometer not touch the bottom of the beaker?
___ 6. How can you explain what happened when these two were mixed?
___ 7. What's a better word for "green stuff"?
___ 8. Do you agree that he has a sampling error in his data?
___ 9. Want to try it and see if you can keep it from moving?
___10. Why do you say the water did not come from inside the container?
Answers to Exercise III

CT  1. This is a Convergent Thinking question requiring the student to discriminate on the basis of how heavy the two objects feel.

ET  2. This is an Evaluative Thinking question asking the student to explain or justify his classification. It does require recall of information but the end operation is that of defending his previous response.

CM  3. The respondent is asked to observe his list, count and respond, making this a Cognitive-Memory type question.

DT  4. A Divergent Thinking question. The teacher had set up a demonstration unfamiliar to the students and asked the question before doing anything other than asking the students to observe the set-up carefully. If the demonstration had been completed and then some steps taken to alter the situation slightly, the question might have become an Evaluative Thinking one in which students were asked to hypothesize from the data.

DT  5. Students are asked to make an inference, based on previous experiences; so this is called a Divergent Thinking question. If they had been cautioned and the reasons for the precaution told to them, the question would have been called Cognitive-Memory.

CT  6. This question was asked in the course of some laboratory work paralleling an experiment performed during a pre-lab session. The teacher's intent was to require the students to apply their previously acquired knowledge to a new (but similar problem. Can you think of any circumstances in which this question might be classified as Divergent?

CT  7. Another Convergent Thinking question because the teacher is imposing standards in the hope that some student will tell him that the "green stuff" is called chlorophyll.

DT/ET 8. The teacher may be asking a student to give an opinion, making the question one of the Divergent Thinking variety; or the intent may be to have the student(s) critically analyze the situation and make a cognitive-type evaluation.

NT  9. This is a Managerial Question directed at a student to draw her into the class activity?

CT/ET 10. Another question that could be correctly classified in more than one category. Students could be required to work within limitations imposed by the response given (Evaluative Thinking). Such a question needs a contextual setting (written dialogue or tape recording) if the observer is to be more certain of the teacher's intent in asking it.
Wait-time and Questioning Strategies

Wait-time

Results from several studies concerned strategies that teacher did not allow enough time for students to think before answering their questions. Mary Budd Rowe (1969) investigated the verbal behavior pattern of inservice elementary school teachers as they taught science. One questioning strategy that she considered was the extension of teacher question pauses, or wait-time. The pause can be identified into two pauses (see Figure 6). The first pause was

Figure 6
Diagram of Wait-time

the period of time between the end of the teacher's question and the beginning of a student response or further teacher talk. The second pause was the period of time that a teacher waited before replying to a student response. Rowe stated that the factor which characterized by a rapid question-answer sequence in teaching strategies had an effect on students learning science. In studying of wait-time Rowe found that experienced teachers allowed an average of one second for a student to start an answer before they either repeated, or rephrased, the question or called on another student. After a student response, the teacher generally waited slightly less than a second before repeating the student's answer, rephrasing it, or asking another question.

Rowe and her colleagues experimented to test the effect of wait-time. She suggested that when teachers increased the average wait-time to five seconds or more after asking a question, student variables changed as follows:

1. the length of student responses increased;
2. the number of unsolicited, but appropriate, responses increased;
3. incidence of failure to respond decreased;
4. confidence, as reflected by a decrease in the number of inflected responses, increased;
5. the incidence of speculative responses increased;
6. the incidence of child-child comparisons of data increased;
7. the incidence of evidence-influence statements increased;
8. the frequency of student questions increased;
9. there was an increase in the incidence of responses from students rated by teachers as relatively slow learners; and
10. the variety in type of verbal behaviors of students increased.

In addition to these changed student behaviors, Rowe noted that at least three teacher behaviors changed when wait-time increased, as follows:

1. response flexibility scored increased;
2. teacher questioning patterns became manageable; and
3. there was some indication that teacher expectations improved for performance of students rated as relatively low.

Since the effects of increased wait-time are positive changes in both teacher and student performance, teachers are encouraged in training on wait-time of three seconds or longer in their questioning strategies.

Questioning Strategies

In the classroom, questions are usually used to reinforce a student's self-concept, by allowing him to contribute to discussion. Class discussion is a teaching tool that is always used in science lessons. Discussion is used extensively to develop cognitive skills, attitudes, feelings, and sensitivities, and to get the greatest possible use from the content being studied (Taba, p. 75). When conducting a discussion, the teacher must make on-the-spot decisions, diagnoses, and formulation of questions as well as maintain control of the class. The teacher does have to guide the discussion and try to make students listen to and respond to each other and not just to the teacher.

Questioning strategies emphasized in this pamphlet are discussed and suggested teachers to practice in order to improve their questioning techniques.

Using questions to increase student verbal participation while decreasing the amount of teacher talk.
Teacher behaviors to practice:

1. Pause, at least three seconds, after asking a question to allow students time to think.

2. Ask students to expand on their responses if they provide short or fragmentary answers.

3. Word questions clearly.

4. Call on more than one student per question.

5. Encourage students to react to other students' responses.

6. Avoid repeating teacher's own question.

7. Avoid repeating students' responses.

The reason it is desirable to decrease the amount of teacher talk is that the teacher has a tendency to dominate the thinking in the class. He determines if the responses made to his question are acceptable. Students tend to guess what response the teacher desires to hear, rather than feeling free to respond according to their own thinking. Teachers should emphasize their concern with teaching students how to think rather than what to think. If teachers are to know what their students are thinking, they must provide more opportunities for students to talk and present their opinions and ideas during a lesson than are possible when teacher talk predominates.

Purposes of Pausing (Wait-time)

Wait-time has been previously discussed and it has been suggested that, after asking a question, the teacher should pause three seconds or longer before calling on a student or accepting a response, in order to allow time for thinking. Time should be allowed for students to think if they are expected to analyze, synthesize, or evaluate before they respond.

However, the teacher's role in class discussion will vary. The teacher needs to make a conscious effort to serve as a guide and moderator rather than to set himself up as a source of wisdom. If he wants his students to associate science with processing and critical evaluation of data, he should allow students time to think before they respond to his questions.

Figure 7 on the following page provides an overview of some possible patterns of classroom interaction for teachers to follow and to avoid.
Figure 7

Some Possible Patterns of Classroom Verbal Interaction

Patterns to be avoided

I. Teacher asks question
   Student responds
   \{ accepts \}
   \{ rejects \}
   Teacher rejects response
   Teacher asks question

II. Teacher asks question
   Student responds
   Teacher repeats question,
calls on second student
to respond

III. Teacher asks question
    Student responds
    Teacher repeats student's
    answer

NET RESULT: Teacher talks as
much as students do—or more.
Teacher probably talks more than
students do because teacher talk
is usually more detailed and
involved than are student
responses.

Patterns to be encouraged

I. Teacher asks question
   One student responds
   Second student responds
to same question
   Additional students respond

II. Teacher asks question
    Student responds
    Second student comments
    on response
    Additional students enter
discussion

III. Teacher asks question
    Student responds with
    question
    Teacher reflects questions
to student or to class
    Other students respond to
    student's question

IV. Teacher asks question
    Student responds
    Teacher requests additional
    responses
    OR
    Teacher asks for student
evaluation of response

NET RESULT: More student
participation and less teacher
domination of the verbal
interaction during class
discussion.
Asking Open Questions

Teacher behavior to practice:

1. Carefully preplan key Open Questions. This involves recognizing the types of content, objectives, and lessons that promote the use of Open Questions.

2. Word questions clearly.

3. Avoid imposing your own judgment, as teacher, on your students' responses to Open Questions. The fact that you intended to question to be an Open one implies that a wide variety of responses is possible and acceptable.

4. Pause at least three seconds or longer after asking a question to allow students time to think.

5. Call on more than one student per question.

6. Encourage students to react to other students' responses.

Closed Questions are defined in this pamphlet as those questions for which the response is predictable because the number of acceptable is limited. Open Questions are those for which the specific form of the response is not predictable because there is a wide range of acceptable responses.

Open Questions and Closed Questions serve different purposes in teaching. An over-emphasis on Closed Questions would appear to be contrary to all of the stated objectives of science teaching that related to developing critical thinking individuals concerned with the processes of science as well as with scientific knowledge. The results from several studies revealed that science teachers asked questions which primarily emphasized the cognitive-memory and convergent thinking levels in their questioning strategies. This situation may result from the particular lesson being taught. However, it may be due to teachers being unaware of the levels of thinking of their questions and spending little time in analyzing their questioning techniques.

Teachers also need to be concerned with the number of questions needed to be asked to accomplish their purposes. It is not necessary true that "the more questions, the better." A few carefully thought-out questions appropriately placed in the development of the lesson may do more to encourage student thinking than will a continual bombardment of questions. The teacher needs to consider the quality of the question as well as the quantity included in the lesson.

Some purposes of Open Questions. The teacher's questions perform a variety of teaching functions. They may stimulate the discovery of
new ideas or the performance of certain thinking operations. The use of Open Questions encourage students to become increasing more independent in processing information and less dependent on the teacher for support and for final authority. Open Question may be used to stimulate interest, arouse motivation for further study, or to develop insights, appreciations, or attitudes. They may be used when the teacher is introducing a new idea or topic. They may also be used when the teacher thinks that enough background information has been acquired and that the class is ready to use this information to synthesize or to engage in other divergent thinking activities.

Evaluative thinking operations are also used when the teacher asks the students to propose hypotheses to explain a situation or to propose possible experimental designs, because of the implication that the students will be called upon to justify their procedures.

Remember, asking Open Questions involves allowing students time to think before they respond. Frequently teachers ask well-formulated Open Questions and when they do not receive an almost immediate response from a student, they either answer the question themselves or reformulate it into one or more convergent thinking questions. Teachers should be willing to wait for thinking to take place. Teachers should be aware of the fact that their questions serve not only to emphasize the content about which the students are to think about but also the thinking operation to be performed on the content.
Suggested Procedures for Improving Questioning Techniques

This part is concerned with the teacher, the individual reading this material, being interested in using a variety of questioning strategies in science lessons considered effective in stimulating student thinking at levels above that of factual recall.

All of the information needs to be brought together and related to methods for utilizing it in a program aimed at self-improvement in questioning. This part of the pamphlet contains a procedure aimed toward the objective of improving teacher questioning skills.

Planning for Individual Teacher

There are several steps to follow if teachers want to improve their questioning skills.

First of all, teachers need to be interested in improving their questioning behavior. Then teachers need to do more than think about making some efforts at improvement. Teachers need a plan of action.

1. Plan for questions to ask according to objectives for a particular unit or topic and in sequencing instruction to help students achieve those objectives. Teachers should spend time developing several questions and strategies.

2. Plan to record the teacher's own verbal lesson—which is the best way to analyze questioning behavior in a self-improvement program.

3. Listen to the recording of the lesson and attempt to identify the questioning strategies the teacher used, the types of questions asked, as well as to determine the success of questioning techniques.

Specific suggestions are as follows:

1. Planning for teaching
   - Analyze the material the teacher plans to cover; determine it lends itself to Closed Questions or Open Questions.
   - Preplan several questions.
   - Compare questions with the question category listed in the Question Category System for Science (see page 3-6 [of booklet]) and identify each question as being Closed or Open.
   - If Closed Questions predominated, determine if the teacher can modify them and produce Open Questions which still allow teacher to achieve overall objective for that particular lesson.
   - Develop some statements or questions to use to get students to expand their answers.
2. During the lesson
   - Encourage student participation.
   - Make an effort to pause after asking a question, particularly if it's an Open Question. Try to extend your wait-time three seconds or longer.
   - Tape record some of your lessons for later analysis.
   - Use small group discussions from time to time as possible.

3. After the lesson
   - Using the tape recording, identify the types of questions you actually asked. Use the QCSS to identify the questions. Record the number of each type of questions you asked on the chart provided on page 8 [of booklet].
   - Analyze your questioning behavior.

Teachers should realize that any behavior that is learned requires time and practice before its application begins to seem automatic or instinctive. Teachers should not be discouraged if their questioning behavior does not change rapidly.

After teachers have analyzed one or two lessons, they should have a general idea of what their customary questioning behaviors are and what areas they need to concentrate upon improving.
Examples of Questions

This section contains some examples of the various kinds of questions that might be classified under the different thinking operations listed in Blosser's Question Category System.

It is difficult to take a question out of the context of the planned lesson and classroom discussion and arbitrarily write it out as an example of a particular thinking operation. Some of the examples cited might be categorized under different thinking operations if they were used in a different context. These questions are given to be used as general guides in learning to distinguish the place in the Question Category System into which a given question might be classified.

EXAMPLES OF QUESTIONS RELATING TO DIFFERENT TYPES OF THINKING OPERATIONS

A. COGNITIVE-MEMORY QUESTIONS (evidence for answer directly available in some form)

1. RECALL: student is asked to remember and present information previously learned. This may include asking student to repeat or restate a response made earlier in the discussion. Student may also be asked to perform some manual operation that has been explained or to duplicate it as specified in the directions.
   “What is the function of the blood?”
   “What is the definition of osmosis?”
   “What did you tell us a few minutes ago about that?”
   “What is the proper way to focus a microscope?”

2. IDENTIFY, NAME, OBSERVE: student is asked to identify an object by naming it, pointing to it, selecting it out of a group; to state what he observed without drawing any inferences, conclusions, etc.
   “Which flask shown in the picture is the Florence flask?”
   “Give me an example of an igneous rock.”
   “When the copper was heated, what color was the flame?”
   “How many different cell layers do you see on that slide?”

B. CONVERGENT THINKING QUESTIONS (evidence for response directly available but not in form called for by question)

1. ASSOCIATE, DISCRIMINATE, CLASSIFY: student is asked to focus on likenesses or similarities; to equate; or student is asked to compare or contrast, to focus on differences. CLASSIFY (criteria given) is also placed in this category since it involves association and discrimination. Student is given a set of criteria or helped to develop a set and then use this in classifying objects.
   “Why are sandstone, limestone and conglomerate all classed as sedimentary rocks?”
   “What are some common properties of plants and animals?”
   “What're the major differences between [sugar] and [starch]-- they're both carbohydrates?”
   “How can you distinguish [diamond] from [graphite]?”
   “Limestone and sandstone are both sedimentary rocks. How can you tell them apart?”
   “Group the materials listed on the board as elements, compounds, or mixtures.”

2. REFORMULATE: student is asked to give the answer in his own words, not those of the textbook or teacher; to interpret verbal data into graphical form or vice versa; to paraphrase an important idea.
   “What is your version of the results shown in the chart on page 45?”
   “Can you tell us, in your own words, what these data mean?”
3. **APPLY**: student is asked to use previously acquired data in stating the possible causes of a phenomenon, the reasons for a particular procedure or process—providing this goes beyond a memorized definition available in the textbook or previous lesson material (if this is all that is involved the question is a "recall" one). Student may also be asked to use previously acquired knowledge in solving a similar but unfamiliar problem; to cite examples to illustrate a particular phenomenon or process other than those already discussed; or student is given a value, skill or definition and asked to identify or compose an example of its use.

"...and this process is called osmosis. Where might osmosis take place in our bodies?"

"What happened to the air inside the balloon, in terms of molecular motion, when the flask was heated?"

"What caused the limestone to effervesce when acid was dropped on it?"

"Based on what you have just said about the process of convection, what part do you think convection currents play in the heating and cooling of houses?"

4. **SYNTHESIZE**: student is asked to combine pieces of information to form a whole, to make generalizations.

"If the air temperature in a room is 85°F and the wall temperature is 50°F, why might a person feel cold?"

"Explain why it is or is not correct to say that matter is not destroyed when a piece of wood is burned."

"What generalization can you make from the data you gathered?"

5. **CLOSED PREDICTION**: student is asked to form a prediction, using data which limits his answer.

"On the basis of the results we collected in this class, how do you think arm lengths would vary if we were to use younger students in our sample?"

"If both parents were hybrids, what would you expect the F₁ generation to look like?"

6. **MAKE "CRITICAL" JUDGMENT**: student is asked to form a restrictive judgment about the correctness, adequacy, appropriateness, etc. of some situation or response, using standards or criteria that are commonly known by the class.

"Does anyone wish to challenge that answer?"

"How do the relative sizes of these objects compare?"

"Is that the proper procedure to use?"

C. DIVERGENT THINKING QUESTIONS (evidence for response not directly available)

1. **GIVE OPINION**: student is asked for his opinion without also being asked to justify it or to present a rationale for his response. These differ from the "make 'critical' judgment" variety in that the context in which the question is asked is such that there is no implication that only a limited number of responses will be considered acceptable by the teacher.

"Do you think we should repeat this experiment?"

"What do you think?"

"Do you think the results we got would be changed much if we were to increase the temperature two degrees?"

2. **OPEN PREDICTION**: student is asked to make a prediction but the data available are insufficient to limit the response expected; students are asked to speculate, to "brain-storm."

"If we were to land a spaceship on Venus and, if Venus were to be inhabited, what might the welcoming committee look like?"

"What do you think might happen if the Sun were to 'die'?"

"What do you think life on Earth will be like 200 years from now?"

3. **INFER or IMPLY**: student is asked to draw inferences or to point out implications.

"What can you infer, from the evidence you collected in your experiment, about the growth curve of those bacteria?"

"What inferences can you make based on the data you collected?"

"What are the implications of that conclusion?"
D. EVALUATIVE THINKING QUESTIONS (evidence for response may or may not be directly available; criteria for responding are available, either directly or indirectly; implications is that student may be called upon to provide a defense for his response.)

1. **JUTIFY:** student is asked to elaborate on the reasons for his response; to defend his position on some rational grounds; to develop a rationale for his actions.
   - "Why did you use litmus paper rather than hydrion paper?"
   - "Upon what basis did you form this conclusion?"

2. **DESIGN:** student is asked to design or formulate a new method of doing something, to establish a testable hypothesis, etc.
   - "Can you think of a different way of solving this problem?"
   - "Can you suggest a design for an experiment to investigate that?"

3. **JUDGE A:** student is asked to judge some situation involving a matter of value or worth, with the implication that the thing being judged relates to himself or other persons, hence the involvement of affective behavior.
   - "Should we set up a policy whereby human organs are automatically made available for transplant operations when a person dies?"
   - "How would you handle this situation?"

4. **JUDGE B:** student is asked to judge some situation in which the judgment is to be made on the basis of utility, consistency, logical accuracy or other cognitive standard.
   - "Which process should we use if we wish to solve the problem in the most efficient manner?"
   - "Is the conclusion you reached based on valid evidence?"
Bibliography


Far West Regional Laboratory, Minicourse One: Effective Questioning in a Classroom Discussion. Berkeley: Far West Laboratory for Educational Research and Development.


## APPENDIX B

### SAMPLE OF TRANSCRIPT FOR DETERMINING TEACHER'S CATEGORIZING QUESTIONS*

<table>
<thead>
<tr>
<th>No.</th>
<th>Questions</th>
<th>Category</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>If the tendency of population goes higher, what do you think will cause the problems to our country?</td>
<td>C</td>
<td>May be C if students knew before.</td>
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<tr>
<td>2.</td>
<td>Why do we have concern about the problem of food shortage?</td>
<td>D</td>
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<tr>
<td>3.</td>
<td>Anyone else?</td>
<td></td>
<td>Managerial</td>
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<td>4.</td>
<td>What will happen if a lot of people are out of work?</td>
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<tr>
<td>5.</td>
<td>Anymore?</td>
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<td>6.</td>
<td>What are the necessary things for living?</td>
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<td>7.</td>
<td>If we have more population, how are we going to solve this problem?</td>
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<td>How are we going to prevent the lack of food?</td>
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<td>9.</td>
<td>What do you mean by producing more food?</td>
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<tr>
<td>10.</td>
<td>Besides this, what else can we do?</td>
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<tr>
<td>11.</td>
<td>Can we decrease the population?</td>
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<tr>
<td>12.</td>
<td>Explain why do we decrease the number of population?</td>
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</table>

*Translation from Thai into English by researcher.
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<tbody>
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<td>Do you think the result we got would be changed much if we were to decrease the population?</td>
<td></td>
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<td>14</td>
<td>What do you think?</td>
<td></td>
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<td>15</td>
<td>How about the space to live?</td>
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<td>16</td>
<td>What is the proper way to increase the space to live?</td>
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<td>Anyone else?</td>
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<td>How did other countries solve the problem of space to live?</td>
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<td>How did Netherlands solve this problem?</td>
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<td>Who knows about this?</td>
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<td>Do other countries solve this problem the same as Netherlands?</td>
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<td>How are we going to make full use of the land?</td>
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<td>How would you handle this situation?</td>
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<td>Why do we have to know about cultivation?</td>
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<td>Which process should we use if we wish to solve the problem like this?</td>
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<td>Besides expanding the space to live, can you think of a different way to solve the problem?</td>
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APPENDIX C
SUMMARIES OF PRETEST AND POSTTEST RESULTS
FOR EXPERIMENTAL AND CONTROL GROUPS
Table 30
Summary of Pretest Results: Experimental Group (N = 31)
(2 Periods, 100 Minutes)

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**Key:**
- M = Cognitive Memory Questions
- C = Convergent Thinking Questions
- D = Divergent Thinking Questions
- E = Evaluative Thinking Questions
**Table 31**

Summary of Posttest Results: Experimental Group (N = 31)
(2 Periods, 100 Minutes)

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(2 Periods, 100 Minutes)

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