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ABSTRACT

This 10-chapter report provides detailed information on a study which examined what combinations of teacher, student, and curricular variables were associated with more effective life science instruction at the intermediate level. The conception of effectiveness was guided by the normative framework of scientific literacy and by student growth on science outcomes. The definition of scientific literacy used consists of five components: explaining science content; relating to science as a social historical process; relating to science as a reasoning process; relating science and society/technology; and positive attitudes toward science. Among the findings (from students and teachers in 11 classes) are indications that: (1) teachers generally used a typical pattern of academic instruction, relying heavily on recitation, seatwork, and laboratory exercises; (2) students perceived that teachers made relatively little use of the scientific literacy components other than explaining factual content; (3) worksheets were the most commonly assigned activities; and (4) student attitudes toward science generally declined over the academic year, while science knowledge, understanding, and reasoning skills increased. Recommendations based on these and other findings are offered, such as increasing teachers' use of the scientific literacy framework and upgrading the cognitive level of tasks assigned to students. (JN)

Secondary Science and Mathematics Improvement Program

SCIENTIFIC LITERACY IN SEVENTH-GRADE LIFE SCIENCE: A STUDY OF INSTRUCTIONAL PROCESS, TASK COMPLETION, STUDENT PERCEPTIONS AND LEARNING OUTCOMES

Final Report

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November 30, 1984

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SCIENTIFIC LITERACY IN SEVENTH GRADE LIFE SCIENCE: A STUDY OF INSTRUCTIONAL PROCESS, TASK COMPLETION, STUDENT PERCEPTIONS, AND LEARNING OUTCOMES*

FINAL REPORT OF THE INTERMEDIATE LIFE SCIENCE STUDY

November 30, 1984

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PREFACE

This report is produced by the Secondary Science and Mathematics Improvement (SSAMI) Program at the Far West Laboratory for Educational Research and Development. The goal of the SSAMI Program is to study and improve instruction in science and mathematics at the secondary level. This report describes a research study of science instruction in intermediate schools. At the same time, the SSAMI Program has produced reports of two other studies, one examining science instruction in high schools and the other examining mathematics instruction in intermediate schools. Next year, in addition to secondary analyses of data from these studies, SSAMI will develop, implement, and evaluate teacher inservice programs that build upon the results of the studies.

In this report, our goal is to describe and understand the combination of student, teacher and curricular factors that characterize effective science instruction. We begin by addressing the extent to which teachers employed the different components of scientific literacy in their instruction. The quality of scientific literacy use also is examined. An analysis of the nature of academic tasks that students were assigned follows. Next, student pretest and posttest performance on a range of science outcomes is described, and patterns of outcome growth among classes are examined. This is followed by a description of the quality of teaching observed in sample classes. The final sections of the report examine students' perceptions of their class and work from several different perspectives.

We wish to thank Dr. Virginia Koehler, Mr. Michael Cohen, and Dr. John Taylor, Teaching and Learning Division, National Institute of Education, for their support in this and other work. Their interest in exploring innovative ways of approaching the problems that confront educators and their encouragement of educational excellence are appreciated.

We also wish to thank the teachers and principals who collaborated with us in the conduct of this study. Their willingness to welcome us into their classrooms and schools and to describe their programs have helped us to understand better the current state of intermediate science education.

We gratefully acknowledge the contributions of Walter Doyle, Tom Good, Mary Budd Rowe, Lee Shulman, and Pinchas Tamir. All were members of the Advisory Panel or consultants for the study, and their ideas helped shape the research design and measures. Two Stanford graduate students, Rose Giaconia and Lynne Baldwin also made substantial contributions to the research instrumentation. Susan Osaki helped enormously by summarizing several sets of data. Finally, we are ever thankful for the dedicated work and contributions of the classroom observers: Dale Baker, David Haller, Vicki Lambert, Ken Peterson, Mike Piburn, and George St. Clair.

Several individuals gave very valuable help in the preparation of the data and this report. Katie Ruthroff and Mickie Zenger did a superb job of transcribing the class narratives and interviews. Tom Rounds provided editing expertise. Madeline Finch prepared the final copy. To all, thank you.

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EXECUTIVE SUMMARY

The major goal of this study was to describe what combinations of teacher, student, and curricular variables were associated with more effective life science instruction at the intermediate level. The conception of effectiveness was guided both by the normative framework of scientific literacy and by student growth on science outcomes. Our definition of scientific literacy consisted of five components: (1) explaining science content; (2) relating to science as a social historical process; (3) relating to science as a reasoning process; (4) relating science and society/technology, and (5) positive attitudes toward science.

Students and teachers from eleven life science classes participated in the study. The classes were located in both California and Utah. Students completed pre- and post-batteries of science measures. Observers visited each class during the entire presentation of two topics and made detailed narratives; in addition, they recorded teachers' time use, rated each teacher on generic skills, and collected curriculum materials. Teachers were interviewed at the beginning of the year and during each topic interval. Finally, all students completed one perception measure during each topic and six target students per class were interviewed about each topic interval.

Results of this study indicate that the participating life science teachers generally used a typical pattern of academic instruction, relying heavily on recitation, seatwork, and laboratory exercises. When teachers presented academic information, largely through recitation, they rarely, if ever, made explicit reference to the historical, reasoning, social, or attitudinal implications of the subject matter. Furthermore, when these references were made, they often were confusing. Students in the classes also perceived that teachers made relatively little use of the scientific literacy components other than explaining factual content.

Examination of the laboratory activities, worksheets, and exams assigned to students indicated that worksheets were the most commonly assigned activities. Laboratory activities were used less frequently, usually when topics were amenable to microscope work. All teachers used exams as end-of-topic assessments. What all three of these task types shared was an overwhelming reliance on problems requiring low-level cognitive processing (i.e. rote or algorithmic) and verbally restricted response modes (i.e. matching, multiple-choice, fill-in-the-blank, and short answer). These tasks also reflected very little use of the components of scientific literacy other than science content. While teachers held students accountable for most assignments, there was a tendency for them to grade exams for accuracy and to judge worksheets and laboratories simply on a completed/non-completed basis.

Results from the student pre- and post-batteries showed that student attitudes toward science generally declined over the course of the year, while their science knowledge, understanding, and reasoning skills increased. While there were significant differences among classes in student attitudes and performance at the beginning of the year, differences among classes in student growth over the course of the year were limited to attitudinal measures. Teachers' use of the non-content components of scientific literacy were not significantly related to student growth, probably because the occurrence of these components was too low to be meaningful.

Several sources of student perception data were analyzed. Findings from a survey that focused on students' summative perceptions of their classes at the end of the year indicated that they perceived they thought most carefully about science during tests and quizzes, with laboratory activities placing second. Students also rated tests and quizzes as the activities during which they paid the most attention and the most learning occurred. Students rated laboratory activities as the most interesting and also indicated that they would like more laboratory assignments and a greater variety of activities in general. Taken together, these results suggest that students came to define the main goal of science classes in terms of their performance on exams. Thus, it is unfortunate that the exams focused on the rote production of "right answers" rather than analyzing and interpreting natural phenomenon.

Analysis of a student perception measure about the activities of a particular day and target student interviews indicated that students found a variety of academic activities interesting, difficult, and requiring attention and thought. Students were most interested and engaged on days when the academic tasks required their active involvement or when their teachers demanded high levels of student participation during recitation. It is not clear to what extent these perceptions were affected by daily fluctuations in activities and tasks or whether they predicted students' longer-term motivation and learning in science. Although there was variation across classes, students tended to rate laboratory activities and teacher recitations highly, while seatwork was generally rated lower.

The report concludes with our recommendations for how practitioners might best be guided by our findings. We suggest that improvement efforts in intermediate life science focus on increasing teachers' use of the scientific literacy framework and upgrading the cognitive level of tasks assigned to students.

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CHAPTER ONE

INTRODUCTION TO THE STUDY

Pre-college education in science is a subject of fresh concern in the forums of national self-assessment and public policy. Termed by some a "crisis" (American Association for the Advancement of Science, 1982), the concern centers around data indicating that very few of the nation's students experience lengthy science curricula, that students' science achievement has declined during the 1970's (National Assessment of Educational Progress, 1978a), that large portions of teachers who teach science are not qualified to do so, and that many of the available curricula do not represent the multiple goals of science education or recent advances in technology (Good & Hinkel, 1983). Many of the general problems that plague education today are exemplified in today's science classrooms (National Commission on Excellence in Education, 1983). Deficits in this area are especially worrisome given the increasingly important role of science in shaping our society and determining our competitiveness in the world marketplace.

The study presented here is one piece of a national research effort intended to guide and facilitate the improvement of science education in intermediate schools. Its conceptualization is both normative and process-product in nature, stemming from three areas of research: 1) the cumulative experience and research spurred by the launching of the Soviet satellite Sputnik in 1957 which resulted in a redefinition of the goals, concerns, and evaluation techniques of secondary level science education; 2) the recently accrued knowledge of the correlations of effective teaching at the elementary and intermediate school levels which served to reinforce the need for further study of general classroom-process variables, as well as those specifically related to effective science teaching; and 3) the growing research focus on the nature of academic tasks which has raised questions regarding the feasibility and effectiveness of certain in-class activities for achieving scientific literacy. The importance of each of these research areas will be discussed below, followed by a description of the purpose and framework of the current study.

Research in Science Education during the 1960's and 1970's

In reaction to the launching of Sputnik, the federal government, acting through the National Science Foundation (NSF), armed itself by strongly supporting the development of new science curricular materials and the training of science teachers. Many new curricula were developed, and thousands of teachers attended special workshops aimed at introducing them to the new curricula. Reviewers have concluded that such programs achieved small to moderate success overall (Welch, 1979; Shymansky, Kyle, & Alport, 1982), a resolution that some interpret as disheartening given the wealth of resources directed at the problem.

However, such conclusions may not accurately reflect the actual impact of the NSF funded efforts, as evaluations of programs generally utilized poor designs, methodologies, and statistical analyses (see discussion in Shulman & Tamir, 1973). For example, in contrasting a "new" curriculum with one of its "traditional" predecessors, these evaluations often failed to measure appropriate student outcomes (i.e. those that directly reflect the goals of the new curriculum) and/or relevant classroom processes (i.e. those that capture teachers' translations of curriculum into the actual workings of instruction). Further, curriculum cannot be examined in isolation, as undoubtedly it is only one factor among many, including teacher effectiveness, student ability and time on task, that interacts with and influences successful science learning.

While the evaluations of NSF-funded programs were not strongly affirmative, there is little question that these programs indirectly had a pervasive and positive impact on the field of science education. Of particular interest to this study are two indirect effects:

1) The NSF era catalyzed science scholars' energies and created a forum for debate about the goals of science education for the general public. The fruits of this debate are still applicable today. In broad terms, this debate generated the consensus that while student retention of topic-specific knowledge may be an appropriate short-term goal, there are several other student outcomes that are necessary for the attainment of "scientific literacy." These outcomes include:

(a) an understanding that scientific knowledge is accumulated through a historical process of human inquiry rather than through the discovery of facts (Schwab, 1964);

(b) an understanding of the tools and methods of the scientific process, including the ability to solve scientific problems given appropriate data;

(c) an understanding of the interaction between science, technology, and society; and

(d) positive attitudes toward science as a discipline and toward future usefulness of and involvement with science.

In short, there was a recognition that the desired outcomes of a science education are multidimensional, including the mastery of "science facts" as well as the appreciation of the contexts of science knowledge and general features of it as a discipline.

2) Corresponding to the newly articulated multiple goals for science education, the NSF era spawned research efforts to develop new instrumentation to measure attainment of these goals. (Shulman and Tamir (1973) discuss some of this earlier instrumentation.) In the last decade there has been further expansion of measurement possibilities, including the development of "practical," "hands-on" tests for scientific problem-solving (Tamir, Nussinovitz, & Friedler, 1982), and large paper-pencil assessments that address many of the specific goals listed above (National Assessment of Educational Progress, 1978b; Second IEA Science Study, 1983). Also, as with other areas in educational research, interview and case study approaches have been employed as qualitative assessments of science education, providing new insights as well as clarifying the findings of the more quantitative-experimental studies (e.g., Stake & Easley, 1978).

Since the peak of the NSF era, research on science education has progressed to include a wider range of curricular, student, and teacher measures (see Volume 20, No. 5 of the Journal of Research in Science Teaching), indicating a greater appreciation for the numerous potential sources of variation in science outcomes. This research tends to be piecemeal, however, with studies focusing on the relationship, say, between one particular kind of teacher characteristic and one particular kind of student outcome, or between one particular kind of curriculum and one particular kind of teacher behavior.

In light of the advances in methodology and theory, it became possible to contemplate a more integrative and comprehensive approach to the study of science education. Past research generally failed to identify one simple factor operating independently to take the sole responsibility for the success or failure of science education programs. Further, previous studies have employed a limited range of assessment techniques that were predominantly quantitative or qualitative. The basis for the present study lies in the assumption that a more profitable approach is multivariate, examining a range of teacher, student, curricular and instructional factors simultaneously, using a variety of methodological techniques.

Research on the Correlates of Effective Teaching

Research in the last ten years has yielded a number of so-called "teacher effectiveness" studies which provide evidence that particular teacher behaviors facilitate student learning as measured by standardized achievement tests. This work began with large-scale correlational process-product studies at the elementary school level (e.g., Brophy & Evertson, 1974; McDonald & Elias, 1976; Soar, 1973; Stallings & Kaskowitz, 1974) and has expanded to include correlational and case studies at the intermediate school level (e.g., Evertson, 1982; Evertson, Anderson, Anderson, & Brophy, 1980; Evertson & Emmer, 1982; Sanford & Evertson, 1983), as well as experiments where teachers are trained to implement the behaviors indicated as desirable by the correlational studies (e.g., Crawford, Gage, Corno, Stayrook, Mitman, Schunk, & Stallings, 1978; Good, Grouws, & Ebmeier, 1983). Current work in this tradition is also attempting to describe the cognitive processes used by students in classrooms, and understand the ways in which student thinking mediates between the instructional behaviors of the teacher and student outcomes (e.g., Peterson, Swing, Braverman, & Buss, 1981; Rohrkemper, McCauley, & Slavin, 1983; Winne & Marx, 1982).

The teacher effectiveness behaviors that have been replicated in several studies (see summaries by Berliner, 1980 and Rosenshine, 1979) are collectively referred to as "direct instruction" or "traditional teaching". For Good (1979), these behaviors represent "active teaching," where the "teacher sets and articulates the learning goals, actively assesses student progress, and frequently makes class presentations illustrating how to do assigned work" in a way that is sensitive to the particular teaching context (p. 55). Effective teaching behaviors also subsume teachers' classroom management skills, which are viewed as a necessary but not sufficient condition for improved student achievement (Good, 1979). In Brophy's (1983) recent summary of the research on classroom management, he notes the importance of clearly introducing rules and procedures at the beginning of the year, communicating expectations for acceptable and unacceptable behavior, holding students accountable for finishing work on time, and assigning seatwork with enough variety and challenge to keep students engaged. Together, this work indicates that both instructional and management behaviors of individual teachers are important in determining the level of academic growth that students experience.

However, generalizability of these teacher effectiveness findings is not yet clear. There is some evidence that all of the identified teacher behaviors may not be applicable if the learning goals are higher-order thinking skills or attitudes (e.g., Stallings & Kaskowitz, 1974; Peterson, 1979; Hedges, Giaconia, & Gage, 1982). Further, some of the effectiveness behaviors that correlate with gains in one subject area (e.g., mathematics) have not been found necessarily to correlate with gains in another subject area (e.g., English) (Evertson, Anderson, Anderson, & Brophy, 1980). Finally, teacher effectiveness research questions have yet to be systematically applied in the crucial realms of teacher behaviors at the secondary level and/or teacher effectiveness research specific to the subject area of science. While some studies have begun to look at the relationship between different kinds of teacher behaviors (e.g., wait-time, levels of questioning, testing practices) and various student outcomes (see Tobin & Capie, 1982; Wise & Okey, 1983), there appear to be few, if any, attempts to identify overall patterns of teaching practices particular to effective science instruction at the secondary level.

The cumulative research on teacher effectiveness has influenced the conceptualization of this study in at least three major ways. First, prior research in this realm presents convincing documentation that teacher behavior is a relatively powerful explanatory variable for some student outcomes. The current study on classroom instruction then strove to broaden its focus and include a range of teacher variables in an area that historically has been preoccupied with curriculum materials issues. Second, the prior teacher effectiveness research provides a useful guide for framing questions and guiding measurement. It was anticipated, for instance, that some teaching and classroom management behaviors are specifically geared to effective science instruction, while others are applicable across many grade levels and subject areas, including intermediate science instruction. By examining what teachers actually do in their classrooms, the present study of science education can begin to sort out relevent science-specific vs. generic teaching behaviors. Finally, the current interest in the cognitive processes employed by "mythical students" (Doyle, 1982), previously ignored by teacher effectiveness research, directs part of our attention to the cognitive -- as well as behavioral -- engagement of students in science classes, in hopes of tightening and clarifying the conceptual and empirical links between classroom processes and student outcomes.

Research on Academic Tasks

The day-to-day assignments that students carry out in class are the most easily observed, proximal indicators of the student learning process. Yet, until very recently, these assignments have not received the full attention of researchers. Although academic work assignments take shape from the interactions among the curriculum materials, teacher behavior, and student behavior, they deserve analysis in their own right.

Academic tasks have been examined both in terms of their cognitive implications and their functioning in the broader classroom environment. Doyle (1983) suggests four general categories for classifying the cognitive orientation of tasks: memory tasks, procedural or routine tasks, comprehension or understanding tasks, and opinion tasks. According to Doyle's framework, direct instruction is more appropriate than indirect instruction for teaching specific (lower-level) skills (e.g., memory decoding), yet it will have little long-term effect unless combined with instruction in higher order processes which integrate specific skills. He further suggests that indirect instruction may be one method of teaching higher order processes, especially since we do not fully understand the cognitive operations that underlie these processes. Also, we might add that there may be instances when teachers wish to avoid predicting just what cognitive operations students should follow when carrying out higher-order tasks.

In his analysis of tasks in relation to the classroom environment, Doyle regards several features as relevant, including groupings, curriculum materials, and evaluation structures. In particular, Doyle argues that the evaluation system in most classrooms leads students to strive for "getting the right answer" and "getting the work done", at the sacrifice of content and quality performance. In addition, Doyle points out that higher-order tasks are difficult to assign and carry out because they present obstacles for both teachers and students. Teachers will often avoid these tasks because of inherent management problems, and students will do so because they involve high levels of ambiguity and risk.

Because most of the goals of scientific literacy go beyond the acquisition of content to involve imparting higher-level understanding and application, these observations on academic tasks seem especially relevant. They not only provide a framework for guiding observation (e.g., paying attention to the required cognitive processing and accountability system for each task) but also suggest the kinds of activities to anticipate. For example, given Doyle's analysis, one would expect that most teachers avoid presenting higher-order tasks that link content to scientific literacy. Further, if a teacher attempted to introduce such a task on an infrequent basis, one could anticipate the ways in which the intent of the task could be undermined (e.g., by students negotiating the risk and ambiguity "out of" the task so that it is no longer higher-order). On the other hand, teachers who successfully present higher-order, scientific literacy tasks probably do so on a regular basis, altering the established expectations of their students. Clearly, then, it is critical to examine both the intent of an academic task and the way it is actually carried out in the classroom.

Description of the Study

Problem

The overarching question guiding this study can be stated as follows:

> What combinations of student, teacher, curricular, and task factors characterize effective life science instruction, where effectiveness is defined as the acquisition of scientific literacy? Scientific literacy is defined to include the acquisition of the basic knowledge of life science, an understanding of the scientific process of inquiry which allows students to make judgments and solve problems, and an appreciation of science as a valuable cultural endeavor.

This question had at its starting point an articulated, normative vision of what effective science teaching consists of -- namely, teaching the range of goals common to most definitions of scientific literacy (e.g., Arons, 1983; Miller, 1983; Rowe, 1983).

The use of a normative framework is defensible for diagnostic as well as pragmatic purposes. First, the degree to which scientific literacy is lacking in today's schools must be assessed in terms of the standards set by science experts who have given serious thought to how the structure of the discipline should be communicated. On a more practical level, the various components of the current defin[illegible]n of scientific literacy serve to offer useful guidelines for [illegible]ning and conducting future inservice teacher training pro[illegible]. With the current effort to expand knowledge about effective teacher and classroom processes in conjunction with such a professional consensus, the bases for the improvement of science education can be established and disseminated to the classroom. Of course, in so doing, it is hoped that the goal of increased meaningful learning for all students would be reached, especially for the majority who are not bound for science careers, but who, nonetheless, live in a technology-based society.

It was assumed that in order for the goals of scientific literacy to be addressed and met in science classrooms, they must be explicitly taught by the teacher. This assumption guided data collection and enabled an elaborate process-product view of science. We sought to document the presence (or absence) of scientific literacy within the curriculum materials, the academic tasks, and the behavior and perceptions of teachers and students. The creation of a multivariate portrait of the fostering or hindering of scientific literacy was the primary goal of the study.

Given this general goal, several sets of specific questions follow that guide the analyses. These questions include:

1) How do teachers transform the curriculum from a set of raw materials into the experience of instruction? If the curriculum materials do not provide the foundations for scientific literacy, how, if at all, do teachers carry the burden of doing it themselves?

2) What kinds of academic tasks are typically assigned in intermediate science classes? If lower-level tasks predominate, what are the accompanying curricular and environmental features? When higher order tasks are introduced, what determines whether or not they will be executed as intended?

3) Do students who differ on the basis of gender, intellectual ability, entering science achievement, science process understanding, or attitudes toward science also differ in their interest and involvement

in the learning of science? Is this mediated by the instruction they receive from different teachers?

4) How do students perceive the tasks they complete within life science classes? Can they identify the presence or absence of the knowledge and attitudes which define scientific literacy in their science classes?

Given the multivariate, outcome-guided approach taken here, it is important to clarify what the study has not examined as primary issues. The study is not primarily concerned with describing the distributions of a regional sample on a set of designated variables. Several other large surveys already have been conducted that provide more extensive data on science teachers, curricula, and student achievement (e.g., Goodlad, Sirotnik, & Overman, 1979; Second IEA Science Study, 1983; National Assessment of Educational Progress, 1982). The study also is not concerned with comparisons of curricula or available resources.

Rather, this study examined the dynamics of effective science instruction in life science (biology) classrooms at the 7th grade level. Observations in one science area allow for better comparisons between classes in terms of how similar or identical topics are presented and learned. The 7th grade level was selected because, in the FWL's region, this is a grade level where all students typically fulfill their minimum science requirement, usually with a life science course. By looking at this grade level, then, science classes are observed in which the entire range of the schools' population is most likely to be represented (as opposed to higher grade levels, where self-selection in science occurs).

The study was begun during the first weeks of the 1983-1984 school year. At that time, all students in participating classes completed a number of pretest measures. After this, basic curriculum materials were collected and analyzed, and teachers were interviewed about their use of materials and class organization. There were two intervals of observation per class, each centered around the presentation of a particular topic. Topics were preselected and an observer was present in class during the days a selected topic was covered. Observations focused on the way the teacher explained and related science material and on the assigned tasks. Students also completed one perception measure during each topic. Target students were interviewed about their perceptions of class during the observation periods. The following sections of this chapter present the design of the study in more detail.

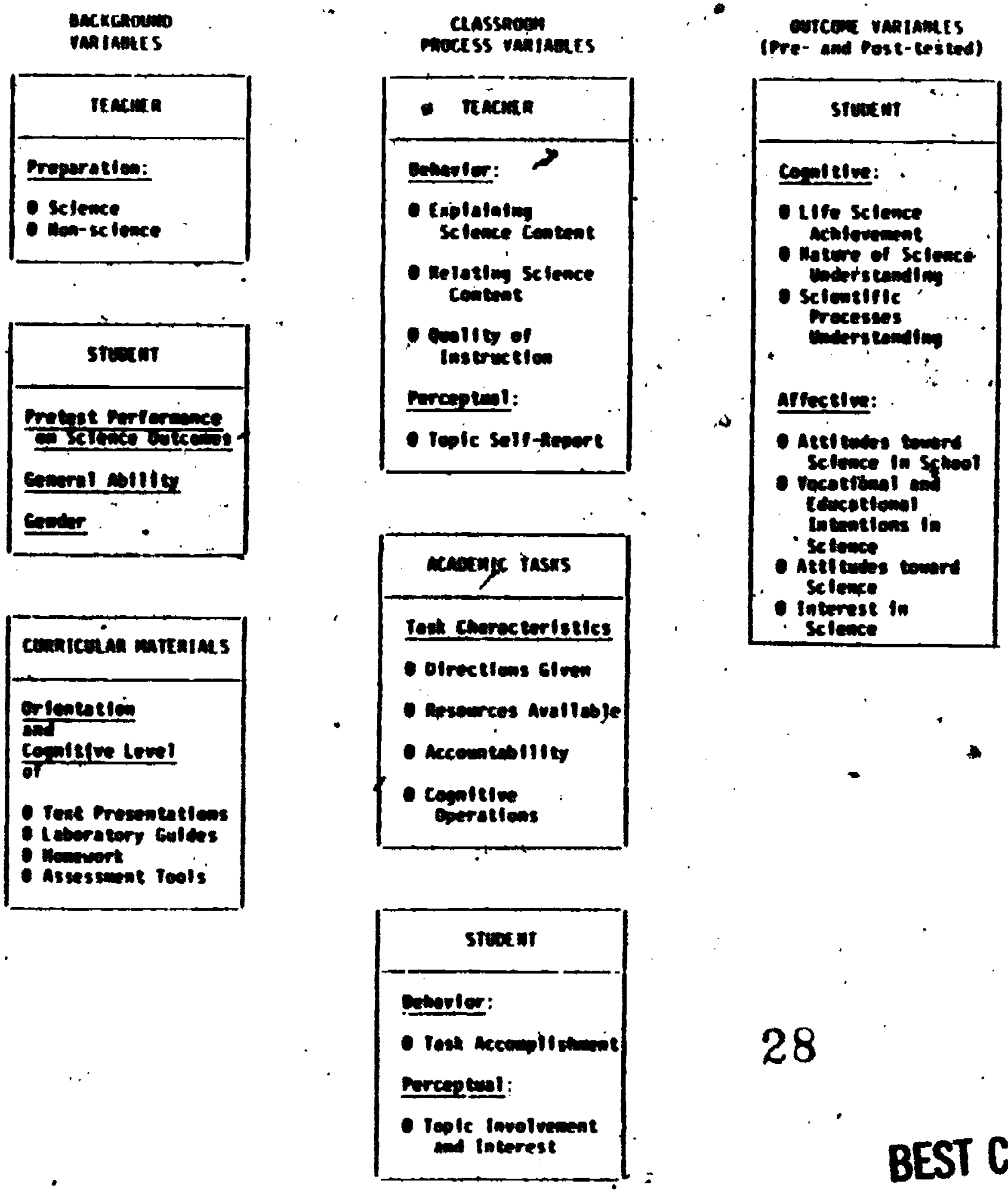
Framework

The framework of the study can be thought of in terms of three groups of variables: background variables, classroom process variables, and outcome variables. This division is parallel to the conceptualization of Welch (1983) who describes the domain of science education in terms of the three components of "context," "transactions," and "outcomes." Following Welch, the background or context variables represent the conditions that exist prior to the process of learning (i.e., the initial student and teacher characteristics and the formal curricular materials). Classroom process or transaction variables refer to the actual classroom interactions that occur during the process of learning (i.e. the instructional behavior and perceptions of teachers and students as well as the characteristics of the academic tasks that are assigned). Finally, outcome variables are intended to measure the results of the learning process (i.e. the cognitive and attitudinal gains of the students. The specific variables that were measured in each of the three framework categories are presented in Figure 1.1.

Background Measures. Figure 1.1 illustrates three subgroups of background variables: teacher, student and curricular materials. Under teacher the variables listed include the teacher's preparation in science and non-science areas, variables on which teachers may differ considerably given the current shortage of qualified science teachers. There is some evidence that the amount of science and non-science preparation has a small, but significant, role to play in explaining student performance (Druva & Anderson, 1983). In this framework, teacher preparation is intended to include both preservice and inservice preparation that may influence science-specific and general teaching skills.

The student subgroup includes those student characteristics that are most likely to explain student outcomes in science, prior to the influence of the particular learning environment. These characteristics include students' pretest (beginning of the year) performance on the outcome measures (see outcomes below), general ability, and gender. Here, students' pretest performance is one measure of the degree to which students have been shaped by prior formal exposure to science, serving to establish important baseline levels. There is always the possibility, however, that students' general ability is an equally strong, or even greater, predictor of some student outcomes than science-specific knowledge. Gender is included because of the evidence that girls' science performance declines relative to boys' as age increases.

The curricular materials subgroup refers to the orientation and cognitive level of all class materials (i.e., textual presentations, laboratory guides, homework, and assessment tools). Orientation represents the extent to which the curriculum materials reflect the multifaceted goals of scientific literacy, whereas cognitive level describes the demandingness of the material. Of course, for both these curricular features, the teacher usually has complete discretion to either reinforce or alter them. For example, if the materials had a narrow content focus and low demands (e.g., memorization), it would be desirable for a teacher to alter and supplement them to achieve a more demanding cognitive level. Examination of how the teacher actually transforms



e 1.1 Framework for research design of intermediate school science instructional study.

the curriculum materials falls under the next category.

Classroom Process Variables. The second category in Figure 1.1, classroom process variables, is composed of three subgroups: teacher, academic tasks, and student. The teacher subgroup includes variables of teacher behavior and perceptions. The teacher behavior variables include explaining science content, relating science content, and quality of instruction. Explaining science content refers to the teacher's presentation of facts and concepts that are fundamental to the understanding of a science topic. Relating science content is a measure of teacher communications that link specific science concepts to one or more of the four non-content facets of scientific literacy, -- e.g., a teacher describing to his/her students the historical context for the discovery of viruses. Table 1.1 outlines in detail the explaining and relating components, providing examples of possible applications. Data for these areas were the focus of observer narratives.

Quality of instruction refers to a number of high-inference categories of teacher skills which were rated by observers. Categories include clarity of instruction, managerial effectiveness, verbal explication and development of a concept, rapport with students, etc. When combined, the descriptions and measures of the teacher behavior variables portray the manner in which the teacher transforms the curriculum materials into the activity stream of the classroom, thus creating the curriculum that students actually experience.

One perceptual measure is listed under the teacher portion of classroom process variables. While acknowledging that instructional behavior has numerous antecedents in addition to "conscious deliberation and choice" (Brophy, 1980), we believe that an understanding of the way in which teachers perceive the "problem space" (Brophy, 1980; Newell & Simon, 1972), defined by intended goals and activities, as well as teachers' perceptions of students' responses to the topic lessons, can illuminate specific instructional behaviors and help us to understand better the relationship between teacher intent and lesson implementation. Accordingly, the teachers' topic self-report contained questions regarding teachers' perceptions of the observed topic's purpose, organization, requirements, and success. This information was gathered with focused interviews.

The academic tasks subgroupings under classroom process refer to the actual work that students carry out. Here, four task variables are of interest (see Doyle, Sanford, & Emmer, 1982): directions given, resources available, accountability, and cognitive operations. Directions given refers to what the teacher communicates about the nature and requirements for the task. These may be written or presented orally, and they may also change over time. Resources available refers to whatever materials, examples, hints, etc. the students have available as

Table 1.1

Scientific Literacy Framework Used in the Study

1. EXPLAINING CONTENT	There are several ways in which a teacher can attempt to communicate content--e.g., by short statements, by writing things on the board, and even by a demonstration. What is important is that regardless of the instructional method used, the teacher is trying to communicate facts and concepts that are fundamental to the understanding of the topic.
2. RELATING TO SCIENCE AS A SOCIAL HISTORICAL PROCESS	This takes place when a teacher attempts to communicate the historical context of some scientific knowledge or process. This context can be portrayed in specific or general terms. In specific terms, the teacher would refer to particular individuals in history and their contributions--e.g., Mendel's work in genetics, Salk's development of the polio vaccine, Fleming's discovery of penicillin, Watson and Crick's determination of the structure of DNA, etc. In general terms, the teacher would refer to scientists or other people, without mentioning specific individuals.
3. RELATING TO SCIENCE AS A REASONING PROCESS	A teacher is relating science content to the specific reasoning process when he/she attempts to communicate how scientific knowledge is acquired. This would include talking about observing natural events, formulating and testing hypotheses and theories, deductive and inductive reasoning, concepts of randomness and probability, and the tools and methods of measurement. This component also includes references to the general point that scientific knowledge is not accumulated in an accidental or arbitrary fashion, but instead is accumulated through a set of agreed upon standards that have a logical foundation.
4. RELATING SCIENCE AND SOCIETY/TECHNOLOGY	This refers to a teacher communicating how specific areas of scientific knowledge have implications for society or for technology. Often, there is a direct link between a technological product (e.g., a new fertilizer) and its societal consequences (e.g., more productive farming). The teacher who does this area well goes beyond a cursory mention of some connection and really encourages students to consider how specific scientific knowledge affects people. Furthermore, it often will be most ideal for a teacher to present at least two points of view (e.g., the advantages and disadvantages of pesticides), thus, modeling parts of a decision-making process that students can apply in their own lives as they consider their use of science-based technologies.
5. POSITIVE ATTITUDES TOWARD SCIENCE	Here, a teacher refers to the individual or collective affective reactions people have towards science as a discipline and specific science knowledge, concepts, and applications. The teacher who does a good job of relating in this area will try to foster well-founded positive attitudes and curiosity toward science. The teacher may also model his or her own positive attitude toward science as a discipline.

they carry out the task. All students may not necessarily have access to the same resources. Accountability refers to the grading policy for the task that the teacher communicates. This policy should indicate the overall importance the teacher attaches to the task, but again the policy may be altered over time. Finally, cognitive operations refers to the level of processing required to complete the task. Doyle's (1983) categories of cognitive operations are applicable here (memory, procedural, comprehension, and opinion tasks).

The student subgrouping under classroom process variables is divided into behavioral and perceptual measures. An assessment of task accomplishment was based on the examination and coding of written homework and classwork completed by a subgroup of target students. Students' involvement and interest during the observations was assessed at the conclusion of the topic through the completion of a structured self-report form. This form contained rating scales, multiple choice and free-response items focusing on students' perceptions of the actual task demands of the lesson as well as cognitive involvement. Our intent was to move the "mediating process" research paradigm (e.g., Peterson, et. al., 1981; Winne & Marx, 1982) out of the laboratory and into the classroom, in order to embed it within a more "ecological" approach (Doyle, 1977; Dawson, Tikunoff & Ward, 1978). Because we were collecting perceptual data in a number of ongoing classrooms where teachers' instructional foci and behaviors varied, the self-report was, by necessity, brief and broad in its assessment of individual cognitive processes (compare, for example, the Student Self-Speech Questionnaire employed by Rohrkemper, McCauley & Slavin, 1983). Nevertheless, we believe it useful to attempt to capture students' general interest in the topic being observed, their expectations regarding the evaluation of their work, the clarity and difficulty of what they are doing, the percentage of class time spent "working," and whether they recognize relationships between their current work and previous science learning. In addition to this general information regarding the perceptions of all students in the study classrooms, more precise data regarding the meaning of science experience and the representativeness of the observed lessons was collected by interviewing target students.

Outcome Measures. Figure 1.1 presents a list of student measures under outcomes. These outcomes are divided into those with a predominantly cognitive focus and those with a predominantly affective focus, and represent a range of scientific literacy goals. Measures listed under cognitive include life science achievement, nature of science understanding, and science processes understanding.

A measure of life science achievement is included as a more in-depth test of life science knowledge than is currently available in a standardized science achievement test. Nature of science understanding refers to students' understanding that science is a historical, fluid process of inquiry. Science processes understanding refers to the ability to apply the logic and measurement tools of science.

Four measures are listed under the affective component of student outcome measures: attitudes toward science in school, interest in science, vocational and educational intentions in science, and attitudes toward science. These affective outcomes are considered an important result of science instruction, because they provide indicators of future participation in science classes and general interest in science as a citizen.

Overview of Report

This report contains ten chapters. Chapter Two describes the methods and procedures of the study. Chapter Three addresses one portion of the classroom process variables: the teacher behaviors of explaining science content and relating science content. The chapter frames these variables by first describing the time teachers spent in different instructional modes, and, then, how much time they spent explaining and relating, respectively. The chapter ends with an analysis of the quality of teachers' relating. Chapter Four focuses on the nature of academic tasks that students were assigned and held accountable for. These tasks are described in terms of their general type (i.e. laboratory activities, worksheets, or exams), their level of cognitive demand, and their representation of the components of scientific literacy. Chapter Five describes student performance on all the outcomes listed in Figure 1.1, including growth on these outcomes from the beginning to end of the school year. This is followed by the results of analyses that tested for the relationship of class membership, student gender, and teachers' use of scientific literacy to student growth. Chapter Six presents data about the general quality of teachers' instruction. The relationship of quality measures to other indicators of teacher and student performance also is addressed. Chapter Seven presents the results of a detailed measure of student perceptions that was administered at the end of the school year. Chapter Eight also addresses students' perceptions; in this case, the results are from a more proximal measure of topic involvement and interest that was administered during each topic interval. Taking particular classes as examples, these perceptions are reviewed in terms of the class activities and tasks on the day the survey was administered. Chapter Nine presents the results of interviews that were held with target students in each sample class. Finally, Chapter Ten presents our conclusions about the most significant findings of the study as well as our judgment about the implications of our findings for current practice and future research.

CHAPTER TWO

METHOD

This chapter summarizes the methods employed in the Intermediate Life Science Study. The chapter first describes the general characteristics of the sample teachers and students. A more detailed description of the background characteristics of the sample appears in Chapter Three. Next, this chapter describes the instruments used in the study. The reliability of these instruments also is reported here. Third, this chapter describes the procedures for the study. These procedures are presented in chronological order, beginning with recruitment of the sample and ending with feedback to teachers following completion of data collection.

Sample

Eleven teachers who taught a full school-year course of 7th grade life science participated in the study. For each teacher, one of their life science classes was selected for data collection (e.g., 4th period life science). There were no stringent criteria for selection of the class for each teacher; teachers simply were asked to nominate a class that was typical of the 7th grade life science classes at their school. All teachers volunteered to participate in the study.

Four of the participating teachers were employed in three schools in the greater San Francisco Bay Area. The other seven teachers were employed in four schools in the greater Salt Lake City area. All three California schools were suburban and labeled as "intermediate" schools; two of these schools served grades 7-8, with the third serving grades 6-8. Three Utah schools were suburban and labeled as "junior high" schools; these served grades 7-9. The fourth Utah school was rural and labeled as a "middle" school; it served grades 6-8. The socio-economic conditions of the schools' communities were generally similar, ranging from middle to upper-middle class. The enrollment sizes of the schools varied greatly, ranging from 492 to 1532 students; Utah had the largest average school size--958 students--as compared with 703 for California.

Table 2.1 summarizes the background characteristics of participating teachers. The table indicates that four of the eleven teachers are female. Three of the teachers have a masters degree, and all but two teachers have some specialization (major or minor) in the field of science. The general teaching experience of the sample ranges widely from 1 to 24 years, with an average of 1[illegible] years. Initial class sizes range from 24 to 32 students, with an average of 28.6 students. (The size of the

Table 2.1

Characteristics of Participating Teachers and Classes

TCHR ID	SCHOOL ID*	TCHR GENDER	HIGHEST DEGREE	DEGREE SPECIALIZATION	TOTAL YRS TCHNG	INITIAL CLASS SIZE
1	1	F	Bachelors	Biology	5	32
2	1	F	Bachelors	Biology	14	29
3	2	M	Masters	Zoology	24	29
4	2	F	Bachelors	Physical Ed. (Botany Minor)	7	32
5	3	M	Bachelors	Biology	15	30
6	3	M	Bachelors	Mathematics & Elem. Ed.	1	24
7	4	M	Bachelors	Science	15	28
8	5	M	Masters	P.E. (Life Science Minor)	17	24
9	6	M	Masters	Physical Ed. (Sci. Minor)	23	29
10	6	M	Bachelors	Biology	10	29
11	7	F	Bachelors	Soc. Science	15	29

*Note. School characteristics are as follows: School 1 has grades 7-9 with 1164 students; School 2 has grades 7-9 with 602 students; School 3 has grades 7-9 with 1532 students; School 4 has grades 6-8 with 535 students; School 5 has grades 7-8 with 492 students; School 6 has grades 6-8 with 700 students; and School 7 has grades 7-8 with 917 students.

student sample used for data analyses is described in detail in Chapter 3.)

In each of the eleven classes, six target students were designated for the purpose of a student interview at the end of the two topic observation periods. Selection of these target students was based on pretest life science achievement (Life Science Questionnaire) scores collected for the study. The six students were selected to represent the following permutations: highest female, highest male, median female, median male, lowest female, and lowest male. If ties occurred between the highest, lowest, or median scorers, then a student was selected at random from the potential candidates. Substitutions, selecting the next best available student, were made in cases where parent permission was not received or if students transferred out of the class.

Instruments

A number of data collection tools were employed in the study. Briefly, the instruments can be viewed as falling into one of two groups. The first group consists of a student pretest and posttest battery, measures that served as baseline and outcome variables, respectively. This group also includes three perception questionnaires that all students completed during the Topic 1 and 2 observations and at posttest. The second group consists of all measures that captured aspects of the classrooms, including the curriculum analysis packet, the observation instruments, and the teacher and student interviews. Copies of and directions for the second group of instruments, in the form of the ILS Observation Manual, appear in Appendix A.

Student Pretest and Posttest Measures

Students completed four science-related measures both at pretest and posttest: a Life Science Questionnaire, Nature of Science Survey, Science Process Survey, and Feelings toward Science Survey. These measures tapped most of the components of scientific literacy identified in the framework for the study (see Chapter 1). The Life Science Questionnaire tapped students' knowledge of science content, i.e. what is commonly referred to as life science achievement. The Nature of Science Survey and Science Process Survey tapped students' understanding of science as a reasoning process. Finally, the Feelings toward Science Survey addressed the component of students' attitudes toward science.

In addition to the four measures listed above, students completed two aptitude measures at pretest: a Word Meaning Survey and Patterns Completion Survey. These instruments were used to obtain measures of crystallized and fluid general ability, respectively. For the posttest, the Word Meaning Survey and

Patterns Completion Survey were omitted and students instead completed an Ideas About Science Survey. This addition was designed to obtain detailed student-perceptions about teacher behavior, task structure, and the curriculum.

Another student perception measure, the Student Class Survey, was administered to all students twice during the year. This instrument was designed as a short and immediate assessment of students' cognitive and affective reactions to class events on the day of the survey administration.

Each of the eight student measures is described in more detail below.

Life Science Questionnaire. This questionnaire consisted of 24 multiple-choice items. Items were selected from four existing science test sources: the National Assessment of Educational Progress (NAEP), the Stanford Achievement Test (Form E, Advanced), the Metropolitan Achievement Test (Form JS), and the Second IEA Science Study. Only life science items were selected, and this selection was done with an effort towards balancing the different life science topics. The result was a questionnaire where three items were devoted to each of eight life science categories; cell theory, germ theory, systems, evolution, growth and development, energy transformation, heredity, and ecology. An example of an item is:

> "The unit of heredity that is responsible for the development of specific characteristics is the
>
> A. chloroplast.
> B. gamete.
> C. gene.
> D. cell.",

Nature of Science Survey. This survey consisted of 20 statements to which students responded "Agree" or "Disagree." The statements were about scientists, the nature of science, theories, or the scientific method. An example of one item is "Different scientists may give different explanations about the same thing." Items were drawn from two existing sources: the National Assessment of Educational Progress (NAEP) and Nature of Scientific Knowledge Scale (Rubba & Anderson, 1978).

Science Process Survey. This survey consisted of 16 multiple-choice items. Items tapped six categories: assumptions, experimenting, measurements, communications, interpretation of data, and observing. Items were drawn from three different sources: the National Assessment of Educational Progress (NAEP), the Metropolitan Achievement Test, and the Test of Integrated Science Processes (TISP, Department of Science Education, University of Georgia, 1979). The following is a sample item:

"Which one of the following is essential in an experiment?

A. Making sure measurements can be made quickly
B. Controlling all important variables
C. Using new equipment
D. Having at least two persons doing the experiment."

Feelings toward Science Survey. This survey had 48 items, divided into 4 subscales of 12 items each. The first subscale asked for students' feelings toward science classes. Here, students responded to 12 statements by marking "Strongly Agree," "Agree," "No Opinion," "Disagree," or "Strongly Disagree." An example of an item is, "There are too many facts to learn in science." The second subscale asked students about their vocational and educational intentions. Here, students responded to 12 statements by marking "Definitely Yes," "Probably Yes," "Not Sure," "Probably Not," and "Definitely Not." A sample item reads: "Do you think working in science would be fun?" The third subscale addressed students' feelings towards science in general. Here, students again responded using the "Strongly Agree" to "Strongly Disagree" scale. A sample item reads, "Money spent on science is well worth spending." The fourth and final subscale tapped students' interest in science activities. Here, students responded to a list of 12 activies (e.g., "visited a science museum," "taken something apart to see how it works") by marking either "Often," "Sometimes," "Seldom," or "Never." Items for this survey were based on two sources: the National Assessment of Educational Progress and the Second IEA Science Study.

Word Meaning Survey. This survey was a shortened, 40-item version of the Verbal Meaning Test from the Primary Mental Abilities battery (Thurstone, 1962). It was created by deleting every third item from the original 60-item test. Each item consisted of a target word in capital letters followed by four lower-case words. Students were asked to circle the appropriate synonym for the target word.

Patterns Completion Survey. This survey consisted of 22 items selected from sets A-E of the Standard Progressive Matrices (Raven, 1958). The first item was from set A and was used as a practice item in the directions (i.e., it was not scored). From sets B-E there were 4, 5, 8, and 4 items chosen, respectively. These items were presented in order, by set. Each item consisted of a large pattern from which one piece was missing. Students were asked to select the appropriate piece to complete the pattern from one of six or eight alternatives.

Ideas About Science Survey. This instrument was developed by staff members (Mergendoller & Mitman, 1984) for the purpose of collecting student perceptions about many specific aspects of the science class environment. Many items were written specifically to tap aspects that also were judged by observers, thus permitting a test of the match between student perceptions and observer accounts.

The Ideas About Science Survey consisted of 150 items organized under three parts. In Part I, students responded to 15 items about the extent to which their respective teachers talked about the various components of scientific literacy. Three items were devoted to each of the five components (i.e., explaining content, science as a social historical process, science as a reasoning process, science and society/technology, and positive attitudes toward science). For example, one item for science as a social historical process reads: "In science class this year, how often did the teacher talk about the lives of important scientists?" Students responded to all items in this part by marking either "Very Often," "Often," "Sometimes," "Seldom," or "Never." It was anticipated that a useful comparison could be made between students' responses to this section and the observers' ratings of teachers' use of scientific literacy (see Science Class Description instrument below).

Part II contained 22 items designed to measure students' perceptions of the extent to which their teachers engaged in generally effective teaching practices. Here, the items addressed four different realms of teacher behavior: (a) clarity of directions and explanations; (b) system of class and task management; (c) facilitating motivation to learn; and (d) facilitating a fair social structure. As an example, one item in the last realm reads: "The same kids always talk." Students responded to all items by marking either "Strongly Agree," "Agree," "No Opinion," "Disagree," or "Strongly Disagree." While items in this part were not matched precisely to ratings of effective teaching completed by observers (see Science Class Description), it nonetheless was felt that a contrast between the two sets of items would be useful.

Part III of the Ideas About Science Survey contained 113 items measuring students' perceptions about numerous aspects of academic tasks and the formal and experienced curriculum. The length of this part defies easy summarization; thus, the reader is referred to a copy of the survey in Appendix B. Responses to all items were in a four or five-point Likert scale format.

<u>Science Class Survey</u>. Unlike the above measures, the Science Class Survey was administered to students on two occasions, once during each period of topic observation. This instrument was designed to be completed at the end of a lesson, in that most items asked the students to provide their specific reactions to that day's lesson. A combination of fixed and open-ended response items was used. Some items asked students to reflect on their thought processes during the lesson (e.g., whether or not they were confused), while other items asked them to reflect on their work and the behavior of others (e.g., the difficulty of the work, whether the class was quiet enough for them to learn). A copy of this survey appears in Section Eight of Appendix A.

Classroom Measures

This section encompasses all other measures used during the course of the study. Included are three teacher questionnaire/interviews, referred to as the Science Teacher Interview, Teacher Topic Questionnaire, and Teacher Post-Topic Interview. Next are two classroom observation techniques, the Narrative Record and the Science Class Description, followed by a Curriculum Content Analysis. Only one student measure is included here, the Target Student Interview. Each measure is briefly described below.

Science Teacher Interview. The first formal interview with teachers, given at the beginning of the school year prior to any topic observations, served to gather information on teachers' backgrounds, curricula, and forms of classroom organization. At this time, the topic observations were also arranged. The interview schedule contained 25 items (some with sub-questions). A copy appears in Section Three of Appendix A.

Teacher Topic Questionnaire. The purpose of this measure was to assess teachers' perceptions of teaching the selected content topic immediately prior to the beginning of instruction. This questionnaire consisted of 12 open-ended questions some of which addressed the teachers' past experience with the topic and the teachers' intended use of activities and materials. Other items asked the teacher to indicate which aspects of the topic were particularly important, enjoyable, or difficult to teach. Teachers completed this questionnaire prior to each topic (Topic 1 and Topic 2). A copy of this questionnaire appears in Section Seven of Appendix A.

Teacher Post-Topic Interview. This interview was given to each teacher after completing each of the two observed topics. The purpose of these interviews was two-fold. First, they provided an opportunity for the observer to gather any additional data needed to make his/her records of the observations more complete. For example, if it was difficult to gather information on a teacher's intended grading system for an assigned task during class, this interview provided the chance to do so. A second goal of these interviews was to assess each teacher's general perceptions of the outcomes of the topic instruction. For example, teachers were asked to describe any parts that they thought went especially well or not as well as expected, as well as to provide their thoughts about the extent to which students learned what was intended. A copy of this interview schedule appears in Section Ten of Appendix A.

Narrative Record. Following each day of topic observation, observers dictated a Narrative Record of the main events of that that period. As preparation for the narrative, observers made an audio-tape of the period and took notes. The data from these narrative records, then, were the result of naturalistic observation.

The composition of each Narrative Record was guided by two sets of considerations. First, observers were asked to capture clearly the activity segments and kinds of interactions that took place during the period. Second, observers were asked to capture a teacher's use of the scientific literacy components and the general features of any assigned academic tasks. For the scientific literacy and task foci, observers included as much verbatim talk from the teacher and students as possible.

As a final step in the production of the Narrative Records, observers completed Narrative Record Summary Sheets. In the first of three parts, observers listed all activity segments that occurred during the period and their associated characteristics (e.g., materials used, grouping arrangement). In Part 2, observers listed all academic tasks that were worked on during the period. In Part 3, observers summarized the features of any academic tasks that were completed during the period.

A detailed description of all the concepts employed in producing the Narrative Record and associated Summary Sheets appears in Section Five of Appendix A.

Science Class Description. This instrument was completed by observers after each topic observation visit. The instrument served two purposes. One was to collect concise information on teachers' time use during class. The second was to elicit observers' summary (i.e., higher-inference) judgments about several aspects of the activities, teachers' behavior, and students' behavior. The instrument was adapted from earlier versions by Mitman (1981) and Mergendoller, Mitman, and Ward (1982), which were designed to capture the use of several teacher behaviors deemed by the process-product study literature to be generally effective.

The Science Class Description (SCD) form was divided into three parts. In Part 1, observers estimated the amount of class time devoted to each of nine different instructional modes (e.g., seatwork, recitation). They also rated the degree of teachers' academic task orientation and the number of students generally paying attention in class. In Part 2, observers estimated the amount of teachers' presentation time (i.e., recitation or demonstration) devoted to each of the five components of scientific literacy. Observers also rated several aspects of the quality with which the scientific literacy components were used. Finally, in Part 3, 25 different Likert-scale items were presented that addressed characteristics of the overall effectiveness of the period (e.g., teacher's preparation for instruction, teacher's clarity of directions, teacher's use of monitoring). A copy of the SCD and directions for its use appear in Section Six of Appendix A.

Curriculum Content Analysis. This measure was comprised of eight separate analyses of the curriculum materials. Included were: (1) General orientation of the text; (2) Science orientations and linkages in the text; (3) Concept density in the text;

(4) Graphics in the text; (5) Chapter review questions in the text; (6) Laboratory activity level; (7) Orientations and levels of worksheets; and (8) Orientations and levels of tests and quizzes. Observers were instructed to complete the first four sections for those portions of the textbooks used during the teaching of each topic. The remaining four sections were completed in conjunction with particular assignments. Several of the analyses (sections 5, 7, and 8) used a similar framework which entailed coding, a) the mode of required response (e.g., multiple choice, short answer), b) the problem level (i.e., textually explicit, textually implicit, or scriptally implicit, as defined by Pearson & Johnson, 1978), and c) the degree of science orientation (i.e., the represented components of scientific literacy). A copy of the Curriculum Content Analysis appears in Section Four of Appendix A.

<u>Target Student Interview</u>. This was a semi-structured interview administered to the six target students in each classroom near the end of each topic observation period. The interview had three goals: (a) to gather information on students' perceptions of and reactions to the science class activities they had encountered during the past five days, (b) to gather information on students' understanding of the teacher's lessons during the past five days, and (c) to identify other lessons or activites during the semester that were memorable to students and captured their attention and curiosity. Slightly different versions of the interview were used for Topic 1 and Topic 2. Both appear in Section Nine of Appendix A.

Procedures

Recruitment of Sample

Recruitment of the sample proceeded somewhat differently in the two states. In California, recruitment began with phone calls to nearby districts to determine whether the district had intermediate schools offering a full year of life science at the 7th grade. Of the 19 districts contacted, only 6 (or 32%) had at least one intermediate school offering a full year of 7th grade life science. In the remaining 12 districts, the science offerings varied, indicating no one predominant pattern in the region. Some districts, for example, offered physical science at the 7th grade level while other districts offered only one semester or two trimesters of life science at 7th.

Given the six potential sample districts in California, the next step entailed sending a description of the study to the district and then obtaining permission to contact principals and teachers directly or through the district. Permission was obtained in all cases. Of the six districts, principals and teachers in three of these districts expressed interest in participating. Two of these districts had one intermediate school and the third district had two intermediate schools that expressed interest. Meetings were then held with the principal and interested teacher(s) in each of the four schools, where the ILS project directors further explained the study and answered questions. Three of these schools eventually agreed to participate in the study. When a district or school declined participation in the study, the reasons given involved the teachers--namely, that teachers were already overcommitted to special programs or that they were inexperienced with the subject matter.

In Utah, recruitment of the sample began with contacting a science specialist at the state Office of Education. This specialist recommended two school districts within one hour's driving time of downtown Salt Lake City where there was a reputation for an active science education program. One of these districts was suburban and the other rural.

In the suburban district, the next step involved contact with a district curriculum specialist. This individual suggested four intermediate schools where administrators probably would be agreeable and where a full year of 7th grade life science was offered (7th grade physical science is more typical in Utah). Beyond this point, recruitment proceeded as in California, where project coordinators met with principals and teachers and provided a written description of the study. Eight teachers were contacted in this manner and all agreed to participate. One of these teachers declined further participation after the first two months of the study for unexplained reasons.

In the rural Utah district, contact with district personnel revealed that there was only one teacher in the district with a 7th grade life science course. This teacher agreed to participate in the study after meeting with the project coordinators and receiving the standard information.

Administration of Student Pretest and Posttest Batteries

The student pretest battery was administered to the 11 participating classes during the third or fourth week of the school year. Because of the length of the battery, administration took place over two consecutive days. For the "Day 1" component, students filled out the Feelings Toward Science Survey, Word Meaning Survey, and Patterns Completion Survey. For the "Day 2" component, students filled out the Life Science Questionnaire, Nature of Science Survey, and Science Process Survey.

The surveys were administered by experienced research staff (some of whom later served as observers). Administrators followed a detailed set of instructions to facilitate standardized testing conditions. These instructions included specifications for the order and timing of instruments and also for a set of verbal scripted directions for the class. Teachers were free to carry out their own activities during the survey sessions, although administrators requested that teachers remain in the classroom for management purposes. After administration of each day's surveys, administrators were required to fill out a Survey Administration Record, a form for summarizing student absences and any encountered difficulties or irregularities.

Administration of the posttest battery took place in the same manner during the last three weeks of the school year. The ordering of the measures was identical, except that the Word Meaning Survey and Patterns Completion Survey on the "Day 1" component were replaced by the Ideas About Science Survey.

Observer Training

Eight observers worked on the study to collect all of the classroom measures. Four observers worked at the Utah sites and four at the California sites. Three Utah observers were professors of Education with a background in science education. The fourth Utah observer was an upper level graduate student with strong skills in teacher supervision and classroom observation. Two of the California observers were full-time staff at the Far West Lab with strong skills in classroom observation. The other two California observers were graduate students in psychology or education with strong science backgrounds. In short, the observers all had education-related backgrounds and experience in schools; furthermore, over half of them had done some specialization in the area of science.

In California, each of the four observers was assigned to one teacher. In Utah, three observers were assigned two teachers each, and the fourth observer was assigned one teacher. Assignments were based largely on scheduling and geographical convenience.

Two training sessions were held following administration of the student pretest battery and prior to major data collection, during mid-October and mid-November of 1983. These sessions were conducted in Utah with all eight observers present. Each session lasted four days.

The First Session. The format for the first session was as follows. On the first day, observers were given a copy of the ISS Observation Manual (see Appendix A), and an overview of the manual contents was presented. The observers then read through the Introduction section and the sections on the Narrative Record and the Science Class Description. The content in these sections was reviewed and discussed. The last part of the first day was spent viewing a videotape of an actual life science lesson. The tape showed a high school teacher's recitation on mitosis and meiosis. Observers then discussed the recitation in terms of the components of scientific literacy and the way the recitation should be captured in a narrative.

On the second day, all observers visited one morning period of a 7th grade life science class in a nearby school. Following the visit, observers individually completed an audio-taped narrative and Science Class Description (SCD). All of the observers then met together to practice applying part of the Curriculum Content Analysis Packet to a number of 7th grade life science textbooks. After these scorings were discussed, the remaining part of the day was devoted to discussing observers' ratings on each item of the SCD they had completed in the morning. About half of the items were discussed, and the videotape from the previous day was used as clarification of some of the rating concepts.

On the third day, observers visited the same class they had seen the previous day. After the visit, they completed a second taped narrative. The remainder of the day was spent finishing the discussion of the previous day's SCD and sharing and critiquing the transcripts of each observer's Narrative Record from the previous day.

On the fourth day, the training began with further discussion of guidelines for the completion of a good Narrative Record. As an example, one Far West Lab observer provided copies of his narrative from the previous day. Copies of other second narratives were collected by Far West staff with the understanding that they would be returned with comments. Discussion then turned to the Science Teacher Interview. After the general purpose and strategy for the interview were presented, observers formed pairs and role-played the interview, taking turns at being both the interviewer and the interviewee. These practice interviews were taped allowing for further discussion afterwards.

The Second Session. The second session proceeded in a fashion similar to the first, combining group discussion and actual practice with the instruments. On the first afternoon, a general overview of the classroom instrumentation was presented. Minor modifications of the instruments, based on experience during the last session, were reviewed. In addition, discussion was devoted to selection of topics for observation and data management.

The second day began with a visit to one morning period of a 9th grade life science class. Following the visit, individual observers completed a taped narrative, the Narrative Record Summary, and the Science Class Description. When observers resumed their meeting, the entire Curriculum Content Analysis Packet was reviewed, with special attention to parts not covered during the first training session. The remainder of the day was devoted to discussing observers' ratings on the first portion of the SCD they had completed during the morning.

The third day of this session was devoted largely to working with instruments that had not yet been discussed. First, the Teacher Topic Questionnaire was reviewed. Second, the Student Topic Interest Form and Target Student Interview were discussed. In the mid-afternoon, every observer pilot-tested these last two instruments with one or two 7th grade students at a nearby school. Only parts of the Target Student Interview could be tested because the observers were not familiar with the students' class syllabus. Following the pilot-testing, observers resumed meeting and discussed the results of the pilot-testing. Minor modifications in the instruments resulted from this input.

The fourth day was spent discussing the practice data collection from the second day. By this time, transcripts of the Narrative Records were available; these were shared and discussed. The narrative of one Utah observer was given to the other observers as a model. Next, the observers' Narrative Record Summary Sheets were compared and discussed. Finally, discussion resumed on the SCD, and the last portion of these ratings were compared and discussed.

Administration of the Science Teacher Interview

Observers arranged interview times with their assigned teachers based on mutual convenience. These interviews took place during November. Typically, the interview was conducted during teachers' preparatory periods or after school. In some cases, it was necessary to come back a second day to complete the interview. All interviews were audio-taped except for two, during which the teachers requested that they not be recorded. In the instances of no recording, observers taped their own summary of what transpired. All observers took written notes during the interviews and all interview tapes were transcribed.

Selection of the Topics for Observation

As indicated in the introduction to the study, one major rationale for building observations around specific topics was to enable descriptions of how different teachers handled similar subject matter. In addition, it was desirable to allow some variability within teacher, especially given that some topics might lend themselves to certain treatment more easily than others; thus, it was decided that each teacher should be observed teaching two different topics.

Given these observation guidelines, an ideal design would entail observing all teachers teaching the same two topics. It was clear from the beginning, however, that this would not be possible; different teachers had different life science curricula, some topics already were covered at the very beginning of the year, and observers had their own scheduling limitations. Initially, then, observers were asked to start with a list of five topics and to determine whether teachers addressed these, and if so, when and for how long. The five topics were:

1. Land Ecosystems
2. Seed Plants
3. Genetics and Heredity
4. Protists
5. Human Bone, Muscle, and Nervous Systems.

These five topics were selected to represent ones found in most life science textbooks as well as represent variety on at least three dimensions. For one, the topics differed in their level of organization; Topics 3 and 4 were viewed as relatively "micro" and Topics 1, 2, and 5 more "macro." The topics also differed in the extent to which they had obvious connections to the different "relating" components of scientific literacy. Topics 3 and 4, for example, lent themselves quite easily to science as a historical process. Topics 1 and 4 lent themselves well to science and society/technology. Thus, while it was possible for any teacher to treat any topic using all the components of scientific literacy, it seemed wise to have topics where the obvious connections were varied. Finally, it was conceivable that different topics might hold different motivational values for students; students might be most responsive to those topics most directly related to human experience, Topics 1 and 5.

When the results of polling teachers about the five topics were shared among observers, the necessity of a less constrained and more complex observation schedule became apparent. In part, this was due to several other topic selection criteria: 1) for each teacher, two topics should be selected that represent the micro-macro contrast; 2) the two topic observations should be separated by at least a month's interval of time; and 3) each topic should be well-delineated and receive anywhere from 5 to 10 days of class time. Given these additional criteria, it became necessary to broaden the topic definitions and allow for other specific topics within the same general realm. For example, one teacher taught genetics within the context of cell division; thus, the topic encompassed both cell division and genetics. Another teacher spent almost all of his time on the human digestive system when covering human systems. Thus, observations focused on the digestive system rather than any others.

Table 2.2 shows the final topic observation schedule. A general pattern of micro-macro topic contrasts can be seen. Eight of the eleven teachers taught more "micro" or lower-order animal topics (e.g., cell structure, genetics, protists, sponges) for the first round of observations, turning to more "macro" level topics for the second round of observations (e.g., mammals, human systems, and ecology). Two of the remaining teachers (7 and 11) showed the opposite trend, moving from a "macro" to "micro" topic. The last teacher (5) taught a "micro" level topic for both observation rounds.

A considerable overlap on the number of observation rounds which focused on the same topics can also be seen in Table 2.2. Of 22 possible topics (11 teachers x 2 topics), 5 focused on genetics and/or cell structure, 5 on one or more human systems, 4 on protists, 3 on ecology, 2 on bacteria and viruses, and 1 each on sponges and coelenterates, birds and mammals, and digestive systems of different animals.

Table 2.2 also indicates the number of days each teacher spent covering each topic. Topic length for the first topic

Table 2.2

Topic Subject Matter and Duration in Eleven Classes

TEACHER	SUBJECT MATTER OF FIRST TOPIC	DAYS SPENT TEACHING 1ST TOPIC	SUBJECT MATTER OF SECOND TOPIC	DAYS SPENT TEACHING 2ND TOPIC
1	Reproduction and Genetics	10	Ecology	9
2	Protists	8	Digestive Systems	10
3	Sponges and Coelenterates	7	Human Systems	10
4	Protists	9	Human Organs and Systems	8
5	Protists	7	Genetics	7
6	Bacteria and Viruses	7	Birds and Mammals	4
7	Ecology	10	Genetics	8
8	Protists	5	Human Digestive System	7
9	Cell Structure and Function	10	Human Circulatory System	6
10	Cell Division and Genetics	12	Human Circulatory & Skeletal Systems	9
11	Ecology	5	Bacteria and Viruses	7

ranged from 5 to 12 (average=8.2). For the second topic, the number of days ranged from 4 to 10 (average=7.7). (It was anticipated that Teacher 6, the one with 4 days, would continue on to a 5th day; however, he spent the entire 5th day preparing an inventory of his books.) The average number of days per topic across both observation rounds was 8.0. If anything, this average is a low estimate, because observers were often unable to observe class on the last day when a final topic test was given (and, thus, this day was not included in the observed count).

Administration of the Teacher Topic Questionnaire and Post-Topic Interview

The Teacher Topic Questionnaire and Teacher Post-Topic Interview were administered to each teacher by the observer assigned to his/her class (see below). For Topic 1, observers gave the Teacher Topic Questionnaire to teachers at least one week prior to the beginning of the topic, requesting that teachers have it completed and ready for collection on the first day of observation. The Teacher Post-Topic Interview was administered within one week following the completion of the topic. At the teacher's convenience, the interview was typically held during lunch hour, prep period, or after school. Observers audiotaped the interviews and took notes on the interview schedule.

The identical procedures were followed for Topic 2 with one exception. For this round, observers were given the option of administering the Teacher Topic Questionnaire in the form of an interview. This option was especially encouraged if teachers had been brief in their written responses for Topic 1.

Classroom Observations: The Narrative Records and Science Class Descriptions

Considerable preparation took place prior to observers actually entering the classroom during the topic intervals. First, each observer was assigned to a teacher(s). This procedure, rather than employing a schedule of rotating observers, involved important benefits as well as clear tradeoffs. By giving one observer total responsibility for a class, this observer would be able to identify individual students more easily and be able to maintain more thorough records on how activities fit into the overall course of a topic. This opportunity to be more "expert" in data collection was considered to outweigh the benefits of more certain reliability that would result from using a rotating system. Assignment of particular observers to particular teachers was based on geographic and scheduling considerations. For example, since most observers had other obligations (e.g., classes to attend or to teach) efforts were made to assign them to teachers whose classes met at convienent times. In California, each of four observers was assigned to one teacher. In Utah, three of the four observers were assigned two teachers each; the fourth observer was assigned to one teacher.

The preparations for the observations also included becoming familiar with the classes prior to formal data-collection. Thus, each observer made a least one "familiarization visit" to his/her class(es) and observers obtained up-to-date seating charts, became able to identify individual students by appearance, and acquired a general familiarity with teachers' class routines. Observers were also asked to prepare a complete description of the physical layout of the classroom, including visible class materials.

After the familiarization visit(s), observers maintained contact with their teachers to determine when teachers would begin the topic of interest. Formal observations began on the first day and continued on all following days when the topic was covered. In total, observers missed only a few days of observation over the course of the year due to other obligations. In cases when they could not attend class, observers asked teachers to describe the activities of the missed day and collected any materials that were handed out.

On each day of formal observation, the observer arrived before the beginning class bell. He or she took a seat in the back of the room and prepared to record class events in two ways. First, the observer started an audio-tape recorder and let it run for the course of the period. Second, the observer took detailed hand-written notes, paying particular attention to note the beginning and ending times of activities, the identities of students speaking, and the general nonverbal behavior of students (e.g., the degree to which they appeared engaged in work). Any relevant material written on the chalkboards was also recorded. Observers remained in the back of the room most of the time, in order to be as unobtrusive as possible. However, during lab activities when students often worked in groups, observers often walked around the room in order to get a sense of students' progress and conversations.

After observers left the classroom, several procedures were necessary to complete data collection for the day. First, observers had to create their own audio-taped narrative record of the day's events. Using a second tape recorder to record their own narrative, observers worked from both the tape they recorded in class and their notes. Observers also completed the Narrative Summary Sheets and the Science Class Description for the day. The entire process of recording data for one day of observation was lengthy, usually requiring four to five hours of time. While observers were strongly encouraged to complete all data recording on the day the class was observed, this was not always possible. Because the existence of a class tape preserved much of the detail needed, it was considered acceptable if observers took several days to complete all their data records.

After an observer completed each narrative tape, he or she turned the tape over to the site coordinator in either California or Utah. From here, the tape was put in queue to be transcribed.

Transcriptions were generally returned to the observer within a week of the tape's delivery. The observer then was responsible for reading the transcript and correcting any errors. After this, all transcripts and other forms were sent to the site coordinator for permanent filing at the Far West Laboratory.

Administration of the Student Class Survey

Each observer administered the Student Class Survey to all students in his/her class(es) once during each topic interval. Observers gave teachers notice that they wanted to administer the survey, and a specific day was agreed upon (usually at or near the end of the topic interval). During the last ten minutes of the class period, observers read directions on the survey to students and allowed them to have the remainder of the period to fill it out. The teacher typically was present during the survey administration.

Completing the Curriculum Content Analysis

In order to complete the Currciculum Content Analysis, observers required access to the major textbook(s), if any, used during the topic, as well as copies of all materials given to students. Textbooks were typically borrowed from the teacher or purchased. Copies of materials were collected during class. The appropriate Curriculum Content Analysis sheets were completed at the end of each topic interval, and copies of materials were attached to the analysis sheets for filing purposes.

Table 2.3 shows the primary textbooks that teachers reported using. The table indicates that Exploring Living Things (Smith, Frazier & Magnoli, 1977) was the predominant text among the teachers in Utah (Teachers 1-7). Teacher 5 was the only exception, citing Living Things (Teter, Edwards, Fitzpatrick & Bain, 1981) as his major text. Among California teachers (Teachers 8-11), two texts were equally popular: Life Science (Richardson, Harris & Sparks, 1982) and Life Science: A Problem Solving Approach (Carter, Goodman, Hunter & Schelske, 1974). Nearly all teachers reported the use of supplementary texts in addition to their primary text. Thus, this table does not indicate the full range of textbook resources. Table 2.3 also indicates whether a text (primary or supplementary) was used during the two topic intervals. As can be seen, there were some teachers who did not use a text for one or both of the observed topics. In these cases, observers did not complete Curriculum Content Analysis sheets on the textbook sections. Instead, their analysis was limited to the other materials used during the topics.

Administering the Target Student Interview

As indicated above, six designated target students were chosen from each class. Each of these students was interviewed

Table 2.3

Primary Life Science Textbooks Used in Eleven Classes

Tchr	Primary Text	Authors	Publisher	Year	Text Used for Topic 1	Text Used for Topic 2
1	Exploring Living Things	Smith, Frazier, & Magnoli	Laidlaw Bros.	1977	No	Yes
2	Exploring Living Things	Smith, Frazier, & Magnoli	Laidlaw Bros.	1977	Yes	No
3	Exploring Living Things	Smith, Frazier, & Magnoli	Laidlaw Bros.	1977	Yes	No
4	Exploring Living Things	Smith, Frazier, & Magnoli	Laidlaw Bros.	1977	Yes	Yes
5	Living Things	Teter, Edwards, Fitzpatrick, & Bain	Holt, Rinehart, & Winston	1981	Yes	Yes
6	Exploring Living Things	Smith, Frazier, & Magnoli	Laidlaw Bros.	1977	Yes	Yes
7	Exploring Living Things	Smith, Frazier, & Magnoli	Laidlaw Bros.	1977	Yes	Yes
8	Life Science	Richardson, Harris, & Sparks	Silver-Burdett	1982	Yes	Yes
9	Life Science: A Problem Solving Approach	Carter, Goodman, Hunter, & Schelske	Ginn & Co.	1974	No	No
10	Life Science: A Problem Solving Approach	Carter, Goodman, Hunter, & Schelske	Ginn & Co.	1974	No	No
11	Life Science	Richardson, Harris, & Sparks	Silver-Burdett	1982	Yes	Yes

during each topic, typically at or near the end of the interval so that it was possible to refer back to several previous days of topic activities. Having six interviews to conduct, observers usually scheduled three on each of two consecutive days. Interviews typically were conducted after school, although in some cases teachers thought it better to schedule them during a student's P.E. or free period. In all cases, letters were sent to the students' parents to notify them of the scheduled interview time several days in advance. While each observer typically conducted all the interviews for students from his/her class(es), in some instances one other observer helped out.

All interviews were audio-taped and later transcribed. Observers also took notes on the interview schedule and completed the rating items. Each interview lasted approximately thirty minutes.

Data Analyses

As indicated in Chapter One, combined quantitative and qualitative methods were planned for analyses. Only particular instruments were amenable to direct, quantitative translation. These were: (1) the Student Pretest and Posttest Batteries; (2) the Student Class Survey; and (3) the Science Class Description. Other data sets were primarily descriptive in nature (e.g., the Narrative Records) or of a small enough quantity to make hand summation possible (e.g., the Curriculum Content Analysis).

The Student Pretest and Postest Batteries and the Student Class Surveys were keypunched and initially combined to form one student-level data set. The Science Class Description forms also were keypunched and structured as one data set. While this data set initially existed with records for each teacher for each day of observation, an additional aggregated data set was created with one average per variable per teacher. All data analyses were conducted with the Statistical Package for the Social Sciences (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975).

Specific data analysis strategies are presented as appropriate in each results chapter.

CHAPTER THREE

TEACHERS' TIME USE OF DIFFERENT INSTRUCTIONAL MODES AND SCIENTIFIC LITERACY COMPONENTS

This chapter addresses three aspects of classroom processes measured in the Intermediate Life Science Study. First, we shall report on the amount of time devoted to nine different instructional modes in the sample classrooms. Second, we examine the proportion of time teachers spent dealing with each scientific literacy component during their presentations. Third, we address the qualitative adequacy with which the teachers used the relating areas of scientific literacy.

Data Source

The Science Class Description (SCD) measure was the source of data on teachers' time devoted to the different instructional modes and scientific literacy components. Two items of this form are of particular interest: they are reproduced in Figure 3.1. The first item, Item 1, asks observers to estimate the amount of time, both allocated and actual, devoted to each of nine different possible modes of generic instruction. The first six of these modes (seatwork, recitation, group discussion, demonstration, laboratory exercises, and surrogate instruction) refer to ways of communicating appropriate academic subject matter. The remaining three modes (non-academic instruction, procedures, and other) encompass the kinds of activities and behaviors that are sometimes necessary but nonetheless take away from academic time. In Item 1, a distinction is made between allocated minutes and actual minutes. "Allocated" minutes refers to the formal amount of time allocated to the mode, while "actual" minutes refers to the amount of time that was truly spent in the mode, after any "slippage" (e.g., procedures and interruptions) is taken into account.

The second item of interest, Item 4, asks observers to estimate the amount of the teacher's academic presentation time that is devoted to each of the five major components of scientific literacy: 1) explaining content; 2) relating to science as a social historical process; 3) relating to science as a reasoning process; 4) relating to science and society/technology; and 5) positive attitudes towards science. Here, academic presentation time refers to the sum of the actual recitation and demonstration time given in the first item. Item 4 focusses on the sum of the scientific literacy components in this very specific context because our study is primarily concerned with how the teacher makes use of scientific literacy when he or she is communicating with the entire class (as defined here, recitation and demonstration necessarily involve the entire class). It should be noted that observers were instructed to code only very explicit instances of teacher use of scientific literacy. Here the logic was

Figure 3.1. Two items on Time Use

1. Estimate the <u>percent</u> of <u>actual</u> (not allocated) time devoted to the following:

	Mode	Allocated Minutes	Actual Minutes	Actual % of Time
Academic	Seatwork			
	Recitation			
	Group Discussion			
	Demonstration			
	Laboratory Exercises			
	Surrogate Instruction			
	Nonacademic Instruction			
	Procedures			
	Other: Transitions, Interruptions, Waste Time			
	TOTAL (time between bells)			100%

4. Estimate the <u>percent</u> of teacher academic presentation time (recitation and demonstration) devoted to the following science emphases:

Science Emphasis	Minutes	% of Time	Linkage to Content	No Linkage
Explaining Content				
Relating to Science as a Social Historical Process				
Relating to Science as a Reasoning Process				
Relating Science and Society/Technology				
Positive Attitudes Towards Science				
TOTAL RECITATION AND DEMONSTRATION TIME		100%		

that in order for the references to scientific literacy to be salient to students, they at least would have to be salient to observers. While it is possible that individual teachers developed idiosyncratic ways of signalling that they were relating rather than explaining scientific content, and that our observers failed to notice these, we find this rather unlikely.

Time Devoted to Different Instructional Modes

Tables 3.1 and 3.2 present the average percentage of class time devoted to each of the nine instructional modes, for Topics 1 and 2, respectively. The tables show the averages for each teacher separately and for the sample as a whole. These data were originally computed on each day of obervation; here the average over all days of observation during the topic is reported for each teacher. For a more detailed account of the specific nature of the instructional activities during each topic, the reader is referred to Appendix C.

Topic 1

Turning first to Table 3.1, the top figure in each cell of this table represents the average percentage of class time use, while the number or numbers in parentheses show the highest and lowest percentages in the range for each teacher. The overall averages across teachers are presented in the column furthest to the right. Looking at the overall averages, it is clear that recitation is the predominant mode, taking up 31 percent of the class time. Recitation outdistances the next most frequent mode--seatwork--by over 10 percent. Thus, the life science teachers in our sample spent on average over one quarter of available class time during Topic 1 reciting academic information to the whole class.

There is some individual variation among teachers in this finding, however. Recitation is the predominant mode for eight of the eleven teachers, but one teacher (Teacher 2) made virtually no use whatsoever of this mode of presentation: instead seatwork, laboratory exercises and surrogate instruction made up 54, 19, and 10 percent, respectively, of this teacher's class time. The two remaining teachers (Teachers 3 and 5) also allocated most of their class time to seatwork (35 and 22 percent, respectively).

The second most predominant mode, as indicated by the overall average of time allocation, is seatwork. Students spent an average of 20.4 percent of their class time doing assigned seatwork. Variation across the classes of different teachers is great, however. Teacher 9 gave no seatwork, while two others (Teachers 7 and 10) made minimal use of this mode (3 and 5 percent, respectively). The remaining teachers generally used seatwork to a moderate extent.

Table 3.1. Average Percent of Class Time Use During Observations of Topic 1

TEACHER:	1 N=10*	2 N=8	3 N=7	4 N=9	5 N=7	6 N=7	7 N=10	8 N=5	9 N=10	10 N=11	11 N=4	TOTAL AVERAGE
Seatwork	24.3 (4-68)	53.6 (44-58)	34.7 (24-70)	15.8 (12-62)	22.1 (15.5-47)	16.5 (11-44.4)	2.5 (7-9)	20.2 (16-42)		5.0 (4-16)	29.5 (17-63)	20.4
Recitation	27.3 (3-77)	2.3 (18)	17.2 (2-66)	29.4 (4-85)	12.1 (7-31)	37.9 (11-78)	38.4 (9-82)	40.0 (13-68)	44.5 (7-88)	49.3 (16-78)	40.5 (8-69)	30.8
Group Discussion												0.0
Demonstration				1.0 (4)	0.3 (2)	2.3 (16)	11.9 (5-89)	0.4 (2)				1.4
Laboratory Exercises	11.9 (11-52)	18.8 (18-24)		23.1 (24-66)	15.0 (47-58)	4.8 (33.3)	18.8 (16-56)	17.8 (9-51)	21.0 (18-58)	15.8 (51-67)		13.4
Surrogate Instruction	5.5 (8-27)	9.9 (8-12)		7.1 (20-24)	4.4 (31)	6.0 (20-22)	7.3 (10-32)		3.3 (33)	2.0 (22)	11.0 (44)	5.1
Nonacademic Instruction	1.5 (4-11)	2.5 (20)	4.0 (12-16)	2.2 (20)	3.1 (22)	3.1 (22)	1.1 (11)	5.2 (2-22)	2.5 (25)	2.4 (4-22)	4.3 (17)	2.9
Procedures	17.4 (4-47)	3.8 (2-10)	8.9 (4-20)	14.8 (5-30)	11.1 (4-24)	8.5 (2-22)	5.8 (2-13)	10.8 (4-27)	12.6 (2-26)	11.9 (2-31)	7.3 (4-15)	10.3
Other: Transitions, Interruptions, Waste Time	12.0 (2-28)	9.3 (4-20)	32.5 (12-62)	6.7 (2-10)	31.9 (7-69)	20.9 (6-40)	13.6 (7-22)	5.4 (4-7)	16.1 (9-23)	13.7 (19-20)	7.5 (4-10)	15.4

*Note. The given N's are the number of days for which data were collected.

Laboratory exercises are the third most common mode. Here, the overall average is 13.4 percent. Translated into daily terms, this means that students spent approximately 1 out of every 7 days doing a lab. Again, there is some noteworthy variation among teachers. Teachers 3 and 11 had no lab during the first topic, and Teacher 6 had only one short lab.

The remaining academic modes--group discussion, demonstration, and surrogate instruction--occurred relatively infrequently or not at all (0.0, 1.4, and 6.4 percent, respectively). Of these, surrogate instruction was used with some regularity by most teachers. Examination of the narratives indicates that the form of surrogate instruction employed was usually films, videotapes, or filmstrips. The demonstration mode was used by only a small group of teachers, and only for brief periods. It is interesting that the two teachers who did not use laboratories also did not use demonstrations. Finally, there were no instances where teachers used group discussion. While teachers did use question-and-answer sessions frequently (this was coded under recitation), they did not take this idea further, to the extent of letting their students have considerable input into the discussion ideas and selection of participants (the distinguishing feature of our definition of discussion).

Turning to the last three modes, nonacademic instruction is the least frequently employed, taking up only 2.9 percent of the time, on average. The presence of this mode at all is largely attributable to the fact that time spent administering this study's Student Class Survey was coded in this category. On the other hand, the procedures and "other" modes have substantial overall percentages (10.3 and 15.4, respectively). In fact, the "other" mode is the third most predominant of all the nine modes. While some unproductive "other" time can be expected in any classroom, there is reason to believe that percentages for this mode of from 20 percent to over 30 percent (as Teachers 3, 5 and 6 had) are indicative of teachers having serious difficulties in classroom management or allowing a lot of "free time" to occur. Because the procedure mode encompasses teachers' directions to students about assignments and the use of materials, all teachers spent some time in activities categorizable under this mode. Relative to the other modes, the variation across teachers is not great, ranging from 3.8 percent for Teacher 2 to 17.4 percent for Teacher 1.

Topic 2

Table 3.2 presents the average percentages of class time use across the nine instructional modes for each teacher during Topic 2. Looking at the overall averages in the right column, we see that recitation is again the predominant mode, accounting for 33.6 percent of the time. Seatwork is once more the runner up,

Table 3.2. Average Percent of Class Time Use During Observations of Topic 2

TEACHER:	1 N=9*	2 N=10	3 N=10	4 N=7	5 N=7	6 N=4	[illegible]8	8 N=7	9 N=6	10 N=9	11 N=7	TOTAL AVERAGE
Seatwork	24.4 (10-61)	36.5 (10-90)	41.2 (20-76)	10.4 (2-62)	28.9 (16-44)	51.3 (35-67)	10.3 (2-22)	17.4 (4-72)		13.4 (6-51)	22.9 (21-66)	23.3
Recitation	16.2 (4-33)	27.2 (10-68)	32.6 (20-84)	55.0 (7-85)	26.4 (16-49)	14.5 (18-40)	51.0 (24-73)	40.0 (28-81)	53.2 (44-81)	31.7 (9-74)	22.1 (8-48)	33.6
Group Discussion												
Demonstration	4.0 (14-22)			1.9 (13)			2.0 (7-9)	5.3 (4-16)		1.0 (9)		1.3
Laboratory Exercises	9.1 (20-36)	15.5 (25-54)	1.0 (10)	9.4 (66)			3.4 (12-15)	10.1 (31-41)	9.2 (23-32)	4.9 (44)	7.4 (52)	6.4
Surrogate Instruction	10.4 (4-42)						4.1 (33)			10.7 (40-56)	4.4 (6-25)	2.7
Nonacademic Instruction	1.1 (10)			1.1 (8)	1.1 (8)	5.0 (20)	2.3 (7-11)	4.1 (7-22)	3.2 (19)	8.4 (20-56)	5.3 (6-31)	2.9
Procedures	13.3 (6-37)	8.0 (4-26)	8.4 (4-24)	9.9 (2-20)	13.1 (4-31)	2.5 (2-4)	8.1 (2-18)	11.4 (5-19)	14.8 (2-42)	18.2 (7-35)	17.6 (8-29)	11.4
Other: Transitions, Interruptions, Waste Time	21.0 (14-28)	12.8 (4-28)	16.8 (8-48)	12.3 (2-32)	30.4 (20-42)	26.8 (22-33)	18.8 (9-24)	11.6 (5-18)	19.5 (9-30)	11.4 (4-20)	20.3 (13-25)	18.3

*Note: The given N's are the number of days for which data were collected.

at 23.3 percent. During Topic 1, Teachers 1, 3, and 5 allocated more time to seatwork than to recitation. For the second topic, considerably more of the teachers used seatwork as their most predominant mode. Here are included not only Teachers 1, 3, and 5, but also Teachers 2, 6, and 11. It is interesting to speculate what might be behind this increase in the use of seatwork. It might be the case, for example, that as the school year passed, teachers grew more weary of preparing for lectures and opted, instead, to fill the time with worksheets (i.e., seatwork). This clearly does not mesh with these data, though, since the overall average for teacher recitation during Topic 2 is higher than that for Topic 1. In fact it is interesting to note that Teacher 9, who avoided using any class time for seatwork during Topic 1, also avoided it during Topic 2.

A more likely origin for the upward trend in seatwork appears by looking at the percentages for laboratory exercises and surrogate instruction in Table 3.2. It will be noted that, compared with Topic 1, there is a drop in the proportion of time allocated to these modes. Thus, it is possible that teachers were in part substituting seatwork where they had used laboratories and audio-visual supplements in Topic 1. The reasons for this could be several. Setting up labs--or scheduling films--certainly requires extra planning and preparation; and, again, teachers may have tired of this as the year progressed. Also, it is possible that most of the specific topics taught during the second round were less amenable to lab or audio-visual activities. Many teachers covered one or more human systems during Topic 2, for example, and it may be that lab activities (or films) in this area are less available or prohibitively expensive.

Of the remaining modes, group discussion, demonstration and nonacademic instruction are virtually unchanged from their Topic 1 values; they took up 0.0, 1.3 and 2.9 percent of the time, respectively. Time occupied by procedures shows a slight increase, from 10.3 to 11.4 percent. The 'other' category showed nearly a 3 percentage-point increase over its already high Topic 1 percentage. Transitions, interruptions and waste time took up a high 18.3 percent of class time on average. Examination of individual teacher's data for this mode shows that Teachers 5 and 6 still had problems in this area, with 30.4 and 26.8 percent respectively. Teacher 3, who had the highest figure for this mode in Topic 1, had improved to a relatively moderate 16.8 percent. Finally, Teachers 1 and 11, who both had relatively low percentages of "other" for Topic 1, increased in this category to the extent of exceeding 20 percent.

Summary

In sum, it appears that for this sample of life science classes, teachers carried out academic instruction largely through means of recitation, seatwork, and laboratory exercises--in that order--followed by a fairly consistent use of audiovisual materials (surrogate instruction). These data can be compared to those from the Goodlad, et. al. (1979)"Study of Schooling". As reported in Sirotnik (1983), science at the junior high level involved 23.6 percent recitation, 20.1 percent seatwork, 15.6 percent lab, and 8 percent audiovisual. These figures are remarkably close to those for Topic 1 presented here, falling within three percentage points, except in the case of recitation, which received about seven percent more time in this study. Our percentages for Topic 2 are more discrepant, with even more time for recitation and less time for lab and surrogate instruction. Looking at Sirotnik's time use data across all subject areas at the junior high level, it is the presence of laboratory (or what is referred to as "psychomotor/physical practice or performance") that distinguishes science from the other basic subjects of English, mathematics, and social studies.

Teachers' Use of the Components of Scientific Literacy

We now turn attention to the normative framework of the study, one specific to science classes. It will be recalled that this scientific literacy framework has one explaining component and four relating components. Here, we examine the extent to which teachers incorporated each of these components into their oral presentations to the whole class (recitation or demonstration). While according to the normative framework, a greater use of the relating components of scientific literacy would indicate more effective science teaching, there are two reasons why such an interpretation might be misleading. First, doing something in greater quantity does not assure its quality. In this case, a teacher who used a relating component well but only occasionally might be preferred to a teacher who used the same relating component poorly but frequently. We examine the quality of relating component use in the last portion of this chapter. A second factor that deserves consideration is whether use of the scientific literacy relating components is associated with growth on student outcomes. This form of empirical confirmation is highly desirable if a strong case is to be made for the value of incorporating scientific literacy into teaching. Examination of the association between scientific literacy use and student outcomes is discussed in Chapter Four.

Topic 1

Table 3.3 presents the percent of academic presentation time that teachers devoted to the five components of scientific literacy during Topic 1. The top number in each box is the percent, while the bottom number in parentheses indicates the actual number of minutes used. (The actual minutes vary widely across teachers not only because teachers devoted different proportions of time to academic presentation, but also because the number of days per topic ranged from 5 to 12.) What is immediately salient here is the low incidence of percent time in components of scientific literacy other than explaining content. There are three

Table 3.3. Average Percent of Teacher Academic Presentation Time Devoted to Five Components of Scientific Literacy During Topic 1

TEACHER:	1 N=10*	2 N=8	3 N=7	4 N=9	5 N=7	6 N=7	7 N=10	8 N=5	9 N=10	10 N=11	11 N=4	TOTAL AVERAGE
Explaining Content	86 (112)	100 (9)	99 (59.5)	95 (127)	100 (39)	99 (110)	99 (225.3)	100 (90)	94 (146)	98 (245.8)	95 (74.5)	96.8
Relating to Science as a Social Historical Process	7 (8.5)		1 (0.5)	1 (2)						2 (3.8)	1 (.5)	1.1
Relating to Science as a Reasoning Process	5 (7)			4 (5)			1 (1)			<1 (.5)	4 (3)	1.4
Relating Science to Society/ Technology						1 (1)			1 (2)			0.2
Positive Attitudes Towards Science	2 (2.5)								5 (8)			0.6

*Note: The given N's are the number of days for which data were collected.

teachers (2, 5, and 8) who are shown as having devoted 100 percent of their academic presentation time to explaining content only. Three other teachers (3, 6, and 7) devoted no more than 1 percent of their academic presentation time to any of the relating components. Four other teachers (4, 9, 10, and 11) have relatively small percentages for relating components ranging from 3 to 6. Only one teacher, Teacher 1, has a relatively substantial percentage of time devoted to the relating components--a total of 14 percent.

At this point, it is worth pausing to consider just what Teacher 1 was doing so differently from other teachers. The narrative records for this teacher indicate that she began her 10-day unit on the topic of "Genetics" by talking about people's ideas about spontaneous generation prior to the 1800's and Louis Pasteur's experiments that discredited these ideas. In the course of this historical overview, the teacher also made explicit reference to scientific experiments and their properties, including hypothesis formation. In short, most of the time devoted to relating components was accumulated during this one presentation on the first topic day and coded under relating to science as a social historical process and relating to science as a reasoning process. There were five other days during the topic where this teacher made brief use of some relating components. The most notable of these was Day 5, when the teacher spent three minutes asking students to hypothesize how planaria regenerate, and this was coded under relating to science as a reasoning process. There were four days during the topic when the teacher did nothing in areas other than explaining content. Also, it should be noted that this teacher never did any relating of science to society and technology.

What is important about this example is that the kind of relating this teacher did sounds so unremarkable--and yet this teacher was quite atypical in this sample. It also should be noted that just because this teacher spent a relatively large amount of time going beyond content, this is no guarantee that she did an especially good job in relating to other areas of scientific literacy. Teacher 1, in fact, was generally rated by observers as doing a "moderately effective"--that is, average--job of using the scientific literacy components. A more complete picture of the quality of scientific literacy relating appears later in this chapter.

Topic 2

Table 3.4 shows the percent of academic presentation time teachers spent on each of the five components of scientific literacy during Topic 2. Again, the vast majority of time was devoted to explaining content. Four teachers (2, 3, 6 and 10) devoted 100 percent of their academic presentation time to explaining content only. For three teachers (7, 8 and 9), the relating components took no more than 1 percent of their class time. The remaining four teachers (1, 4, 6, and 11) had

Table 3.4. Average Percent of Teacher Academic Presentation Time Devoted to Five Components of Scientific Literacy During Topic 2

TEACHER:	1 N=9*	2 N=10	3 N=10	4 N=7	5 N=7	6 N=4	7 N=8	8 N=7	9 N=6	10 N=9	11 N=7	TOTAL AVERAGE
Explaining Content	93 (83)	100 (136)	100 (159)	97 (171)	94 (78)	100 (24)	99 (193)	99 (122)	99 (137)	100 (121)	98 (89.5)	98.1
Relating to Science as a Social Historical Process				1 (2)	4 (3)		1 (1)		1 (1)			0.6
Relating to Science as a Reasoning Process												
Relating Science to Society/ Technology	7 (6)			2 (3)	1 (1)			1 (1)			2 (2)	1.2
Positive Attitudes Towards Science					1 (1)						<1 (.5)	0.1

*Note: The given N's are the number of days for which data were collected.

percentages ranging from 2 to 6 for relating components. It is noteworthy that Teacher 1, outstanding in Topic 1 for her devoting of 14 percent of her academic presentation time to relating components, is no longer an outlier. Her figure is still the highest, but at 7 percent it is not unusually so.

Summary

In summary, our observations of teachers' use of the components of scientific literacy present a bleak picture. If our sample is at all representative--or even if it represents teachers that tend toward being better than average (which is likely with a sample of volunteers)--it appears that seventh grade life science teachers rarely or never go beyond explaining content by trying to relate the content to meaningful concepts. Explanations for this state of affairs can only be speculative now. One possibility is that teachers actually do devote more time to the relating components of scientific literacy over the course of the school year, but that they do it in discrete segments of their curriculum. For example, some textbooks used by teachers in the study devoted one or more initial chapters to defining and illustrating the scientific method. To the extent that teachers followed their textbooks, it thus is likely that some teachers actually covered a topic on the scientific method -- or what we would call science as a reasoning process. While this may have been the case, what our data illustrate is that teachers rarely, if ever, took opportunities to refer back to concepts that probably were introduced in such a topic. In short, what was clearly intended as laying a foundation for understanding science was not used by teachers as a continuing theme throughout the year. Instead, it was covered like any other topic and then left behind as the teacher faced the logistical difficulties of covering all the remaining topics. While this suggested line of events is understandable (especially if it is reinforced by the organization of textbooks), it is lamentable from the standpoint of pedagogy. This kind of segmentation makes it unlikely that students will actually remember the basic relating concepts of scientific literacy, much less understand their significance as a means to conceptualizing and drawing implications from science facts.

Another factor that may have contributed to the results is that teachers may be aware of the relating components of scientific literacy but feel they are unable to find the time to use them. There is some evidence for this in the case studies reported by Olson and Russell (1983), where teachers cited time pressure as a major factor preventing them from addressing the relationship between science and society. Of course, one retort to this is to say that the amount of time spent addressing the relating components of scientific literacy need not be very great--increments of one minute would appear to be important given these data. Also, it seems that the amount of nonacademic time (procedural or "other") being spent by most teachers (see Tables 3.1 and 3.2) could be trimmed to permit more time for addressing scientific literacy.

A related possible explanation for the bleak results is that many teachers may simply not have a framework of scientific literacy in their minds that approximates that held by the scientific community at large. Indirect evidence on this possibility comes from interviews with 40 science teachers at the high school level (Guthrie, Mergendoller, Leventhal, & Kauchak, 1984). These data indicate that only a small percentage of teachers were unable to articulate a definition of scientific literacy given prompting. The remaining teachers could articulate some reasonable definition either with or without prompting. This majority of teachers also cited time pressure to cover specified content as the reason they did not actually use the notions of scientific literacy in their classrooms. This suggests, then, that there is an implementation chasm: most teachers seem aware of scientific literacy but for some reason are unable to insert it into their daily presentations. At most, they may address some of the relating components as isolated segments in their curriculum. Clearly, more research is needed to understand the nature of this failure, for "time pressure" alone does not seem to be a sufficient excuse.

Qualitative Analysis of Episodes When Teachers Used the Relating Components of Scientific Literacy

This section presents a closer examination of the episodes of teacher presentation when teachers related the scientific content they were teaching to one or more of the following themes: science as a social historical process, science as a reasoning process, and science and society/technology.

One question we have tried to answer in this chapter so far was how frequently teachers employed the relating components of scientific literacy. We have already reported the low average percentages of academic time teachers devoted to the relating components. Another way of examining these data is in terms of the quality of the episodes when relating to the components of scientific literacy took place. The issue of quality is at least as important -- if not more so -- than that of quantity. Properly relating content to scientific literacy entails sophisticated planning and communication on the part of the teacher. If this is not done well, students are likely to ignore or be confused by the information. This, in turn, may discourage the teacher from further attempts at relating. Thus, we might speculate that a few high quality episodes of relating are preferable to many low quality episodes. In this section, we analyze the quality of the relating episodes from the standpoint of accuracy and logic. Admittedly, the analysis is partly subjective. To aid the reader who wishes to draw his or her own conclusions about quality, we provide verbatim accounts of the key portions of episodes.

Throughout the Topic 1 observations, there were a total of nine cases of relating to science as a social historical process, twelve of relating to science as a reasoning process, and three of relating science to society and technology. During Topic 2, there were a total of six cases of relating to science as a social historical process, none of relating to science as a reasoning process, and eight of relating science to society and technology. Occasions where the teacher displayed positive attitudes towards science proved hard to identify in a reliable way, and will not be reported upon here.

In order to carry out a detailed analysis of the effectiveness with which teachers used relating components, it was necessary to select a subset of episodes. Accordingly, we shall present a total of fourteen episodes, taken from observers' transcripts. These episodes represent approximately half of the total number of relating episodes. In Topic 1, the twenty-four cases of relating occurred in seventeen episodes, of which we shall discuss nine. (Some episodes were coded as involving two or more kinds of relating.) In Topic 2, the fourteen cases of relating occurred in twelve episodes, five of which we shall discuss. Episodes were selected on the basis of their interest and typicality. Brief analytic comments are made after each episode, with the exception of Teacher 1, whose episodes are considered in greater detail due to their unusual length.

Teacher 1

Teacher 1 began the year with a unit on how scientists learn and what is meant by scientific inquiry. She then moved on to physical influences, and the plant and animal kingdoms. By mid-year, students learned about plant and animal structure and function. The last portion of the year focussed on ecology and interactions between mankind and the environment.

Science fairs and student projects played an important role in several of Teacher 1's units, each of which was 2-3 weeks in length. Units were organized around worksheets requiring hands-on activities and giving brief defintions of key vocabulary terms, taken from the textbook. Units generally began with an inquiry activity or a movie.

Teacher 1 spent 10 days on a reproduction and genetics unit for Topic 1. As indicated earlier, Teacher 1 made the greatest use of relating components during both topics, relative to other teachers: 15.5 minutes in Topic 1 and 6 minutes in Topic 2. Here we present two major segments of this relating, which occurred on Days 1 and 2 of Topic 1, respectively. Each segment is followed by an analysis.

Topic 1, Day 1.

TEACHER: You know, students, before the 1800s, which was not very long ago, very little was known about reproduction. Let's look at some of the ideas people had about how living things reproduced. [She turns on the overhead projector, and shows a slide which describes six specific ideas about spontaneous generation.] It might be surprising to see what people used to think about how life could reproduce. One idea was spontaneous generation, which means that certain non-living materials could produce living things. You might think these people were crazy. How do you suppose they got an idea like that? Bradley?

BRADLEY: Well, they see worms on meat.

TEACHER: That's right. They thought that the meat had produced the worms. A doctor thought up one of these ideas and scientists thought up others. Here's one idea: that sour wine produces vinegar yields. And, I have here a jar of vinegar with a good fungus in it. [She holds up a jar of vinegar with a mold or fungus growing in it.] Another idea that people had was that a dirty shirt in wheat could produce mice. Some people thought that trees, certain kinds of trees, produce geese. These were ideas about spontaneous generation, that non-living materials could produce living things. People thought this up until the 1800s.

About this time, there was a man called Pasteur, who began to question the idea. How hard is it when you question what everyone else believes? How hard is it to raise your hand and disagree with everyone else? That's what Pasteur did. What Pasteur worked with were microorganisms associated with fermentation. Jake, what are microorganisms?

JAKE: Microorganisms are very small living things.

TEACHER: That's right, Jake. Microorganisms are minute living organisms. How many of you have seen wine-making at home? Denise, have you seen wine-making at home?

DENISE: Yes, you can see the cherries rising to the top.

TEACHER: Yes, and sometimes there's a strong smell. [She puts a second transparency on the overhead. It gives a description of Pasteur's experiments. The description has a 'Problem Statement: Do microorganisms associated with fermentation come from the air?' and a 'Hypothesis: Microorganisms are found in fermenting juices and do come from the air.' The transparency then shows a series of diagrams of the swan-necked flasks which Pasteur used. The teacher states the problem that Pasteur dealt with. Then she moves to the hypothesis.]

Remember, a hypothesis is an educated guess. [She describes the experiments.] Now, what was his final conclusion? Jake?

JAKE: That the little things...

TEACHER: Microorganisms. . . .

JAKE: . . . got in from the air.

TEACHER: Yes. That's right. The microorganisms came in from the air and caused fermentation. Now wasn't that an interesting way to prove Pasteur's idea?

Now, I think you guys have really good ideas. And, I'm going to give you an assignment. I want you to make a hypothesis about spontaneous generation and then to think of a good way of proving it. I want you to write the assignment on your sheet of paper. First of all, this is your problem right here. Does life come from non-living materials? Non-living materials can be just about anything. Now, for your extra credit project, you are to come up with your own hypothesis, and what is a hypothesis? It's an educated guess. And, if I pick your experiment, you'll get extra credit. First, what I want you to do is to state your hypothesis and then design an experiment to prove your hypothesis. I want you to set up your experiment, explain how you could experiment to prove your hypothesis. I want you to think at home of some really good ways that you could do an experiment. Remember, when we've talked about how to do inquiry thinking? Use your good minds, not your textbook.

. . . Get your ideas tomorrow on a way to disprove spontaneous generation.

Comments. During the nine and one-half minute episode above, the teacher introduced material from two of the relating components. The observer recorded approximately seven and one-half minutes relating to science as a social historical process and two minutes of relating to science as a reasoning process. It is clear, though, that these two ways of relating science were intertwined throughout the episode. On the one hand, the teacher is presenting material from the history of science--specifically, from the history of the area which is the focus of this first topic: reproduction. At the same time, she is introducing a basic vocabulary of scientific terms concerned with the reasoning process which is used for theory generation and testing.

The teacher begins by introducing the term "spontaneous generation," as an "idea" which was held until the 19th century. She implies that this was a time of ignorance, and that people held uninformed views. The teacher appears to make a distinction in her talk between what scientists "know" in their current work, and the "ideas" that people had, "what they thought" in the past. These ideas are, she suggests, surprising to the students, immersed as they are in current scientific views, and it may at first seem that the people who held such ideas "were crazy." Yet she goes on to imply--though she does not state it explicitly--that such mistaken ideas were actually based upon observation, which she seems to be introducing as one of the characteristics of the scientific process. She calls upon the students to suggest what the basis for the idea of spontaneous generation might have been, and encourages Bradley when he replies that observation of worms coming out of meat would give rise to the naive theory that the meat was itself the source of the living matter.

When she describes Pasteur's experiments she notes that "what Pasteur worked with were microorganisms" without adding that Pasteur was postulating the existence of such organisms, precisely in order to argue that there were non-observable agents at work in fermentation and disease, thereby explaining why observations with the naked eye were inadequate and misleading. Pasteur's vitalist contemporaries found his theory ridiculous precisely because it appealed to an invisible material agency: they argued against it on grounds of parsimony. It would be misleading to maintain that Pasteur discovered microorganisms; he hypothesized their existence, and conducted his experiments in the attempt to convince others that some such entities were responsible for infection and decay.

When Teacher 1 says "it might be surprising to see what people used to think about how life could reproduce," she gives the impression that earlier theories were ungrounded ideas, matters of belief rather than scientific endeavor, and that Pasteur's contribution was one of courage as much as controlled experimentation. She could equally well have drawn out the similarities between the different views of reproduction, noting that both are based on observation; that both also involve an appeal to a non-observed entity: a vital agent, or a microscopic entity. In short, her presentation is in danger of confusing her students.

The teacher's concluding remark in her discussion of the swan-necked flask experiments is "now, isn't that an interesting way to prove Pasteur's idea." She fails here to maintain a distinction between proving a hypothesis and falsifying competing hypotheses. It is commonly accepted that there is no way to finally 'prove' a hypothesis in science; one can only disprove or falsify competing hypotheses. Pasteur's experiments ruled out the possibilty of vitalist influence in fermentation, and so lent support to the theory of the role of microorganisms. They could not 'prove' this theory, however.

The teacher also loses the distinction she seemed to be making earlier between 'ideas' and 'knowledge.' She described people's mistaken 'ideas' about reproduction; now she calls Pasteur's hypothesis an "idea" too, which might seem to imply that it also has a lower epistemological status than scientific knowledge; yet this is a point in the episode where the teacher is intent on emphasizing that the hypothesis has become accepted as truth.

One suspects that seventh grade students are new to scientific vocabulary, and so will be unable to distinguish those terms with fairly precise definitions--"hypothesis," "theory," "prove," "disprove"--from those which do not, and are being used colloquially--"idea," "think," "produce."

Despite these problems in her presentation, Teacher 1 does succeed in conveying a sense of the revolutionary nature of scientific progress, and the way that a single individual can be responsible for changes in the way phenomena are understood. She implies that progress has been rapid in biological science.

Topic 1, Day 2

The second episode occurred on the next day, and concerned the nature of science as a reasoning process. This episode took place at the very start of the period, just as the class bell rang, and the students were in their seats, quietly talking to each other. The teacher began in a way which related to the discussion of the previous day, and to the episode just discussed.

TEACHER: Okay, students, in getting started today, I want to finish some ideas of yesterday by way of review. I want to tell you about a man named Aristotle, who lived about 2,300 years ago. Now, this is an example of how people reason and look at life. He noticed that he watched ponds dry up every year and the life in them dried up. But, then next fall, when the rains came, and the ponds filled up, the life would come back. He watched this and he came to the conclusion that the life came from the mud. Now what do we call this?

STUDENTS: [No response.]

TEACHER: What name do we give this? When non-living things create living things?

STUDENTS: [Still no response. The teacher proceeds, giving them little time to think.]

TEACHER: Well it starts with "spontaneous." Do you remember spontaneous generation?

STUDENTS: [Many say, "Oh yeah."]

TEACHER: This is what we call it when non-living things produce living things. Now, I gave you an extra credit assignment and this you can turn in Monday. The assignment was to design an experiment on spontaneous generation which can be done in class. You're supposed to design a simple experiment or plan. State your problem. The problem is, can non-living materials produce life? State your hypothesis, which is your careful guess. Then write a simple experiment to prove of disprove your hypothesis. Now, I thought it would be interesting to see what you've come up with. Does anybody have their's ready for today?

DAVID: [Raises his hand.]

TEACHER: I'm glad to see that you have it. Turn it in sometime during the period today.

[The teacher now begins the next segment of the class, which will be an eleven minute recitation about an asexual reproduction handout.]

Comments. The teacher marks her entry into her brief non-explanatory relating in several ways, one after another. First she announces that she "wants to finish some ideas of yesterday by way of review." Then she names what she is about to "tell you." Third, she states that it is an "example" and then summarizes what it exemplifies: "how people reason and look at life."

Again, there is overlap in identifying this episode in terms of our categories of relating. The teacher is at the same time providing an example of the nature of scientific observation and reasoning, and an example of the history of science. The observer recorded approximately one minute of time spent on each of these categories. The episode occurs in the context of the previous day's discussion of spontaneous generation.

The teacher's intention is presumably to jog the students' memories, and to have them recall the topic of the previous days' work. She sketches a brief example of the type of reasoning which exemplifies the theory of spontaneous generation. First she states the observed association of events: "[Aristotle] noticed that. . . ponds dry up every year and the life in them dried up. But, then next fall, when the rains came, and the ponds filled up, the life would come back." She then draws the conclusion purportedly based on these observations: "the life came from the mud." However, the teacher confuses things by shifting her terminology. She uses several different terms from one statement to the next: "dried up," "rain," "filled up" and "mud." In order to follow her argument, the students must at the same time construct for themselves an additional implied set of connections. These will be something of the following form: Ponds dry up because there is no rain. When rain falls the ponds fill up with water. They are no longer dry when they are full. When they are no longer dry, mud will form.

The teacher also uses three distinct terms to describe the key relationship in the concept of spontaneous generation: that of the form of reproduction involved. She first says that life "came from" the mud. Later in the episode, she uses the phrase "non-living things create living things," and then she defines spontaneous generation as "when non-living things produce living things." These three terms--"come from," "create," and "produce"--have rather distinct connotations. To a young adolescent it probably is a familiar observation that pond animals "come from" mud. Yet this is the way the teacher states Aristotle's conlusion, which she wants to impress upon the students as being aberrant.

Perhaps more seriously, at no time in this admittedly brief episode does the teacher explicitly either affirm or deny Aristotle's conclusion--or, more broadly, spontaneous generation as a view of reproduction. Its epistemological status remains vague, and at one point her words -- "what name do we give to this; when non-living things create living things?" -- seem to imply that spontaneous generation is an actuality.

In short, Teacher 1 intends to present to her students an "example" of "how people reason and look at life" which illustrates the tenuous and deceptive quality such reasoning can take, as discussed the previous day. She wants them to recall the term used for this particular specious theory of reproduction: that living beings are spontaneously generated from inorganic matter. However, her presentation is potentially misleading in two respects. First, the terms she uses for the observations and reasoning in her example leave unclear just what is wrong with the conclusion, and also just how the conclusion was derived from the observations. Is the logic faulty? Are the observations incorrect? Or are they inadequate? Second, when she asks the students for the general term for the type of theory Aristotle's reasoning is an example of, she is inconsistent in the central term of the theory: is it "creation," "production," or "coming from"? Perhaps not surprisingly, the students appear not to recognize what she is talking about, even when she prompts them with the first part of the phrase she is seeking.

Teacher 2

Teacher 2 began the year teaching about plants, animals, and seed plants, and then moved to bacteria, protozoa, and viruses. The land and ecosystems were the next foci, and she ended the year with units on bones, muscles, the nervous system, genes and heredity. As she taught, Teacher 2 frequently departed from the text. Students sometimes worked in groups of four or five, following programmed, self-instructing lessons. Teacher 2 monitored these lessons continuously. Materials for these activities came from diverse sources. A traditional paper and pencil test concluded each topic.

Teacher 2 had no episodes of relating during her teaching of either Topic 1 or Topic 2.

Teacher 3

Each topic taught by Teacher 3 during the school year lasted for a week to ten days, and covered one chapter in the textbook. The teacher followed the text directly, with the exception of the month before the winter vacation, when science fair projects took place. Each topic began with some kind of vocabulary work, followed by handouts which students traced, labelled, and colored. These materials, completed as seatwork and homework, were turned in at the end of the topic as "journals." Practical activities were relatively rare, and there were no true laboratory assignments during either of the two observed topics. For Topic 1, which focused on sponges and coelenterates, students passed around jars of preserved specimens; for the second topic, on human systems, they recorded information on a laboratory sheet. Each topic ended with a test, preceded by a full class period of review.

There was one occasion of relating for Teacher 3 during Topic 1. One half-minute of relating to science as a social historical process was recorded on Day 3. No relating episodes occurred during Topic 2.

Topic 1, Day 3

TEACHER: Does anyone know what the word 'evolution' means? Yes?

BARRY: How something came to life?

TEACHER: Okay, evolution means change--changing from one form to another. Now scientists believe that all of these animals started as a very simple form and over many, many years they developed all these forms we have here. [He points to the animal evolution chart.] Now in the Rocky School District, we're allowed to teach that as a theory. That means that's one of the possible ways these things could have come forth. How many understand what I'm saying?

STUDENTS: [No response.]

TEACHER: Now all I care. . . I don't care whether you believe anything like that. All I want to do is show you here, you see at the bottom of this tree we have the simplest form, and they go up to the more what? Complex forms. Now, what is the simplest form on this particular tree? Roy?

ROY: Sponges.

TEACHER: Why do you say sponges?

ROY: Because they're the lowest.

TEACHER: Okay, they're the lowest. They come off on one side and then the coelenterates that we're studying, on the other side and they're a little bit higher. Then comes the flatworm. . .

ROY: Roundworm.

TEACHER: Roundworm, and then we get a whole bunch of branches and a lot of people are not sure which is the most complex. Some say the most complex of all animals is the arthropods, some say it's the echinoderms and some man, on the vertibrates. But I don't care about that particular part either. This is just a possible way these particular organisms could have come forth, and it also shows it from the simplest to the most complex. Now does everybody understand?

STUDENTS: [Six hands are raised.]

Comments. Teacher 3 seems to be trying to bring up evolutionary theory in a manner which is sensitive to the religious beliefs of the students; his school is in a region where creationism is still a widely held doctrine. Hence, his comments that "we're allowed to teach [evolution] as a theory," and "I don't care if you believe anything like that." One consequence is that he provides his students with a weak definition of what a theory is: "one of the possible ways that things [could have happened]." He also gives the students no indication of how to test a theory in order to select among competing theories, and so he misses an opportunity to introduce a key element of scientific literacy: scientific reasoning.

Teacher 4

Teacher 4 built her lessons around the text, though not in chapter sequence. She generally began each topic with a reading assignment and vocabulary words. Presentations and laboratory exercises followed. The students answered chapter review questions for homework, and a review and test ended each topic. The teacher began the school year with cell types, and then covered protists, the animal kingdom, classification of species, and ended with the human body (including heredity and evolution).

This teacher had six brief episodes of relating during Topic 1, on protists, and one episode during Topic 2, on human organs and systems. On Days 4 and 6 of Topic 1 there was one minute of relating to science as a social historical process. On four occasions, Teacher 4 related to science as a reasoning process: for one minute each on Days 1, 4 and 6, and for 2 minutes of Day 3.

Topic 1, Day 1

On Day 1, Teacher 4 engaged the class in a discussion of the kingdoms of living creatures, specifically the question of which kingdom fungi belong in. The type of reasoning process which is involved entered the discussion:

TEACHER: Scientists question, at this, I should say right now, at a period of time, questioned whether or not mushrooms and your different types of fungus should be considered plants or if there should be a totally different kingdom for them.

STUDENT: [Asks an inaudible question.]

TEACHER: Okay. It breaks down organisms that are in the soil to make your humus, true, but it does not have chlorophyl, so that it is not green, but it is considered a plant. Because it doesn't eat, and because it doesn't move around. So: a fungus, or a mushroom, is considered a plant. Yes.

STUDENT: But they're not green.

TEACHER: True, they're not green. So do they make their own food?

STUDENTS: No.

TEACHER: No they do not because they don't have chlorophyll. So because they don't have chlorophyll then that's where the question comes up. If they don't really fit into the plant kingdom, what are they? Scientists have decided, "Yes, we will put them in the plant kingdom for now." However, you will have other scientists who will disagree with you, and they will say, "Well, we can't say that they are in the plant kingdom, or they are in this other kingdom." What is this other kingdom?

STUDENTS: Protists.

TEACHER: No, you're bringing up a whole new thing we haven't talked about yet. Okay, at the beginning we said, every living thing has to be either this, or it has to be that. . .?

STUDENTS: Plants or animals.

TEACHER: If it is not a plant then we have to say that it is animal. Scientists are saying, "Well, it doesn't really fit." Some of them think that, well, it's a plant. Well, ~~up to~~ this point then, we have decided that there are only two kingdoms: plant or animal kingdoms.

Comments. Several interesting aspects of this episode are apparent. First, some relating to science as a social historical process takes place; the teacher talks of "scientists questioning" decisions about the placement of the species. Her presentation implies, correctly, that such decisions can be temporary and reversible. She then draws the students into a discussion where she elicits characteristics of plants. It seems likely she intends to direct the students' attention to the various criteria used for differentiating species and kingdoms. However, she does not make entirely clear that this is her intent, and she ends the discussion without any conclusion.

Topic 1, Day 3

The second episode for this teacher is one of relating to science as a reasoning process. It developed in response to a question from one of the students:

GEORGE: What do they do when somebody finds out more about. . . um. . . a. . . you know. . .

TEACHER: A new discovery?

GEORGE: Yeah. And you're learning about it one way, like in the books. Let's say that they discover that that's wrong.

TEACHER: You mean, like the monerans that we've been looking at today? This new fourth kingdom?

GEORGE: Yeah. What do they do? Do they just make new books?

TEACHER: That is indeed what they do. When things or ideas are outdated, like these monerans we've been talking about today--when something becomes more accepted, then new textbooks are simply printed.

Comments. In this brief exchange, the teacher does communicate the notion that new scientific discoveries call for modification of existing scientific materials. However, as the observer noted at the time, Teacher 4 passes up an opportunity to elaborate on the dynamics of scientific progress here--in particular, the type of reasoning which takes place as scientific views are formulated and reformulated. The teacher does not indicate clearly that reformulation is part of science in general or give any further examples of such a process. Also, to say that "new textbooks are simply printed" is an overly simplistic account of how new knowledge is absorbed by the scientific community and promulgated by educators.

Topic 1, Day 4

The next episode is one of relating to science as a social historical process:

TEACHER: What you might be interested in finding. . . there was a fellow by the name of von Leeuwenhoek. He's the one who discovered microorganimsms and he's the one who discovered the microscope and how to use it. He did his study with peppercorns. We have in one of the dishes up here peppercorns in some water and that's been sitting here since December. So, you might find some interesting little microorganisms in there.

A few minutes later a brief episode of science as a reasoning process occurred. The discussion was still about the observation of microorganisms:

TEACHER: There's some pond water that's been sitting here for quite a while. You'll need a liquid with that. . .

STUDENT: But won't they die?

TEACHER: Yeah, once you take them out, you're going to lose them, but don't think of it as killing them. We are sacrificing them to make a scientific study to educate you people.

Comments. In the first of these two brief segments, the teacher introduces an individual who is responsible, Teacher 4 claims, for the first observation of microorganisms and for the invention of the microscope. The application of the term "discovery" to both microorganisms and the microscope is an unfortunate one; Teacher 4 fails to make an important distinction between the manufacturing of a scientific instrument and the observation of a natural phenomenon.

In the second of the segments, the teacher alludes briefly to the difference between the wanton destruction of life-forms, and their utilization for the purposes of education and research. The brevity of her comment suggests that it may have been intended to communicate humor; the issue is nonetheless an important one.

Teacher 5

Teacher 5 devoted the end of the fall semester to cell types. Following Christmas, four weeks were spent on plants, including bacteria, followed by genetics and the heredity of plants and animals. The year ended with bones and muscles. Each topic began with students reading the appropriate chapter from their textbook, and answering the review questions. Teacher presentations and laboratory activities occupied the rest of the topic, followed by a verbal review and/or a review worksheet, and test. No homework was assigned.

There were no occasions of relating for the teacher in Topic 1. During Topic 2, three episodes occurred which we examine here. Two of these took place on Day 1: one minute of relating to science as a social historical process, followed by one minute relating science to society and technology.

Topic 2, Day 1

TEACHER: There was a man by the name of George, no Gregory Mendel. He was an Austrian monk. And he found all these traits out by working with peas, common ordinary peas, like you plant in your garden. See back there in the back, I've got my tomatoes and my cucumbers and my peppers growing. When your father or your mother or whoever plants their garden, they're going to look for the best variety. And a lot of them will go and buy hybrids and that's a cross-breed between, and that's a cross-breed between plants. We'll be learning about, snap-dragons and cows, rabbits and dogs and stuff like that.

Twenty minutes later, Teacher 5 takes ~~up this~~ theme again, this time talking about the way hybridization is used to selectively breed varieties of vegetables with desirable properties:

TEACHER: So, we'll get into it a little bit, but I don't want to get into it too deeply because, see, we're touching on genetics, which is covered in your 9th grade biology class. And see, all 7th grade is, is just to give you a general overall, and maybe it's an area you want to go into. There are a lot of geneticists in the world that make a good amount of money, by working with different crosses, with animals getting hybrids of plants that grow better for an area than some plants do. If you get a chance, next time you're at the store, you look, like tomatoes, peppers, cucumbers. Now, I'm not sure if I've still got my packages over here. Okay, here's an example. There's 55 cents it costs for this package. This is a tomato which is a hybrid tomato, which means it's been crossed with other tomatoes and they come up with a particular tomato and they call it a hybrid and it's called a beefsteak tomato. Now for example, you've got different kinds of tomatoes from different areas. You've got Moscows, grugers, or bunkers they call it. . . . They produce sooner or later than your normal tomatoes. Some people, like in our area right now. I'd rather plant a tomato right now that I know is going to bloom, ripen, bear fruit in maybe 40 or 50 days. The closest tomato I could get was this hybrid and this one produces, when you plant it, from the day you plant it, it produces in 60 days. . . . Within a month I'll have tomatoes popping before my next door neighbor will. Because I bought an earlier, healthier, more meaty tomato than anybody else on my block.

Comments. In the first segment, the teacher introduces a famous name from the history of science, in the context of his introduction of the topic on heredity. However, other than indicating that Mendel did some work on traits, he provides no indication of Mendel's importance or the nature of his research. His remarks might be taken to suggest that Mendel was merely a practitioner of plant husbandry! Teacher 5 then implicitly ties scientific terms--"hybrid," "cross-breed," "traits"--to everyday terms which he links to the students' experience--"variety," "plants."

In the second segment, the teacher touches on the fact that there are geneticists employed to cross-breed animals and plants, and that cross-breeding is often done to take advantage of particular characteristics that may be advantageous for different environmental conditions. Unfortunately, these ideas are presented in a confused and inarticulate manner, combined with irrelevant comments. Teacher 5 characteristically drifts from one item to another when lecturing his students, in a 'stream of consciousness' manner. The likely consequence here is that students remain uncertain just what the relationship is between basic genetic research and its practical implementation.

Topic 2, Day 9

The teacher leaves the classroom while the students are working on a series of questions on genetics. He re-enters the room dressed in a brown monk's robe, the hood over his head.

TEACHER: Hey, what do you guys think?

STUDENTS: [They moan and groan.] Oh, come on, [Teacher 5].

TEACHER: Well, that's what Gregory [sic] looked like. I had to borrow my outfit from last year that I had. I stored it away and I couldn't find it, so I had to go to my skeleton closet. Gregory Mendel was an Austrian monk. Remember, I told you that.

STUDENT: Mendel wore glasses?

TEACHER: Well in those days they wore monocles, and I couldn't find my monocle.

STUDENT: Why are you dressed up like that?

TEACHER: I found this outfit just for you guys and I'm going to wear it all period, and it's hot!

<u>Comments</u>. The teacher again seems to be attempting to introduce Gregor Mendel as a significant figure in the science of genetics. However, his manner of presentation, although intended to be entertaining, distracts the students from the work he had assigned them. Their groans and comments suggest that they are familiar with his style -- and unappreciative of it. The teacher would appear to be creating a situation where he can "bring history to life" by play-acting some of Mendel's activities and ideas. In fact this never occurs, and instead the period continues with ribald joking and many distractions. At one point Teacher 5 refers to Mendel as an Australian monk, and he consistently uses the name Gregory. Teacher 5 also calls in a teacher from a neighboring class and talks with him in pidgin German. Finally, he introduces a review of a worksheet the students had completed. The observer noted that until the review began, most the period had been down-time, filled with interruptions.

Teacher 6

Teacher 6's instruction was built around the textbook. He had his students read a chapter from the text, outline it, and then answer the questions at the end of the chapter. Lecturing was restricted only to the provision of supplementary information. Labs were used occasionally to illustrate a specific idea.

Topic 1 concerned bacteria and viruses; Topic 2 concerned birds and mammals. During both topics the only recorded episode of relating by this teacher was of one minute duration, on Day 1 of Topic 1.

Teacher 7

Teacher 7 built most of his lessons around verbal presentations and laboratory activities, using the textbook only as a minor resource. Students kept track of their activities in a folder which they turned in for grades at the end of each topic. Quizzes and tests were relatively infrequent, with a unit test given only every 3-4 weeks for objective grading. Homework was not used.

In the first topic, on ecology, this teacher related to science as a reasoning process for one minute on Day 8. During Topic 2, on genetics, there was a single episode of relating on Day 4.

Topic 2, Day 4

The teacher introduces a lab on mitosis. Although he spends the majority of time explaining content, he remarks on the difficulty of science as a reasoning process, alluding to discovery not by direct observation but by interpreting reactions:

TEACHER: Page 514 talks about some of the things they found are on these chromosomes that you saw. Now remember you saw them magnified 400 times. They have been able to identify on those chromosomes what the genes are made of. Now stop and think about the work that was involved. In fact, the Nobel Prize was given to Watson and Crick, the two men who discovered what the gene was made of. And it took years of experimenting with these things. Most of it by seeing reactions and seeing what happens, and trying to put it together, rather than actually seeing the gene. Because they knew what a gene was made of long before they could see what the gene looked like. Through experimentation. The gene is so small it's very difficult to see. If you took one of those little strands that you saw, each little strand may contain thousands of genes, just a section of that. You've just seen that they were doubled. They're just very, very small and hard to see. And so you had a hard time, as you think about this, you find out that someone had to put a lot of time and study into figuring out what genes are made of.

<u>Comments</u>. Certain characteristics of the reasoning processes characteristic of scientific investigation are touched on here -- most notably the idea that inference based on the results of experimentation enables researchers to go beyond the limits of simple observation, particularly what is apparent to the naked eye. It's not certain, however, that Teacher 7 gets this across when she makes a distinction between what a gene is "made of" and what it "looks like," particularly since a central point of this episode is that the gene can't be seen.

Teacher 8

Over the course of the year, Teacher 8 taught the following topics: an introduction to science, the cell, an overview of the plant kingdom, plant physiology, an overview of the animal kingdom, human body systems, and family life education. Each topic followed a similar routine, beginning with an introductory presentation and discussion of new vocabulary words. Lectures and note-taking followed, and then a laboratory exercise, structured through the use of lab worksheets which detailed the procedure, and on which students recorded their observations and conclusions. This cycle of events was sometimes repeated several times during the course of a single topic, as was the case with each of the two topics observed.

There were no occasions of relating for this teacher in Topic 1, which concerned protists. In Topic 2, on the human digestive system, there was a single episode of one minute for relating science to society and technology.

Topic 2, Day 3

TEACHER: Okay, I just want to mention one thing about the esophagus before we go on. Every year a lot of people die because they choke on food. There seems to be two sets of people in the population that seem to be most vulnerable. One is young children, very little toddlers. They can choke. One reason is perhaps they don't chew their food as well as they should, and they're always very active. The other are adults, and it happens especially when they're talking and eating at the same time, and it also happens when they've been drinking too much alcohol because alcohol is a depressant and that causes that little reflex action to slow down.

He goes on to talk about the Heimlich maneuver:

TEACHER: We don't have a first aid class at this school. We should and we've talked about it, but everybody, everybody in the world should know what to do in an emergency for people who are choking because it's fairly simple. Now two years ago I took a class at General Hospital on CPR which involved a little session on choking, and everybody should try to take something like that.

Comments. In this episode Teacher 8 relates an item of the curriculum to a practical aspect of their world which is likely to be familiar to students, by report if not direct experience: choking on food. The anatomy of the digestive and respiratory tract is then related to a first aid technique which Teacher 8 encourages the students to learn. Somewhat surprisingly, he doesn't make any effort to teach the maneuver himself, even though he describes it as simple and recommends that everyone learn it.

Teacher 9

Teacher 9 started the year with a topic on chemistry, since he believes that this is the basis for an understanding of life science. He then taught a series of topics on the human body, in alternation with topics on plants and plant evolution. Zoology and animal evolution ended the year, with an inserted topic on the circulatory system. Teacher 9 felt that inserting topics on the human systems helped to break monotony and maintain student interest.

Each topic began with a series of lectures, and then progressed to various lab activities which were selected to illustrate the topics discussed. Lab write-ups were seldom required, though lab sheets were checked and graded four times a year. A test ended each topic.

Teacher 9 related science and society for two minutes on the first day of Topic 1, on cell structure and function, and related to science as a social historical process for one minute on the fourth day of Topic 2, on the human circulatory system. Here, we present the latter episode.

Topic 2, Day 4

TEACHER: In early 1900, even in 1920, they didn't know. Hey, we're talking about 60 years ago. Hey, we're really kind of young when it comes to knowledge. People get transfusions--this person could get into an automobile accident, and this other person would offer to give him blood and they would put him on the operating table. They'd put them next to each other like that. And the one that needed the blood dies, and they couldn't understand it. And they did it to someone else and they lived. They couldn't understand why until they finally got down to finding out about the protein that was in the blood, and that's where your blood typing came in. Then they found out, just like I said, AB can receive from anybody but can only give to itself because you can't give AB to O.

Comments. Teacher 9 draws attention here to the rapid pace of increased understanding in the biological sciences. He notes the comparative youth of the biological sciences. He also tacitly notes the way that research can be motivated by problems which develop in the course of practical endeavors; in this case, the need to give blood to accident victims. However, his description of the logic behind the discovery of blood types is short and muddy.

Teacher 10

Teacher 10 relied on lecture presentations and notetaking in most of his classes. Textbooks were used as a resource for some topics, but not all. Labs or demonstrations were usually employed to illustrate the topic of discussion. Each topic typically ended with a test.

This teacher had three episodes of relating in the first topic, concerning cell division and genetics, but none in the second, which concerned the human circulatory and skeletal systems.

Topic 1, Day 5

The teacher was discussing with the class their answers to a set of questions they had worked on after reading an article on the work of the biogeneticist Barbara McClintock.

TEACHER: Okay, first of all, does somebody want to volunteer an answer for number one? Who is Barbara McClintock?

MACK: She is an 81-year-old scientist.

TEACHER: Okay, can you make that a little more complete by telling me what she studies?

MACK: She studies genes.

TEACHER: Good. And is she doing that work right now? Has she been doing it awhile or. . .?

MACK: Two decades.

TEACHER: It's actually four decades. Yeah, the discoveries she's getting credit for she actually made some time ago, but now they're starting to understand the importance of her discoveries. Okay. Number two. What did she discover?

SUSAN: She discovered that the genes in corn don't stay in one place.

TEACHER: Okay, right. She discovered that genes, particularly in corn, which she was studying, don't stay in one place. We've described genes when we've talked about them in here as little particles that are lined up in a certain order on a chromosome, but according to her, some genes can move, right, can move from one place to another on the chromosome. That's what she discovered.

The discussion turns to the importance this work may have for an understanding of cancer:

TEACHER: What they think may be possible is that maybe because genes are capable of moving, according to Barbara McClintock, that this may be one method that cancer gets started in the normal cells.

DOREEN: What starts the gene jumping?

TEACHER: I don't know: maybe some genes do, maybe some don't, but scientists used to think that genes stayed all in the same place, and what she's shown is that that may not be true.

Comments. The teacher communicates to the students the notion that individuals can be responsible for scientific discovery. His emphasis on the length of time Barbara McClintock has been working may suggest to the students both that scientific researchers make personal committments of time and energy, and that rewards and the recognition of the peers are not immediately forthcoming. The nature of a "discovery" is not fully or explicitly developed, however, in terms either of the nature of the research program which leads to it, or how it relates to the body of received opinion it presumably conflicts with.

The teacher talks of the "findings according to [McClintock]," suggesting the personal nature of scientific discovery, but his words are also open to the interpretation that scientific theory is simply a matter of personal opinion, and the students may have been misled here. The link which Teacher 10 suggests may hold between 'jumping genes' and cancer is also not elaborated; tacit here is a complex story involving gene expression, mutation, cell metabolics and cell division.

Teacher 11

This teacher began the school year teaching a topic on human body systems, and then moved on to ecology and the environment. She began the next semester with a discussion of plants and animals, tracing their evolutionary progression from simple to complex forms. The year ended with several weeks of drug and sex education, as mandated by the State of California.

Teacher 11's two episodes of relating to science as a reasoning process occurred during Topic 1, which concerned ecology. Both episodes focused on the conversion of scientific units. The first concerns conversion from degrees Fahrenheit to Celcius; the second from centimeters to inches.

Topic 1, Day 2

TEACHER: Eight hundred centimeters sounds like 800 inches, but it's actually about 300 inches of rain. [She goes on to explain that the easiest way to change centimeters to inches is to divide by two and a half.] It's 2.5 centimeters per inch. I was showing people in the last period. There was one area, I think it was the desert, that gets 25 centimeters. It gets 25 centimeters of rain a year, so you take 25 centimeters and divide by 2.5. You find that 25 centimeters of rain is really 10 inches. You can do the same thing with 800 centimeters. [She carries out this calculation on the chalkboard, and demonstrates that the answer is close ~~to~~ 300 inches.] Okay, that's the way you do it. That's as far as we're going to go today. We're going to spend the rest of our time writing down facts.

Topic 1, Day 3

TEACHER: So if you look at the two thermometers, you'll find that zero on the Celsius side is the same as 32 on the other side. Your book says that if you lived up in the northern part of the eastern United States, where Pennsylvania, New York, that area is, that the highest temperature in the summer is 20 degrees Celsius, which sounds kind of cold if you're talking about 20 degrees, but if you find 20 degrees Celsius on the thermometer and look across from it, it's pretty close to 70. So they're saying the average temperature is 70. So by looking across, you can get the relationship between one kind of degree and the other.

The teacher passes the thermometer around the class.

STEVE: I want to ask you something. Okay, on these the numbers are here and here, right? [He points to the two scales.] How come there's numbers on both sides and they're not the same?

TEACHER: Because one side is Fahrenheit and the other is Celsius. There's two different ways you can read thermometers.

STEVE: What's the difference?

TEACHER: Celsius has freezing at zero degrees. It's a more scientific way. . .

STEVE: [Interrupting] It's 75 degrees right now?

TEACHER: If you're holding on to it, it's probably going to get warmer too because of your body heat. Celsius is the more scientific way that scientists use. Fahrenheit is the way you've been used to. When everyone talks degrees, when the weatherman talks degrees, he obviously means Fahrenheit. When you start talking science, you're going to get into Celsius, so to make a correlation, to try to make a little sense to you, a thermometer will show both.

DREW: Which started first, Celsius or Fahrenheit?

TEACHER: Well, if you look it up in the encyclopedia, you'll find there was a man named Fahrenheit, and they named it after him. Celsius, I don't know.

Comments. In these two episodes, the teacher conveys the impression that there are "real" or "obvious" systems of measurement -- inches and degrees Fahrenheit -- with each of which she contrasts a "scientific" system -- centimeters and degrees Celsius. While it is true that the MKS (Meter-Kilogram-Second) system of scientific measurement employs centimeters and degrees Celsius, this is hardly because these are more "scientific" ways of measuring. Furthermore, many countries, including most of Europe, employ the metric system as their everyday, "obvious" system. What is notably absent in this episode is any implication or statement by the teacher that the two measurement systems are equally valid, but perhaps differ in their comprehensibility or ease of use. As a consequence, the arbitrary or conventional character of systems of measurement, which itself is a central component of scientific reasoning, is not presented to the students. On the contrary, they are being led to think that some systems are more "real" than others.

Conclusion

The initial results of this portion of the study indicate that the participating life science teachers generally use a typical pattern of academic modes of instruction, relying heavily on recitation, seatwork, and laboratory exercises. When teachers present academic information to the entire class, largely through recitation, they rarely, if ever, make explicit reference to the historical, reasoning, social, or attitudinal implications of the subject matter. Given this finding, several questions seem of particular interest for further analyses. First, it will be interesting to determine whether or not students' curriculum use and actual work assignments also reflect a lack of emphasis on the relating components of scientific literacy. Second, given a very low incidence of using relating components, it will be interesting to see whether even a minimal use of these components accounts for any differences in student outcomes among teachers.

In terms of our interpretive account of the quality of the relating episodes, it is possible to draw a composite summary picture of the way the teachers we studied presented these components of science to their students.

Science as a Social Historical Process

Several teachers emphasized that our scientific understanding of events has changed over the years. Since the topics concerned biological science, teachers were able to remark appropriately that change in understanding and practice have been rapid.

There was also a focus on the contributions that individuals make to scientific invention and discovery. Indeed, it may be the case that the role of individual scientists, and of their sudden insights and discoveries, was overemphasized, and the contribution of patient, organized teams of researchers given insufficient attention. The reason for this emphasis appeared to be two-fold. First, teachers used the rhetorical device of personalizing and individualizing research and discovery. The most extreme example of this was Teacher 5's dressing up as Gregor Mendel. Second, teachers seemed to subscribe to a 'great person' approach to the history of science; naming Aristotle, Pasteur, Watson, Crick, McClintock as milestones of progress.

Perhaps because of this focus on the role of individuals in scientific historical change, the teachers generally did not convey any sense that there are scientific paradigms, and that science advances through resynthesis and new discoveries, and through the work of scientific collectives as well as individuals.

There was also a simple sense of unalloyed scientific <u>progress</u>, as though older conceptions of the world--or, more specifically, of reproduction--were simply in error, and that nothing had been lost by their abandonment. A key component of the scientific enterprise is that its practitioners scrutinize their findings and theories and argue their superiority over competing or older positions. Yet the superiority of contemporary scientific accounts was simply <u>assumed</u> by the teachers, and no explicit arguments were given, or criteria presented, for concluding that scientific inquiry inevitably leads to truth and practical benefits. The way these teachers' tacitly justified what they taught was usually by appeal to authority, rather than to logical and rational evaluation.

Science as a Reasoning Process

There is controversy among philosophers and historians of science over the precise nature of scientific reasoning: is it a hypothetico-deductive process of attempted falsification (e.g., Popper, 1963); or is it, rather, inductive and creative (e.g., Kuhn, 1962); or is there no one method, but a variety of approaches, all equally valid (e.g., Feyerabend, 1978; Lakatos and Musgrave, 1970). In general, there has been a shift from an empiricist philosophy of science, which saw scientists simply describing and recording a reality independent of their efforts, to a constructive philosophy of science, which sees data as structured by prior theorizing.

The teachers' episodes of relating science as a reasoning process reflect this controversy. They seemed unsure whether experiments were intended to prove theories, falsify them, or merely provide support for them. Are major scientific innovations --such as the "jumping gene"--inventions or discoveries? What are the differences among hypotheses, theories and ideas? And, what of differences among observations, descriptions and concepts?

These issues are complex ones, and are likely beyond the grasp of the typical seventh-grade science student. Nonetheless, it seems unlikely that these students are acquiring even a fundamental grasp of the scientific process which would enable them to move to a greater sophistication of understanding in later grades.

Science and Society/Technology

Most of the teachers' episodes of relating this aspect of science were brief, and concerned either with the appearance of the topic under discussion in the students' own experience, or with the positive benefits that science had made in the broader society. There was little, if any, discussion of contemporary controversial matters, such as recombinant DNA research, the reduction in gene variation due to selection of single stocks for cultivation, the impact of technology upon the environment, and so forth. Again, these issues are complex, but they are not beyond the understanding of seventh graders, or without interest to them, if presented correctly.

CHAPTER FOUR

ACADEMIC TASKS ASSIGNED TO STUDENTS

This chapter discusses academic tasks used in this sample of seventh grade life science classes. The discussion focuses on the intrinsic character of tasks (e.g., cognitive demands, scientific orientation), and how they are applied in the classroom. As Doyle (1983) notes, the demands inherant in tasks play a significant role in directing students' attention to particular aspects of science content, as well as in specifying the level at which students should process that information. In addition, academic tasks are the cornerstone of teachers' accountability systems and clearly shape the learning environments students actually experience.

This overview of academic tasks consists of five major sections: (a) Task Types and Their Usage; (b) Task Demands (problem level and mode of response); (c) Orientation to Scientific Literacy; (d) Task System Congruence; and (e) Accountability Systems.

The data were compiled primarily from instruments included in the Curriculum Content Analysis packet: Laboratory Activity Levels, Orientations and Levels of Worksheets, and Orientations and Levels of Tests and Quizzes. Observers completed these questionnaires in conjunction with each lab, worksheet, and exam that was assigned during the observed topics so that basic descriptive information could be obtained about each task. Additional information was drawn from the Narrative Records, Science Class Descriptions, and the actual curriculum materials collected from the teachers. (See Appendix A for a complete description of the measures.)

Task Types and Their Usage

The majority of the academic activities observed during the course of this study can be subsumed under one of three general categories: Laboratory Activities, Worksheets, and Exams (Tests/Quizzes). Excluding optional or extra-credit assignments, 128 labs, worksheets and exams were analyzed across all eleven teachers and both observation periods. A brief definition of each of these task types is necessary before beginning a discussion of the data.

Laboratory assignments are typically in-class, group activities which allow students to actively participate in the learning of science content (e.g., view slides through a microscope, test for caloric content of food, etc.). A range of theoretical and empirical aspects of science can be emphasized, including (a) scientific techniques or procedures (Methodological); (b) the discovery of relationships or events (Observational/Exploratory);

or (c) the testing of specific questions or hypotheses (Fact Gathering and Hypothesis Testing). Assignments, such as worksheets, drawings or lab manuals, are often completed in conjunction with lab activities. A certain level of knowledge about procedures and content is sometimes a prerequisite.

Written assignments or worksheets not used in conjunction with labs are likely to comprise the bulk of tasks assigned to students. In comparison with laboratory activities, worksheets are more conducive to completion outside the classroom (i.e., homework), to coverage of review as well as new material, and to non-interactive (solitary) seatwork. Like labs, however, worksheets potentially focus on a range of aspects of science content and theory and can require various modes of response (e.g., labeling, short answer, drawing, essay, etc).

Lastly, exams are important indicators of the learning demands placed on students. They are likely to be conducted in-class and to require that each student tap only his/her own knowledge of the topic (i.e. "closed-book" or non-interactive). Traditionally, exams are administered for final assessment purposes after all pertinent topic content has been covered. However, they can also provide feedback on a student's progress as well as guide studying during the topic.

Table 4.1 presents the percentage of each task type (labs, worksheets and exams) assigned by each teacher during the two observation periods.

For Topic 1, seven of the eleven teachers (63%) included tasks of all three types in their curriculum plan. As expected, worksheets comprised the greatest proportion of assignments overall (44.3%), yet two teachers did not assign any worksheets (7 and 9). Labs were used next most frequently on the average (33.3%), assigned by 9 of the 11 teachers. The slight preference for worksheet assignments is also seen in the fact that 6 of the 11 teachers chose worksheets as their most frequent activity type, whereas three teachers (5, 7, and 9) used labs more often than worksheets.

Although exams were the least frequent of the task types during Topic 1, all teachers administered at least one final or "end of topic" exam to assess students' overall mastery of the topic content. Only one teacher (Teacher 4) gave a quiz during the topic (Day 4 of 8). (This task consisted of ten short answer questions and took 10-18 minutes of in-class time). Note that the end of topic exam used by Teacher 5 was identical to the worksheet assigned as homework four days earlier.

Turning to Topic 2, slightly fewer teachers (45.5%) included all three task types in their class's work system. In fact, one teacher (who had used labs, worksheets and exams with equal frequency - 1 each - during Topic 1) did not require any tasks for Topic 2 (Teacher 6). Again, worksheets were used with the greatest average frequency (50.7%) and were the preferred task

Table 4.1. Overview of Task Types: Percentage of Labs, Worksheets, and Exams Assigned*

	TOPIC 1			TOPIC 2		
Tchr.	Labs	Worksheets	Exams	Labs	Worksheets	Exams
1	23.6	57.1	14.3	15.0	70.0	15.0**
2	15.0	70.0	15.0	12.5	68.7	18.7**
3	0.0	80.0	20.0	10.0	60.0	30.0
4	28.5	43.0	28.5	0.0	66.7	33.3*
5	50.0	25.0	25.0***	0.0	50.0	50.0
6	33.3	33.3	33.3	--	--	--
7	75.0	0.0	25.0	50.0	25.0	25.0
8	33.3	33.3	33.3	75.0	0.0	25.0
9	86.0	0.0	14.0	0.0	50.0	50.0
[illegible]	20.0	60.0	20.0	0.0	57.0	43.0
11	0.0	80.0	20.0	20.0	60.0	20.0
M	33.3	44.3	22.4	18.3	50.7	31.0

*All extra-credit or optional assignments have been excluded.
**Final test identical to pretest.
***Final test identical to worksheet.

type for eight teachers. Laboratory activities were assigned much less often during Topic 2, and only two teachers (7 and 8) preferred them to worksheet assignments.

The overall frequency of exams was slightly higher during Topic 2 (31%) than Topic 1. Except for Teacher 6 (who did not make any assignments that were collected), all teachers required that students take an exam at the end of the topic, and Teachers 1, 2, and 3 assigned quizzes during the topic. As noted in Table 4.1, however, on two occasions, these assignments were "pre-tests" identical in content and format to the end of the topic exam. Each was given on the first day of the topic and were either "not graded" or evaluated on a "completed/not-completed" basis. (See Accountability Systems for more information on teachers' evaluative criteria.)

For both topics then, exams were likely to be used as final assessments. Teachers relied primarily on worksheet assignments, supplemented frequently by labs, especially during Topic 1. This preference may be attributable to pragmatic factors (e.g., laboratory assignments require more set-up time and materials than worksheets). Alternatively (or perhaps additionally), worksheets are more generally applicable to a range of content areas, they need not require in-class time, and they can serve to introduce as well as review topic content. Tables 4.2 and 4.3 explore these latter possibilities.

Table 4.2 presents an overview of task types by five major topic content areas: Protists or Bacteria and Viruses; Human or Animal Systems; Genetics and/or Cell Structure; Ecology; and Sponges and Coelenterates or Birds and Mammals. The average percentage of labs, worksheets and exams assigned is shown for the number of teachers covering each content area.

The proportion of exams remained fairly constant across topic, ranging from 18-28% (average = 22%); however, the frequency of labs and worksheets appeared to be sensitive to shifts in topic content. For example, when the topic concerned Cell Structure or Genetics, laboratory assignments comprised almost half of the tasks (42.3%). They were assigned much less frequently on the average for the other topics (16.2%) and not at all for topics concerning Sponges and Coelenterates or Birds and Mammals. Even though worksheets were used during every topic area, the average percentage varied from 38% with Genetics and Cell Structure to 80% with Sponges & Coelenterates or Birds & Mammals.

Table 4.3 outlines the use and coverage of worksheets for Topics 1 and 2. In general, worksheets were completed during class time, although students were sometimes encouraged to take home an assignment if they needed extra time to complete it. Rarely, however, were worksheets intended specifically as homework, as only two teachers in Topic 1 and three in Topic 2 did so for even a portion of their exercises. In addition, only 22% of the worksheet assignments allowed students to interact with

Table 4.2. Overview of Task Types by Topic Content Area: Percentage of Labs, Worksheets, and Exams Assigned

Topic	No. of Tchs*	Labs	Worksheets	Exams
Protists, Bacteria, and Viruses	6	29.0	45.2	25.8
Human or Animal Systems	6	13.9	58.1	28.0
Genetics and/or Cell Structure	5	42.3	38.5	19.2
Ecology	3	22.7	59.1	18.2
Sponges and Coelenterates; Birds and Mammals	2	0.0	80.0	20.0
Total	22			

*Refers to the number of teachers covering that content area of the 22 possible topics (11 teachers x 2 topics).

Table 4.3. Percentage of Worksheets by Classroom Use and Coverage

	TOPIC 1					TOPIC 2				
	Use			Coverage		Use			Coverage	
Tchr.	In-Class Only	In-Class/Take Home	Home-Work Only	New	Review	In-Class Only	In-Class/Take Home	Home-Work Only	New	Review
1	80		20	80	20	78		22	89	11
2	100			83	17	100			83	17
3	75	25		100			100		100	
4		67	33	67	33		100		50	50
5		100		100			100		100	
6	100			100						
7							100		100	
8	100			100						
9								100	100	
10	67		33		100	75		25	100	
11	100			50	50	100			67	33

others while completing them. In contrast, labs required microscopes or other classroom equipment and encouraged students to discuss the assignment with their classmates. Of the 31 labs in this sample, 28 or 90.3% fit this pattern. Therefore, both types of tasks were used primarily as in-class activities, even though worksheets are inherently more "mobile" than laboratory tasks. It appears that teachers distinguished between these two activities by reserving worksheets for seatwork and labs for those times when interactive activities were desired.

As seen in the Coverage column of Table 4.3, worksheets served primarily to introduce new material to the students (e.g., answer questions while reading text chapter). However, five teachers utilized some portion of their worksheets to review vocabulary or topic content prior to the exam, and Teacher 10 did so exclusively for Topic 1. Four teachers (1, 2, 4, and 11) devoted an average of 28% of their worksheets to review material for both Topic 1 and Topic 2. Labs, in contrast, generally required prerequisite knowledge of content and were thus more frequently intended as review or reinforcement of content already introduced in the text, classroom presentations, or worksheets.

Summary

Based on this brief overview, it appears that worksheets are the preferred academic assignments for these science classes. Their proportion of the total task system varied with subject matter to some extent, yet teachers consistently relied upon worksheet assignments for a wide range of topic contents. The use of laboratory activities was more sensitive to shifts in topic as teachers were more likely to assign labs during topics emphasizing microscope work, such as Cell Structure or Protists, Bacteria, and Viruses.

An examination of the function of laboratory assignments and worksheets revealed that both types of tasks were used primarily as in-class activities. Teachers rarely took advantage of the mobility of worksheets, infrequently assigning them specifically as homework. Labs generally involved group interaction, whereas teachers encouraged students to work individually when completing worksheets. In addition, compared to labs, worksheets were more likely to introduce material at the beginning of a topic or prior to participation in a group activity.

Lastly, all teachers (except Teacher 6 in Topic 2) assigned an end of topic exam to assess how well students mastered the material covered throughout the topic. Few task systems involved quizzes during the topic which might have provided supplemental information on performance. On two occasions pretests were assigned, yet the students did not receive explicit feedback about their performance.

Task Demands

We now turn to a discussion of academic tasks and the demands they place on students' information processing and reasoning capacities. Two general task characteristics are of interest: Problem Level and Mode of Response. Together, these determine the cognitive operations students must invoke to achieve the required end-products or goals specified by the labs, worksheets and exams assigned in these life science classes.

Problem Level

The problem level of a task is defined by what a student must do in order to be ready to complete it. Using Doyle's (1983) metaphor, problem level can be viewed as the "gap" between an initial state (e.g., beginning of task) and the desired end state (e.g., task completion). The extent of this gap (problem level) is determined by the interaction of two factors: (1) the cognitive operations intrinsic to the task itself (e.g., executive level decision-making vs. memorization), and (2) the availability and structure of resources students tap to perform those operations (e.g., teachers, text materials, other students, etc).

Laboratory Activities. As mentioned above, labs can emphasize a range of theoretical and empirical aspects of a particular topic which can be viewed to pose different cognitive requirements for the student. This range can be broken into three general categories: Methodological; Observational/Exploratory; and Fact Gathering and Hypothesis Testing. Among this sample, however, there was little variation in the type of lab assignments. Of the 31 labs observed, 30 or 96.7% were characterized as observational or exploratory (e.g., observing prepared slides of protists and drawing pictures; using a key to identify soil types). These required students to apply an observational approach in discovering relationships or events and rarely involved higher-order skills, such as the systematic manipulation of variables. The remaining lab exercise (Teacher 7, Topic 2) was methodological and focused on the systematic procedure applied when tracing genetic relationships. Four lab activities, used by Teachers 1, 2, 4, and 8 in Topic 1, provided students with the opportunity to prepare the materials for as well as participate in observations (e.g., make own slide from cultures); however, the procedural or methodological aspects of these activities were not the primary emphases. None of the labs required students to apply high-level skills, such as gathering observational data under a variety of conditions or deductively reasoning about hypotheses.

The demands of a laboratory activity are also determined by the availability of information from materials presented to the students. As conceptualized by Herron (1971), the cognitive complexity of laboratory assignments varies as a function of whether the problem, the method for solving that problem, and the solution to that problem can be derived directly from information provided for the student ("given"), or whether the student must rely on his/her own decision-making skills, ingenuity, cognitive abilities, etc. ("open"). Four levels of problem difficulty ranging from total specification of all components (Level 0) to complete discovery (Level 3) are outlined below.

		Problem	Method	Solution
Problem Level	0	Given	Given	Given
	1	Given	Given	Open
	2	Given	Open	Open
	3	Open	Open	Open

Table 4.4 presents the percentage of laboratory exercises for each teacher at each of these problem levels for the two observation periods. In general, labs required very little discovery on the part of the student, as virtually all of the assignments (30 of 31 or 96.7%) were categorized as either Level 0 or 1.

In Topic 1, 33.3% of the assignments were Level 0, and provided a statement of the problem, the means to solve it, and the answers needed to complete the assignment. For example, as an introduction to Topic 1 on protists, Teacher 2 required students to locate protozoa on prepared slides, identify structures, and label those structures on a worksheet. The students were given step-by-step instructions on what [illegible] look for and how to perform those observations. In addition, a completed worksheet with the target structures labeled appropriately was provided by the teacher. The solution to the problem (i.e. completion of the worksheet) simply required that students copy the answers from the model -- actual observations of the slides were not necessary. Furthermore, this assignment was not graded according to the accuracy of the answers, but simply whether or not it was completed and turned in to the teacher.

The majority of labs assigned during Topic 1 (55.6%) allowed students to develop their own answers; yet, explicit step-by-step instructions were provided on how to do so (Level 1). For example, students observed and recorded the number of times a fish opened its gills in warm and cold water (Teacher 7) or drew and colored pictures of protists after observing slides (Teacher 5). In these type of lab assignments, the variability in performance across student is rarely a function of the individual students' abilities, but rather of the lab materials themselves (i.e. which fish was chosen or which slides were used).

Table 4.4. Percentage of Laboratory Assignments by Problem Level

	TOPIC 1 Problem Level				TOPIC 2 Problem Level			
Teacher	0	1	2	3	0	1	2	3
1	100				100			
2	50	50			100			
3						100		
4	50	50						
5		100						
6	100							
7		100			100			
8				100	100			
9		100						
10		100						
11						100		

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For Topic 2, Level 0 activities were much more frequent than in Topic 1 (66.7%) and only 33.3% of the labs were Level 1 (Teachers 3 and 11). Thus, while one might have anticipated that teachers would have assigned increasingly challenging laboratory work as the year progressed given that students are presumably more familiar with laboratory procedures, the contrary appears to have occurred.

As can be noted in Table 4.4, no lab in either topic presented a problem, leaving the discovery of a solution and the means to reach that solution to the student's own productive problem solving skills (Level 2). On one occasion, a teacher assigned a Level 3 lab (complete discovery) during a Topic 1 unit on protists (Teacher 8). In this case, the materials simply instructed students to identify five species of protists. The students prepared their own microscope slides from solutions and recorded the shape and movement patterns of the protozoa they observed. By discovering the helpfulness of various resources, such as text, teacher, peers, and their own knowledge of protozoa gained from the worksheet completed on the previous day, the students were successful at identifying each specimen and answering worksheet questions based on those observations.

Worksheets. For worksheets, as for labs, problem level is a reflection of the direct availability of information (from a variety of resources) needed to complete the task. As outlined by Pearson & Johnson (1978), three categories that reflect varying cognitive requirements of worksheet items can be defined as follows: (1) Textually Explicit (Level 1) -- the item simply requires that students pull information directly (i.e. verbatim) from available resources, such as text, notes copied from board, etc.; (2) Textually Implicit (Level 2) -- the item requires an answer that is implicit in the information given to the student (e.g., text, classnotes, etc.) and thus can be derived by inference; and (3) Scriptually Implicit (Level 3) -- the item requires that the student go beyond the information given to tap prior knowledge, general reasoning skills, or other resources.

Table 4.5 presents the percentage of each teacher's worksheet task items in these problem level categories for the two observation periods. For Topic 1, an average of 95.2% of the worksheet task items used were textually explicit. For each of these, students could simply transfer the answers directly from the resource materials to the worksheet. Level 2 questions comprised an average of 4.1% of worksheet items and a mere 0.8% of the task items required that students draw upon their own experiences or higher-level cognitive skills (Level 3).

For Topic 2, the average percentage of higher-level items increased to 22.8% and 2.3% for Levels 2 and 3, respectively. Yet low-level, textually explicit items requiring rote processing (e.g., spelling, defining or labeling) were again clearly the most typical (74.9%). (A large portion of the Level 2 items were Punnett squares which required students to apply an algorithm used for determining the genetic relationship between themselves

Table 4.5. Percentage of Worksheet Task Items by Problem Level

	TOPIC 1			TOPIC 2		
	Problem Level			Problem Level		
Teacher	1	2	3	1	2	3
1	96.2	3.8		42.5	56.0	1.5
2	93.7	6.8		86.3	4.1	9.6
3	100.0			80.4	9.8	9.8
4	94.7	3.5	1.8	59.2	40.7	
5	100.0			17.4	82.6	
6	100.0					
7				100.0		
8	100.0					
9				100.0		
10	78.2	20.0	1.8	96.3	3.7	
11	93.6	2.6	3.8	91.7	8.3	

and their family members.)

Not only did high-level (Level 3) task items appear infrequently when they were used, but only three teachers in Topic 1 (4, 10 and 11) and Topic 2 (1, 2 and 3) included any Level 3 items at all. As an example of these exceptions, several questions on a worksheet assigned by Teacher 3 (Topic 2) asked students to describe which muscles allowed the body to perform activities, such as combing hair or disco dancing. To complete these tasks, students needed to master the text material regarding the basic muscle functions, as well as reason how those functions could be translated into an everyday, yet complex, series of movements. Another example is the amazingly straightforward Level 3 question (used by Teacher 1 on a worksheet about ecology) which asked students to suggest ways they could personally conserve energy and other natural resources.

Exams. Using the categories of Textually Explicit (Level 1), Textually Implicit (Level 2), and Scriptually Implicit (Level 3) described above, Table 4.6 outlines the percentage of exam items in each problem level for the two observation periods. Note that the preponderance of Level 1 items was even more overwhelming for exams than for worksheets. For Topic 1, an average of 97.9% of the quiz items were Textually Explicit (Level 1), with that average percentage dropping slightly to 91.7% for Topic 2. Only 5 of the 11 teachers included any questions other than those which required students simply to recall verbatim the facts they had memorized (Levels 2 and 3).

Recall that the end of unit test for Teacher 5 (Topic 1) was identical to a worksheet assigned earlier in the unit and that Teachers 1 and 2 included pretests in their curriculum schedules for Topic 2. In these cases, not only was the fact that the test would tap the memorization of the material made explicit, but the students knew exactly which particular items were going to be tested, in which order, and using which phrasing.

Mode of Response

Mode of Response refers to the form of the product generated when completing a task. As mentioned above, together with the problem level of tasks, what students must actually do (e.g., define vocabulary words, construct a two paragraph-long essay, etc.) is crucial to a complete picture of what various tasks demand of students' intellectual and creative abilities. And, although a task's mode of response does not determine its cognitive complexity, certain modes lend themselves to particular cognitive operations.

Laboratory Activities. Labs potentially direct students' attention to the process of solving a problem rather than its end-result or product. Yet, in actuality, written work such as completing a worksheet or reproducing what was observed, is often assigned in conjunction with labs and tends to become the focus

Table 4.6. Percentage of Exam Items by Problem Level

	TOPIC 1 Problem Level			TOPIC 2 Problem Level		
Teacher	1	2	3	1	2	3
1	100.0			100.0		
2	100.0			97.3		2.7
3	100.0			66.6	16.7	16.7
4	95.3	4.7		100.0		
5	100.0			100.0		
6	100.0					
7	100.0			100.0		
8	100.0			100.0		
9	100.0			100.0		
10	81.4	14.0	4.6	65.0	35.0	
11	100.0			88.5	11.5	

of the activity. These serve as the teacher's tangible record of a student's participation in and completion of the activity."

Of the 31 labs observed, 97% required that students generate some sort of record of their work; one activity did not (Teacher 4, Topic 1). In 52% (16) of the labs, the required written assignments were composed of questions involving one sentence answers or identifying and labeling structures; 29% (9) of the assignments asked students to draw or color in addition to labeling or completing short answer questions; and 16% (5) required only drawing or coloring. Thus, there were no labs requiring any extended writing that one might typically associate with a lab writeup (e.g., statement of the problem, description of procedures, etc.).

Worksheets. The products students generated while completing worksheet assignments fall into three major categories: Verbal Restricted (matching, true/false, fill-in-blank/label, multiple choice, and short answer); Verbal Extended (paragraph and essay); and Other (numerical calculations, figures, and miscellaneous). The percentage of worksheet task items in each of these three major categories and ten sub-categories of response modes for each teacher is presented in Tables 4.7 (Topic 1) and 4.8 (Topic 2).

As can be seen, the majority of worksheet items were classified as Verbal Restricted, comprising 91.5% of the items for Topic 1 and 80.8% for Topic 2. Paragraphs, essays, and numerical calculations were conspicuously absent and indeed, it appears that the worksheets assigned in these science classes were likely to consist of items requiring a minimum of verbal or expository skills.

Within the Verbal Restricted category, the most popular worksheet items were "fill-in blank/label" questions. Of the nine teachers who used worksheets, this type of item was included by eight teachers in Topic 1 and seven in Topic 2. In fact, the worksheet exercises assigned by Teachers 6 and 8 during Topic 1 were composed of fill-in/label questions exclusively. Further, fill-in items were used with the greatest average frequency, 50.9% and 42.7% for Topics 1 and 2 respectively. Examples include labeling the various bones in the body or chambers in the heart (Teacher 10) and listing the four major organism kingdoms (Teacher 4). Short answer questions which can be answered in one sentence (e.g., "Describe the function of the circulatory system in the space provided") were also quite frequent, comprising an average of 24.7% of the worksheet questions for Topic 1 and 33.8% for Topic 2. True/false items were the least frequently used of all of the Verbal Restricted item types composing an average of 1.3% of worksheet questions for Topic 1 and 0.8% for Topic 2.

In general, worksheets did not include questions which required the student to generate a paragraph (at least two sentences) or an essay (at least two paragraphs). For Topic 1, five teachers (55%) assigned some Verbal Extended items, yet none of

Table 4.7. Percentage of Worksheet

Task Items by Mode of Response (Topic 1)

TCHR.	Verbal Restricted					Verbal Extended		Other		
	Matching	True/ False	Fill-in Blank/ Label	Mult. Choice	Short Answer	Para-Graph	Essay	Calculation	Figures	Misc.
1			47.2		41.5	7.5			3.8	
2			69.0		17.8	13.2				
3			70.4						29.6	
4			36.8		57.9	5.3				
5	53.3			46.7						
6			100.0							
7										
8			100.0							
9										
10	16.4	5.5	25.4	9.1	40.0	3.6				
11		6.4	9.0	6.4	65.4	12.8				

Table 4.8. Percentage of Worksheet Task Items by Mode of Response (Topic 2)

TCHR	Verbal Restricted					Verbal Extended		Other		
	Matching	True/ False	Fill-in Blank/ Label	Mult. Choice	Short Answer	Para-Graph	Essay	Calculation	Figures	Misc.
1	10.5	7.5	28.3		37.3	11.2	3.7		1.5	
2			56.6		16.9	11.0			0.9	14.6
3			96.1							3.9
4					59.2					40.7
5			69.6						30.4	
6										
7					100.0					
8										
9			50.0							50.0
10			79.7		20.3					
11	10.4		4.2	10.4	70.8	4.2				

these required more than two sentences. In addition, these items comprised only an average of 8.5% of the total number of worksheet items students were assigned.

For Topic 2, three of the teachers who assigned Verbal Extended items during Topic 1 also did so for Topic 2 (1, 2 and 10), although these items were still quite infrequent on the average (3.3%). One teacher required essay responses for a homework worksheet on ecology (Teacher 1) in which students described the natural habitat of an animal. These descriptions extended over a period of five days, and although the assignment was required, only about one-third of the students completed it.

Worksheet items that were not Verbal Restricted or Verbal Extended were classified as "Other." Within this category, figures (e.g., graphing, drawing, coloring) were included as worksheet items an average of 3.7% and 3.6% for Topics 1 and 2, respectively. Miscellaneous items, such as completing Punnett squares which involve both numerical and figural activities (Teacher 4) or alphabetizing vocabulary items (Teacher 2) were assigned an average of 12.1% for Topic 2. (No Miscellaneous items were used in Topic 1.)

Exams. Tables 4.9 and 4.10 outline the modes of response for exams assigned by each teacher in Topics 1 and 2, respectively. Like worksheets, the overwhelming majority of exam items were classified as Verbal Restricted for both Topic 1 (97.4%) and Topic 2 (93.8%). Within this category, fill-in/label questions were used quite often in Topic 1 (22.3%) and Topic 2 (23.8%); however, other verbal restricted modes were also popular. Short-answer exam items were popular during Topic 1 (26.3%), although their use decreased substantially during Topic 2 (8.8%). Matching items comprised an average of 24% of questions on exams during Topic 1 and 28.4% in Topic 2. Multiple Choice items were included on exams an average of 20.7% for Topic 1 and 26.1% for Topic 2.

This increase in the proportion of matching and multiple choice questions compared to worksheets is worth noting in terms of the memory skills these items demand of students. On several occasions, the teacher simply converted fill-in questions from the worksheets to matching by adding a set of responses from which the students should pick their answer. While fill-in/label items require the student to recall (albeit only one word or one sentence) the target name or concept, matching and multiple choice items require the student to only recognize the correct answer from among several possibilities provided for them.

Not unexpectedly, few exam items (an average of 1.6% for Topic 1 and 0.4% for Topic 2) entailed the generation of a paragraph or essay. As with worksheets, then, Verbal Extended items were clearly not emphasized on exams.

In the Other category, items required students to complete tasks involving circling the correct spelling (Teacher 2) or

Table 4.9. Percentage of Exam Items by Mode of Response (Topic 1)

	Verbal Restricted					Verbal Extended		Other		
TCHR.	Matching	True/ False	Fill-in Blank/ Label	Mult. Choice	Short Answer	Para-Graph	Essay	Calcu-lation	Figures	Misc.
1			32.3		61.3	3.2			3.2	
2			52.6		47.4					
3	23.3		51.1	23.3		2.3				
4	30.2		2.3	30.2	23.3	7.0			7.0	
5	53.3			46.7						
6	55.6			38.8		5.6				
7		45.4	18.2	18.2	18.2					
8	50.0			50.0						
9			45.0		55.0					
10	11.6		16.3		72.1					
11	40.0		28.0	20.0	12.0					

Table 4.10. Percentage of Exam Items by

Mode of Response (Topic 2)

TCHR.	Verbal Restricted					Verbal Extended		Other		
	Matching	True/ False	Fill-in Blank/ Label	Mult. Choice	Short Answer	Para-Graph.	Essay	Calculation	Figures	Misc.
1	28.0	20.0		40.0	12.0					
2	41.7				30.5					27.8
3			83.3	16.6						
4			41.7	41.7		4.2				12.5
5	66.7			33.3						
6										
7		30.8	15.4	33.3	2.6			7.7		10.2
8	50.0			50.0						
9	20.0	16.0	54.0	8.0	2.0					
10	38.7		40.0		21.3					
11	38.5		3.8	38.5	19.2					

calculating genetic relationships using Punnett squares (Teachers 4 and 8). These were included an average of 0.9% for Topic 1 and 6.3% for Topic 2.

Summary

Problem Level and Mode of Response are two determinants of the cognitive operations students must perform when engaging in and completing academic tasks. In general, the tasks assigned in these life science classes involved the reproduction of topic content through rote memorization or the application of an algorithm. Further, students generally did so by drawing lines (matching), circling letters (multiple choice), labeling pictures (fill-in) or writing single sentences (short answer). The interaction between mode of response and problem level for the labs, worksheets, and exams points to the disconcerting conclusion that these academic tasks rarely encouraged students to construct conceptual representations of scientific content, integrate that content into prior knowledge and understanding, or express their mastery of the material using verbal or expository skills.

Specifically, laboratory activities typically prescribed a set of procedures needed to obtain descriptive data. Encouraging the discovery of <u>explanatory</u> scientific principles through the systematic manipulation of more than one independent variable or the evaluation of methods and testing procedures was rare. In addition, these exercises did not foster creativity or ingenuity. Successful completion of labs rarely depended upon students accessing information or resources not directly available in the context of the activity. If teachers felt the need to compensate for the procedural complexity of labs or students' unfamiliarity with lab equipment, one would expect an increase in the problem level and response requirements of labs with time. However, the situation in these classes appeared to worsen, not improve, as the year progressed. Further investigation of classroom processes and the sources of lab activities would be necessary to completely understand this trend.

Worksheets and exams assigned in these classes also reflected an overwhelming preference for lower-level, textually explicit items requiring a minimum of expressive skills. These items tend to focus students' attention to surface aspects of topic content, rather than its underlying conceptual structure, and encourage mnemonic rather than integrative processing strategies. Although it might appear that teachers assigned more demanding tasks as the year progressed, this trend was most likely a function of the topic content, in particular the use of Punnett square problems by the two teachers who taught genetics during Topic 2 (whereas the two teachers who taught genetics during Topic 1 did not use Punnett squares). The textually explicit lower-level character of task items was even more striking on exams, magnified on several occasions by a teacher's inclusion of pretests and worksheets that were identical to the end-of-topic exams.

Orientation to Scientific Literacy

The normative framework of scientific literacy adopted in this study includes both the mastery of science content (i.e., definitions, facts, and concepts) as well as the appreciation of the contexts of science knowledge and broad features of it as a discipline. However, as discussed in Chapter Three, teachers generally did not go beyond science content to relate it to other meaningful concepts or possible personal or societal implications. The following attempts to supplement these findings by determining the degree to which academic tasks assigned in these classes also reflect a "bleak" foundation for the attainment of scientific literacy.

Recall that scientific literacy is defined in terms of the presentation of science content and four additional relating components: (1) Science as a Social Historical Process; (2) Science as a Reasoning Process; (3) Science and Society/Technology; and (4) Positive Attitudes Toward Science. An examination of tasks in terms of these five components and effective science teaching requires a discussion of (a) the intrinsic orientation to scientific literacy of these tasks; and (b) the alignment of academic tasks with teachers' in-class presentations of the components of scientific literacy.

Scientific Literacy on Worksheets and Exams

Table 4.11 presents the percentage of each teacher's worksheet and exam items devoted to the various components of scientific literacy for the two observation periods. (Laboratory activities are not included in this discussion.) The Content columns list the percentage of items that pertained to topic content, while the Relating columns present the percentage of items that reflected any of the four relating components. The specific components are identified by the number(s) in parentheses beneath the percentage figures.

For Topic 1, a clear majority of worksheet and exam items were devoted exclusively to topic content. In fact, of the 9 teachers who assigned worksheets, only 2 (2 and 10) included any items that linked topic content to any of the relating components of scientific literacy. There were only four such items comprising an average of 0.7% of the total worksheet items assigned during Topic 1. These focused on historical aspects of science (e.g., "What did Louis Pasteur do?" and "Why was the microscope important in the discovery of the kingdom protists?") and science and society (e.g., "How is bacteria useful to man?"). It is interesting to note that all of these relating items required students to generate a single sentence or paragraph-long answer.

Table 4.11. Percentage of Task Items Devoted to Science Content and to Relating Components of Scientific Literacy on Worksheets and Exams*

Tchr.	TOPIC 1				TOPIC 2			
	Worksheets		Exams		Worksheets		Exams	
	Content	Re-lating	Content	Re-lating	Content	Re-lating	Content	Re-lating
1	100.0		100.0		76.9	23.1 (3)	86.0	14.0 (4)
2	85.8	4.2 (1,3)	100.0		100.0		100.0	
3	100.0		100.0		90.0	10.0 (4)	83.0	17.0 (4)
4	100.0		93.0	7.0 (2,3)	59.0	41.0 (2)	87.5	12.5 (2)
5	100.0		100.0		100.0		100.0	
6	100.0		100.0					
7			100.0		100.0		100.0	
8	100.0		100.0				100.0	
9			75.0	25.0 (1,2)	82.5	17.5 (2,4)	78.0	22.0 (2)
10	98.0	2.0 (1)	98.0	2.0 (1)	100.0		100.0	
11	100.0		100.0		96.0	4.0 (3)	87.0	13.0 (3)

*Numbers in parentheses refer to the following components of Scientific Literacy:

1) History of Science
2) Science as a Reasoning Process
3) Science and Society/Technology
4) Positive Attitudes toward Science

Relating items appeared slightly more frequently on the exams assigned during Topic 1 than on the worksheets. Three teachers (4, 9, and 10) included items relating science to its historical origins (e.g., "Who named the first cell?") and science as a reasoning process (e.g., "Which antibiotic would you prescribe given the following information...?"), yet these items still comprised an average of only 3.1% of the total number of exam questions.

Turning to Topic 2, an increase in the proportion and popularity of relating terms is noticeable. Five teachers (1, 3, 4, 9, and 11) included items that related science content to other components of scientific literacy, comprising an average of 10.6% and 7.9% of the items on worksheets and exams, respectively. These items were likely to focus on the relationship between science and society/technology (e.g., "Describe four problems facing your community today that are related to population growth") or the formation of attitudes about the significance of science to everyday life (e.g., "What ways can you personally conserve natural resources?" or "List the niches in your community and show how you are dependent upon them."). As in Topic 1, these relating items were likely to require at least a short answer response or paragraph, even for those teachers whose tasks were composed of items from a variety of response modes (e.g., Teachers 1 and 11). Furthermore, because these items linked science content to the students' personal lives, they required a certain amount of ingenuity in going beyond the information provided and could be categorized as textually or scriptally implicit.

Effective science teaching is most likely to be achieved if the relating components of scientific literacy are addressed consistently within a teacher's task system. For Topic 1, only one teacher included relating items on a worksheet as well as the end of topic exam (Teacher 10). Here, the same short answer item was used in both cases ("Who was Barbara McClintok and why was she important?"). Looking across task types in Topic 2, all five teachers who included relating items on worksheets also did so on their exams. In all but two cases (Teachers 4 and 9), however, the identical items were used for both tasks. (See the Task System Congruence section for more discussion on the alignment across tasks.)

In general then, the tasks assigned by these teachers did not reflect a substantial representation of those components of scientific literacy other than topic content. This situation appeared to improve somewhat in Topic 2 as relating items comprised approximately one-tenth of the total worksheet and exam questions for that topic. Interestingly, and certainly not necessarily, the relating items that were included were likely to involve some writing or expository skills and higher-level cognitive processes, such as integrating content with past personal experience or knowledge.

Tasks in Relation to Teachers' Academic Presentation Time

We now turn to the interaction and alignment of academic tasks and teachers' time use in terms of scientific literacy (as discussed in Chapter Three). Three scenarios representing that relationship are outlined here (although others surely exist as well). First, one could expect complete overlap in the degree to which teachers incorporate each component of scientific literacy into their recitations or demonstrations and the orientation to scientific literacy of their tasks. In other words, those teachers who devote some portion of time during class to the relating components carry those emphases through to worksheets and exams; whereas, those teachers who focus only on topic content do so exclusively on tasks as well. Secondly, a complementary relationship could exist between curriculum content and teachers' academic presentations. In this case, those teachers who devote class time to the relating components do so (perhaps) because they feel the need to compensate for the lack of such emphases in the text and/or on worksheets and exams. Or, in the opposite situation, teachers do not devote recitation time to the relating components because these are adequately addressed in the academic tasks students are required to complete. Lastly, no relationship could be found between teachers' presentation time and task composition in terms of the five scientific literacy components. Here, a teacher's devotion of class time or task items to the relating components, is not likely a result of conscious effort to anchor topic content in a potentially meaningful context. Clearly, deciding among these possibilities is difficult and requires extensive analyses of teachers' motivations and intentions. It is hoped, however, that the following can offer some direction and insight.

Table 4.12 outlines those teachers who made explicit reference to any of the relating components of scientific literacy during any portion of their in class presentations (see Chapter Three) and/or who included any items on a worksheet or exam that addressed those same relating components. (Numbers refer to specific teachers.) For this preliminary look, we are concerned only with whether the relating components of scientific literacy were addressed at all during these two activity modes (recitation/demonstration and worksheets or exams), not with the quantity or quality of presentation.

After a glance at Table 4.12, it is clear that there is little consistent application of the relating components to science curriculum. A teacher's use of the relating components of scientific literacy during class rarely predicted the degree of scientific orientation on their academic tasks, and vice versa. In fact, only 2 teachers in Topic 1 (4 and 10) and 2 in Topic 2 (1 and 11) exhibited any similarity in orientation to the relating components during these two activity modes.

To illustrate these exceptions, recall how Teacher 4 briefly discussed the "discovery" of the microscope by Von Leeuwenhoek on

Table 4.12. Comparison of Teachers Who Devoted Any Academic Presentation Time and/or Task Items to the Four Relating Components of Scientific Literacy*

Component	TOPIC 1			TOPIC 2		
	Academic Presentation	Work-Sheets	Exams	Academic Presentation	Work-Sheets	Exams
Relating to Science as a Social Historical Process	1, 3, 4, 10, 11**	2, 10	10	4, 5, 7, 9	None	None
Relating to Science as a Reasoning Process	1, 4, 7 10, 11	None	4, 9	None	4, 9	4, 9
Relating to Society/ Technology	6, 9	2	4	1, 4, 5, 8, 11	1, 11	1, 11
Positive Attitudes toward Science	1, 9	None	None	5, 11	3, 9	1, 3

*See Chapter Three for discussion of data on academic presentation.
**Numbers indicate teacher.

Day 4 of the topic. A question directly related to that discussion appeared on the end-of-topic exam asking students to explain this historical event in light of the discovery of microorganisms. In another case, after discussing a famous scientist's work in class, Teacher 10 included a related item on both the worksheet and end-of-topic exam for Topic 1 ("Who is Barbara McClintock and why is she important?"). Here, the in-class presentation of information concerning the relating components of scientific literacy was reinforced by its inclusion on a worksheet and/or exam. However, these were clearly exceptions rather than examples of a typical pattern.

There is some evidence that a complementary relationship exists between teachers' orientation to scientific literacy and academic tasks. For example, for one component each during Topic 1 (Positive Attitudes) and Topic 2 (History), several teachers made explicit references to aspects of science knowledge during class time, yet these were not reflected in the tasks students were required to complete. The opposite held for Teachers 4 and 9 during Topic 2. Each of these included items on worksheets and exams which made explicit reference to science as a reasoning process, yet neither teacher devoted class time to that component of scientific literacy. It is not clear, however, what motivated each teacher's use or neglect of the relating components.

Unfortunately, the data suggest that any alignment between teachers' academic presentation time and tasks in terms of the relating components is random or accidental. In these science classes, 90.9% of the topics reflected <u>no</u> relationship between class time and task items; and, compared to the presentation of factual content, the relating components were rarely addressed both in class and on academic work. Thus, it would be difficult to assume that teachers made a conscious effort to focus on any aspects of science besides factual content. However, further analyses are necessary before such a statement can be considered conclusive.

Summary

In general, academic tasks reflected a bleak foundation for the attainment of scientific literacy. A minority of teachers included a small percentage of task items which pertained to the relating components on worksheets and exams. Further, little overlap between teachers' time use and academic tasks indicated a minimum of focused effort to reinforce such concepts across the range of academic activities. On an optimistic note, the relating items that were used often required drawing inferences from topic content and the application of expressive skills. Clearly, stressing the importance of scientific literacy in academic work has ramifications for students' cognitive growth, as well as more effettive science teaching.

Task System Congruence

After making some comments about task demands and degree of orientation to scientific literacy, it is useful to briefly consider task systems in terms of their "congruence" (Doyle, Sanford, Clements, French, & Emmer, 1983). The congruence (or similarity) across tasks within a topic determines how students tend to process and master topic content in two ways. First, if students are aware that end of topic exams require lower-level mastery of the material (e.g., rote recall of terms, definitions, etc.), their learning or study strategies will not facilitate the creation of high level semantic representations or the conceptual reorganization of topic content. Such a level of cognitive effort is not necessary nor reinforced. Second, similarity across task types has bearing on which learning strategies or aspects of topic content students master simply by influencing the amount of practice with a particular type of problem (Doyle, et al., 1984). For example, the more frequently students encounter the need to draw inferences from text or lecture material, to generate extended written passages, or to view science content in terms of the relating components, the more adept those skills will become.

Task Demands

Returning first to Tables 4.4, 4.5 and 4.6 concerning problem level, we see that the majority of labs, worksheets, and exams assigned were considered lower-level, requiring that students simply follow explicit instructions, transfer information from one piece of paper to another, or memorize terminology. Problem levels were generally lower on exams than worksheets implying that those tasks that "count" did not reinforce the few higher level skills required of some of the worksheets. If this is an established pattern across teacher (only 2 of 5 teachers in Topic 1 and 4 of 7 teachers in Topic 2 who included Level 2 or 3 items on worksheets also did so on exams), students may learn to anticipate an absence (or de-emphasis) of higher-level items on exams based on the structure of worksheets. Over the course of the year, such patterns clearly have an impact on the level at which students orient themselves to the completion of worksheets and the mastery of topic content.

Moving to Mode of Response and Tables 4.7, 4.8, 4.9, and 4.10, the preference for Verbal Restricted and the neglect of Verbal Extended items is seen on both worksheets and exams. As mentioned earlier, teachers tended to alter the composition of exams by increasing the proportion of multiple choice and matching items on exams. Often this was a result of teachers supplying a set of responses from which students could choose the correct response taken from fill-in or short answer items on worksheets (i.e. convert to matching and multiple [illegible]e). By altering the requirements of these task items from recall to recognition, the teachers <u>decreased</u> the overall problem level of these items.

This situation was amplified when items on the exam were taken verbatim from worksheets or laboratory materials, and most severely, when pretests or worksheets identical to the exam were used. On several occasions, the potentially higher-order cognitive complexity of task items was successfully undermined by the teacher. For example, Teacher 3 asked students to describe which muscle movements were required for the <u>exact</u> same set of activities on the exam as on the [illegible]sheet. Thus, even though it was necessary for students to [illegible]yond the information provided for them when completing the worksheet, success on the exam required only the recall of those same responses. In essence, teachers succeeded in making the exams easier for the students than worksheets.

Scientific Literacy

For scientific literacy to be effectively addressed in science classrooms, it is important that when teachers use the relating components, they do so consistently and in a variety of academic situations. For example, both the worksheet and exam assigned by Teacher 4 during Topic 2 included unique sets of problems that emphasized the scientific reasoning process (via Punnett squares used to determine gene combinations). For these problems, the students needed to master the appropriate algorithm as well as its logic and potential applications. The relatively high-level of understanding and linkage of topic content to reasoning processes were reinforced for the students when they had to apply the algorithm to unique situations on the exam.

However, for the majority of occasions when items addressing the same relating component appeared on both worksheets and exams, identical items were used. This was the case for Teacher 10 during Topic 1 and Teachers 1, 3, and 11 during Topic 2. Although this is clearly more desired than not including any relating items at all, the fact that students were simply expected to memorize that information reduced the potential significance of those items and hindered their durability in memory after the administration of the exam.

Summary

In general, the task systems employed by the participating teachers revealed a high degree of congruence. Unfortunately, such similarity across tasks merely serves to reinforce (1) low level processing and learning strategies, (2) limited application of verbal skills, and (3) a de-emphasis on the relating components of scientific literacy. The tendency for teachers to reuse or alter items from worksheets on exams, besides ensuring the "success" of more students, manages to further limit the cognitive and creative demands of academic tasks.

Accountability Systems

As a final point of discussion, we turn to the accountability systems of the teachers in this study and focus further on how academic tasks are transformed into the reality of the classroom. As noted by Doyle (1983), the way teachers judge academic work connects tasks to the reward structure of the classroom. Students are motivated by the established evaluative climate to determine the goals of that reward structure and the most efficient and appropriate ways to attain those goals. How teachers define tasks within those reward structures often orients students toward academic work in ways that undermine the characteristics inherant in individual tasks (e.g., problem level). Further, evaluating academic work provides the teacher with crucial information regarding classroom functioning. Such feedback is useful in determining the effectiveness of the teacher's topic presentations, as well as in identifying individual differences in students' abilities or attitudes that might warrant attention.

Two general characteristics of the accountability systems used by these teachers on labs, worksheets and exams are captured in Tables 4.13 and 4.14 for Topics 1 and 2, respectively: 1) the type of grading strategy utilized with the various tasks (i.e. Accuracy, Completion or Not Graded); and 2) the clarity of that evaluative criterion (i.e. whether the grading criterion was made explicit to the students). Evaluative clarity was high for those tasks listed in columns labeled Accuracy, Completion, and Not Graded. Accuracy refers to when students were aware that their work would be evaluated according to the accuracy of the answers. Completion refers to when students were aware that their work would be judged in terms of whether they had completed the assignment, without concern for the quality of their responses. Not Graded refers to when students were aware that the task would not be evaluated in any way.

In contrast, the Unclear category reflects a low level of evaluative clarity. Here, the evaluative criterion applied by the teacher could not be determined from the assignment or the narrative records of the classroom interactions. In some cases, the students might have been aware of the teacher's grading strategy (e.g., if the teacher utilized the same pattern of grading for all topics); however, such an assumption can not be justified based on the current information.

The columns labeled Notebook on the right hand side of Tables 4.13 and 4.14 indicate those teachers who utilized a notebook system for Topics 1 and 2, respectively. Here, the bulk of the work that the students completed was compiled and turned in at the end of the topic. In most cases, the work included in the notebook was graded on a completed/not-completed basis.

Table 4.13. Overview of Accountability Systems: Percentage of Tasks by Grading Strategy and Evaluative Clarity (Topic 1)*

Tchr	LABS				WORKSHEETS				EXAMS				Notebook
	Accuracy	Completion	Not Graded	Unclear	Accuracy	Completion	Not Graded	Unclear	Accuracy	Completion	Not Graded	Unclear	
1				100	25	50		25	100				No
2		100				100						100	No
3		NONE			50			50	100				No
4	50			50	100				100				No
5	50			50	100				100				No
6				100	100				100				No
7		100				NONE				100			Yes
8				100	100				100				Yes
9				100		NONE			100				No
10		100				100			100				Yes
11		NONE			100				100				No

*Categories of Grading Strategies and Evaluative Clarity are defined as follows:

ACCURACY: Students were aware that the correctness of their answers was the primary evaluative criterion.
COMPLETION: Students were aware that the completion of the task or its presence in a notebook was the primary evaluative criterion.
NOT GRADED: Students were aware that the task would not be graded.
UNCLEAR: The teacher's evaluative criterion and/or its awareness by students could not be determined.
EBOOK: Student work was compiled in a notebook.

Table 4.14. Overview of Accountability Systems: Percentage of Tasks by Grading Strategy and Evaluative Clarity (Topic 2)*

Tchr	LABS				WORKSHEETS				EXAMS				Notebook
	Accuracy	Completion	Not Graded	Unclear	Accuracy	Completion	Not Graded	Unclear	Accuracy	Completion	Not Graded	Unclear	
1		100				100			50	50**			Yes
2				100		100			66		33**		Yes
3				100				100	66			33	No
4	NONE					100			100				No
5	NONE							100	100				No
6	NONE				NONE				NONE				No
7		100				100				100			Yes
8	33	66			NONE				100				Yes
9	NONE							100	100				No
10	NONE					100			100				Yes
11	100				100				100				No

*Categories of Grading Strategies and Evaluative Clarity are defined as follows:

ACCURACY:	Students were aware that the correctness of their answers was the primary grading criterion.
COMPLETION:	Students were aware that the completion of the task or its presence in a notebook was the primary grading criterion.
NOT GRADED:	Students were aware that the task would not be graded.
UNCLEAR:	The teacher's grading criterion and/or its awareness by students could not be determined.
EBOOK:	Student work was compiled in a notebook.

** Pretest

Laboratory Activities. As seen in Table 4.13, the grading criterion for the majority of the labs assigned during Topic 1 could not be determined. Thus, for 6 of the 9 teachers (67%) who assigned labs, their students were not given explicit information about whether the accuracy and/or quality of their work was important, whether completion of the task was sufficient, or whether the teacher would even look at it. Three teachers (2, 7 and 10) evaluated the labs assigned during Topic 1 according to whether the students completed it and two teachers (4 and 5) evaluated the accuracy of the responses. (However, they did so for only one-half of their labs). No teacher explicitly told their students that the labs would not be graded.

Turning to Topic 2, in two cases (Teachers 2 and 3) the grading strategy of the teachers was not clear to the students and/or classroom observers. Three of the teachers (1, 7, and 8) graded their lab assignments on a completed/non-completed basis and only two teachers (8 and 11) evaluated lab work according to the quality of the responses. As in Topic 1, none of the teachers told their students that the lab assignments would not be graded.

For both topics, then, teachers rarely evaluated the quality of their students' performance on laboratory activities. In those cases when the grading strategy was clear, the significant evaluative criterion was instead whether the student followed the instructions and completed the task. Teachers may utilize such a grading strategy because most of the labs assigned required little ingenuity or creativity on the part of the individual students. Due to the structure of the tasks themselves, then, each student who "went through the motions" of the lab activity came up with basically the same set of answers. Individual differences were likely a result of unverifiable variations in the laboratory materials (e.g., which microscope slides that lab group happened to get). In addition, many of the products students were required to produce during laboratory assignments involved drawing or coloring. Science teachers may feel reluctant to make qualitative judgments about students' artistic skills, so task completion is sufficient to obtain the maximum reward. In general, laboratory activities probably were evaluated in terms of completion because teachers simply did not devise a basis upon which to discriminate among students.

Worksheets. As shown in Table 4.13 and 4.14, students were generally aware of the criterion their teachers would use for evaluating worksheet assignments. Only 2 teachers in Topic 1 (1 and 3) and 3 in Topic 2 (3, 5 and 9) did not make their grading stategy explicit for at least some portion of their worksheets. Like labs, no teacher in either topic stated that a worksheet assignment would not be evaluated at all.

Focusing on graded assignments for Topic 1, 7 of the 9 teachers who assigned worksheets (77%) showed some concern about the accuracy of their students' work; and, 5 teachers (55%) graded <u>all</u> of their worksheets on a correct/not-correct basis.

However, consistent with their grading strategy on laboratory activities, three teachers (1, 2, and 10) evaluated the majority of their worksheet assignments in terms of completion.

In contrast, only 1 teacher (Teacher 11) utilized an accuracy grading strategy on the assigned worksheets in Topic 2. The majority (55%) of teachers (even those who had been concerned about accuracy during Topic 1, such as Teachers 1 and 4) preferred to evaluate worksheets on a completed/not-completed basis, rather than on whether their students produced the correct responses. (Teachers 2 and 10 graded all of their worksheet assignments for both topics with a completion strategy.)

Looking only at Topic 1, then, one could assume that worksheets were quite frequently a source of information and feedback for students and teachers in these science classes. However, it appears that this trend was short-lived. Instead of becoming more sophisticated in their feedback (or at least remaining consistent) as the year progressed, these teachers resorted to less informative grading strategies with time.

The general trend of uninformative grading strategies on worksheets is especially puzzling given that the majority of worksheets assigned in these science classes were composed of fill-in, multiple choice and other verbal restricted items -- i.e. items for which a relatively minimal amount of time and effort is necessary for grading compared to those containing extensive essays or numerical calculations. Instead, teachers may justify the evaluation of labs and worksheets on a completed/non-completed basis out of concern for their students. For example, as a technique to motivate some students, teachers may emphasize the adage "don't say you can't, say you'll try," and desire to make the evaluative climate in their classroom as non-threatening as possible. Thus, rather than discourage some students with an accuracy grading strategy, the teacher rewards completion of the activity, while devoting class time to a discussion of the answers. In this way, the teacher provides students with feedback concerning topic content (i.e. what the right answers were), but does not personally threaten any individual student. Unfortunately, this method provides the teacher with little specific information regarding individual performance that could serve as a guide for the teacher's activity plans.

Exams. In contrast to laboratory activities and worksheets, the overwhelming majority of the exams during Topic 1 (82%) and Topic 2 (78%) were evaluated in terms of the accuracy of responses. Exceptions were Teacher 7 who applied a completion strategy for his exams in both topics, and Teacher 2 (Topic 1) and Teacher 3 (Topic 2) whose grading criteria could not be determined. In two cases, pretests were given, yet students were aware that these would not be graded (Teacher 2) or that they would be evaluated on a completed/not-completed basis (Teacher 1).

Therefore, it appears that teachers relied consistently and almost exclusively on exams as the source of information about how well students mastered the material and as the major means for providing individualized feedback about performance. Yet, these tasks were likely to be the least demanding of all assignments, generally composed almost exclusively of verbal restricted items that frequently were similar (if not identical) to items the students completed on worksheets. Thus, the emphasis on the memorization of factual content was reinforced further in these science classes by having exams be the one academic task that "counted."

Notebooks. The right hand columns of Tables 4.13 and 4.14 indicate those teachers whose grading strategy involved a notebook system for Topics 1 and 2, respectively. Three teachers (7, 8 and 10) utilized notebooks for Topic 1, and five teachers (1, 2, 7, 8 and 10) did so for Topic 2.

This evaluative strategy entails having students compile the tasks assigned during a topic into a notebook so that the teacher can have access to all of the relevant academic work at once. Notebooks allow students to work at their own pace and make deadlines for individual assignments more flexible. Yet, feedback on performance is generally not received until after the topic is completed and the exam is taken. However, as can be seen in Tables 4.13 and 4.14, the grading strategy used in conjunction with notebooks was not generally intended to be maximally informative, in that most of the teachers graded notebook assignments on a completed/not-completed basis. In some cases, it was not clear which assignments would be included in the notebooks.

Summary

In general then, it appears that the majority of laboratory assignments and worksheets completed by students in these science courses were not graded according to the accuracy of responses. Simply completing the task or including it in a notebook was sufficient for the student to obtain the goals defined in these task reward systems. In addition, for a large portion of the activities (primarily labs), it was likely that students did not know how the teacher would evaluate their work. In contrast to labs and worksheets, exams were almost exclusively evaluated in terms of accuracy, although there were some exceptions (e.g., pretests). Interestingly, the reliance on a completion grading strategy was even more striking as the year progressed (Topic 2).

Not only do these data imply that students generally did not receive personalized information about their mastery of the material, but that teachers did not access all available sources of insight into the capabilities and performance of their students. It is possible that the structure of the tasks themselves or teachers' concern to maintain a non-threatening classroom environment was responsible for the substantial reliance on completion grading strategies. However, the flexibility and ease of operation of notebooks or the tendency to cover task material during class may also reduce the perceived need for accountability systems based on accuracy. Whatever the reasons, one is left with the question of what students in these classes came to value as a result of the general accountability system. One would predict that they came to value accurate performance on exams foremost, followed by the most expedient methods to producing labsheets and worksheets that appeared complete. This prediction receives considerable support from the student perception data in Chapter Seven.

Conclusion

These data regarding the character and application of academic tasks contribute to an already disconcerting picture of what typical students and teachers do in today's intermediate life science classes. Of particular interest was the finding that the character of the laboratory assignments, worksheets and exams was intrinsically undemanding and rarely emphasized the theoretical, practical or societal applications of science content. When doing academic work, then, students generally engaged in lower-level cognitive processes and utilized a minimum amount of verbal and expository skills throughout their seventh grade science education.

In addition to characteristics of the tasks themselves, insight was gained into how academic tasks are transformed into the reality of the classroom. These science teachers tended to structure their task systems and choose accountability systems that reduced the already minimal demands of the academic work. For example, the re-use of identical items on several tasks, the absence of verbal extended and textually implicit items on exams, and the adoption of completion-based evaluative criteria often succeeded in undermining the impact of the rare intellectual and creative challenges facing these students. In several cases, this situation appeared to worsen, not improve as the year progressed.

While discouraging, this resulting picture of academic work serves to open the door to several avenues of research concerning the structure and application of science curriculum. Future analyses should investigate the sources of academic tasks and text materials to determine which curriculum resources should be targeted for reform (e.g., teachers or commercial sources). In addition, understanding the ways in which students and teachers perceive the academic work and evaluative systems utilized in these science classes would provide insight into the underlying causes and possible avenues of correction. For example, it is possible that the trend to minimize the demands in the academic environment results from teachers' low expectations or underestimations of what students in intermediate level science classes are capable of (i.e., the complexity of the problems they can solve or the nature of the products they can produce). However, the desire of teachers to create a non-threatening learning environment, pressures from students to reduce the expectations placed on them, difficulties inherent in the organization and management of the classroom, and teachers' personal or professional time constraints, should also be considered as factors.

CHAPTER FIVE

STUDENT OUTCOME MEASURES: RELATIONSHIPS AND GROWTH AT THE STUDENT LEVEL

This chapter examines the student outcome measures completed by students in the pretest and posttest batteries, described in Chapter Two. Briefly, the measures include three cognitive science measures--the Life Science Questionnaire, Nature of Science Survey, and Science Process Survey--and a four-part noncognitive measure--the Feelings Toward Science Survey. In addition, students completed two ability measures at pretest, the Word Meanings and Pattern Completion Surveys. Finally, on the posttest only, students completed the Ideas About Science Survey, a perceptual measure that is examined in Chapter Seven.

The first section of the chapter presents the descriptive statistics on the outcome measures. The second section of the chapter addresses the dynamics of change on the outcome measures using several descriptive techniques. The third section examines the relationship between student growth and several factors, including entering ability, class membership, student gender, and teachers' use of the scientific literacy components. All analyses reported in this chapter were conducted at the student level.

Descriptive Statistics on the Outcome Measures

As indicated earlier, a student-level data set was formed consisting of students' scores on the pretest and posttest batteries and the Student Class Surveys. (Results from the Student Class Survey appear in Chapter Eight.) Before beginning analyses, it was necessary to determine the criteria for including students. A decision was made to include only those students with complete data (i.e., total scores) on the ability measures (at pretest), three cognitive measures (at pre and post), and one noncognitive measure (at pre and post). The benefits of dealing with a smaller but constant sample size across measures was viewed as outweighing the benefits of larger sample size where Ns would fluctuate across measures. Complete data on the Student Class Surveys and Ideas About Science Survey was not a requirement for inclusion in the data set since these were perceptual measures that were intended largely for descriptive purposes.

When the specified constraint on data set inclusion was put in place, the resulting sample size was 213 students. This represents about a 25 percent maximum loss of data given the initial class sizes. However, this loss was not randomly distributed. Two classes in one school (those of Teachers 3 and 4) suffered the greatest losses. These losses were attributable to unanticipated student scheduling changes at midyear when at least half of the original class members were assigned to other sections of their teacher's class. Thus, the resulting Ns for the classes of Teachers 3 and 4 were 12 and 13, respectively. Losses for the other classes were due largely to student attrition and absence. The Ns for these remaining classes ranged from 17 to 27.

Entering Ability

Table 5.1 presents the class means and standard deviations for the two ability measures, Word Meanings and Pattern Completion. Recall that these were intended to capture the crystallized and fluid components of ability, respectively. The table also presents a composite of these two measures, termed "Ability." This composite was created by computing standardized scores (z-scores) for each student on the two measures. These two resulting z-scores were then averaged for each student.

The table indicates considerable variability across classes in terms of students' entering ability levels. The students of Teacher 4 scored highest on both ability measures, outdistancing other classes by approximately one-half of the total sample standard deviation. Thus, Teacher 4 has the highest score on Ability. In contrast, the students in the classes of Teachers 5 and 7 scored lowest on the Word Meanings and Pattern Completion Surveys, respectively. Teacher 7 has the lowest score on the composite, with Teacher 5 a close runner-up.

On the face of it, there is no obvious explanation for the patterns of ability scores. Because Teachers 1 through 7 are in Utah, there appears to be more variability in the Utah schools relative to the California schools. However, sample sizes from both states are too small to allow any generalization. The high performance of students in Teacher 4's class clearly is not a school effect since Teacher 3 is from the same school. Nor is school likely to be a factor in the class performance of Teacher 5 since Teacher 6 also is from the same school. Thus, while there is no indication that any of the participating schools engaged in purposeful tracking of students, it appears that classes within a school sometimes were noticeably different in their ability composition. Only the performance of students in Teacher 7's class seems predictable, because these students were in a relatively isolated and very rural Utah school.

The impression of important differences among classes in entering ability was confirmed statistically. A one-way analysis of variance was conducted with the ability composite as the dependent variable and class as the independent variable. The resulting F value was 3.04 ($p < .001$). This suggests the potential importance of ability as a control variable for analyzing student growth on the cognitive science measures.

Table 5.1 Pretest Means on Word Meanings, Pattern Completion, and Ability Composite

Teacher	Word Meanings	Pattern Completion	Ability
1 (N=27)	25.07 (6.56)	11.15 (2.48)	-.14 (1.46)
2 (N=24)	22.58 (7.16)	11.25 (2.89)	-.47 (1.54)
3 (N=12)	26.17 (7.83)	11.42 (2.27)	.10 (1.77)
4 (N=13)	30.69 (3.33)	14.54 (1.66)	1.78 (.92)
5 (N=21)	21.29 (5.84)	10.29 (2.95)	-.98 (1.56)
6 (N=19)	25.84 (5.50)	12.79 (3.07)	.50 (1.59)
7 (N=20)	23.05 (6.19)	9.35 (3.69)	-1.02 (2.00)
8 (N=17)	27.53 (6.69)	12.35 (2.23)	.61 (1.44)
9 (N=18)	26.39 (6.63)	11.06 (2.58)	.02 (1.45)
10 (N=23)	26.61 (7.58)	11.65 (3.70)	.24 (2.03)
11 (N=19)	26.37 (7.37)	12.00 (3.07)	.32 (1.76)
Total (N=213)	25.29 (6.85)	11.49 (3.08)	.00 (1.74)

Note: 41 and 21 total points were possible on the Word Meanings and Pattern Completion Surveys, respectively. The ability composite is the average of the z-scores for the same two measures.

Cognitive Science Measures

Table 5.2 presents both the pretest and posttest means and standard deviations, by class, for the Life Science, Nature of Science, and Science Process measures. Recall that the Life Science measure was a standard achievement measure of science knowledge, while the Nature of Science and Science Process measures tapped other realms of scientific literacy--namely, an appreciation of science as a social historical process and as a reasoning process.

Turning first to the Life Science measure, there are marked differences among classes that are similar in pattern to those for the ability measures. Note that students in Teacher 4's class again have the highest entering score while students in the classes of Teachers 7 and 5 have the lowest and next-to-lowest scores, respectively. The gap between the highest and lowest means is a substantial 6.38 points, well over one standard deviation of the total sample. A one-way analysis of variance on these pretest scores with class as the independent variable yielded an F value of 2.74 ($p = .004$), again indicating highly significant variation among classes in their entering knowledge of life science.

The rank ordering among classes on Life Science achievement changes somewhat at posttest. Clearly, a visual comparison of these means suggests different levels of growth that need to be tested for their statistical significance.

Pretest scores for Nature of Science and Science Process also show similar patterning, with Teacher 4's class having the high scores on both and Teachers 5 and 7 vying for the lowest ranks. Tests for initial differences among these classes yielded Fs of 2.07 ($p = .029$) and 2.69 ($p = .004$) for Nature of Science and Science Process, respectively.

Again, there are obvious contrasts among classes in magnitudes of pre-to-post growth that require significance testing. It is particularly interesting to note that for the Nature of Science measure, one class (Teacher 11) posted a negative overall gain. Also, for the Science Process measure, one class (Teacher 2) posted no change. These contrasts suggest that teachers may not be consistent in presenting students with information that helps them grow in areas that go beyond simple retention of facts. Some additional support for this suggestion comes from examining the overall percentages of gain for the three measures in Table 5.2. Using numbers for the total sample, subtracting the pretest scores from the posttest scores and dividing by the number of points possible indicates the following: while students on average answered approximately 9 percent more questions correctly by posttest for Life Science, they answered only 4 and 6 percent more correctly for Nature of Science and Process of Science, respectively.

It also is worth noting what percentage of questions

Table 5.2. Pretest and Posttest Means on Three Cognitive Science Measures, by Class

Teather	Life Science		Nature of Science		Science Process	
	Pre	Post	Pre	Post	Pre	Post
1 (N=27)	15.37 (4.15)	17.75 (4.13)	14.11 (2.47)	15.33 (2.15)	8.4 (3.21)	9.96 (3.45)
2 (N=24)	14.04 (3.75)	15.86 (4.96)	13.83 (2.60)	14.58 (2.92)	9.08 (2.67)	9.08 (3.34)
3 (N=12)	15.5 (4.80)	17.92 (4.95)	14.83 (2.55)	16.08 (2.15)	9.08 (3.40)	10.4 (3.50)
4 (N=13)	18.23 (2.17)	19.85 (2.51)	16.31 (1.25)	16.69 (2.46)	12.38 (1.85)	12.76 (2.45)
5 (N=21)	13.43 (3.40)	15.81 (4.14)	13.76 (2.41)	14.10 (2.70)	7.33 (2.50)	7.61 (2.91)
6 (N=19)	16.21 (3.87)	19.11 (3.53)	14.89 (1.73)	15.05 (2.60)	9.11 (3.14)	10.59 (1.98)
7 (N=20)	11.85 (3.91)	15.05 (4.05)	13.55 (2.37)	15.30 (1.98)	7.95 (3.39)	10.10 (3.31)
8 (N=17)	16.65 (4.65)	18.29 (4.06)	14.82 (2.35)	15.59 (2.65)	8.88 (2.98)	10.65 (2.71)
9 (N=18)	14.67 (4.58)	17.89 (4.09)	13.67 (2.68)	14.56 (3.62)	9.28 (2.95)	9.50 (3.81)
10 (N=23)	15.83 (5.23)	17.00 (4.90)	14.52 (2.06)	15.61 (3.38)	9.61 (3.00)	10.48 (2.94)
11 (N=19)	15.11 (5.58)	15.79 (7.31)	15.11 (2.21)	14.05 (2.70)	8.68 (3.86)	8.74 (4.38)
Total (N=213)	15.02 (4.47)	17.15 (4.70)	14.39 (2.37)	15.09 (2.75)	8.95 (3.17)	9.86 (3.37)

Note: 24, 20, and 16 total points were possible on the Life Science, Nature of Science, and Science Process measures, respectively.

students were getting correct on average. At pretest, students averaged 63, 72, and 56 percent of the answers correct for the Life Science, Nature of Science, and Science Process measures, respectively. The higher number of correct answers for Nature of Science probably is attributable to the true-false response format of this measure in contrast to the multiple-choice format of the others. By posttest, the percentages change to 71, 75, and 62, respectively.

Noncognitive Measure

Table 5.3 presents the pretest and posttest means and standard deviations for the Feelings Toward Science Survey. This survey had four subscales: Part 1 measured attitudes toward science classes; Part 2 measured intentions for future involvement with science; Part 3 measured attitudes toward science in general; and, Part 4 measured interest in science outside class.

The most notable trend in the table, encapsulated by the scores for the total sample, is that attitudes on all four subscales generally declined from pretest to posttest. This trend is most consistent across teachers for the Part 2 subscale. On Part 1, Teachers 1, 4, and 6 are exceptions to the pattern of decrease, showing a small increase from pretest to posttest (Teacher 8 also appears to be stable on Part 1). For Parts 3 and 4, there also are a few classes with trends opposite to the overall pattern of decline. For Part 3, Teachers 3, 4, and 6 show very small pre-to-post increases. For Part 4, Teachers 1, 2, and 4 show small increases with Teacher 8's scores remaining stable. The nature of pre-to-post changes will be explored more fully later in this chapter.

Table 5.3 also indicates fairly substantial differences among classes at pretest. While these differences are not readily apparent with 3 or 4-point scales, the range in scores suggests distances of approximately one standard deviation between high and low scorers on each subscale. One-way analyses of variance for each subscale indicated that class was a significant factor on all subscales except Part 3.

Intercorrelations Among Measures

Table 5.4 presents the intercorrelations among the measures discussed so far. With a sample size of 213, the correlations are all statistically significant. A more informative approach to the correlations, then, is to examine their relative strength. This table presents many interesting results; only some of the highlights can be presented here.

Turning first to the noncognitive measure, the table indicates that the four "Feelings" subscales generally correlate highly among themselves, both at pretest and posttest, with rs

Table 5.3. Pretest and Posttest Means on Four "Feelings Toward Science" Subscales, by Class

	Part 1		**Part 2**		**Part 3**		**Part 4**	
Teacher	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1 (N=27)	3.51 (.66)	3.61 (.70)	3.23 (.61)	3.16 (.70)	3.74 (.62)	3.70 (.53)	2.29 (.44)	2.34 (.48)
2 (N=24)	3.71 (.38)	3.10 (.80)	3.23 (.62)	2.99 (.72)	3.66 (.44)	3.36 (.60)	2.12 (.46)	2.15 (.48)
3 (N=12)	3.35 (.47)	3.29 (.49)	2.78 (.61)	2.69 (.49)	3.47 (.31)	3.48 (.44)	2.20 (.59)	2.18 (.44)
4 (N=13)	3.70 (.42)	3.75 (.24)	3.52 (.47)	3.42 (.36)	3.80 (.45)	3.81 (.44)	2.35 (.41)	2.53 (.36)
5 (N=21)	3.75 (.44)	3.48 (.66)	3.36 (.63)	3.01 (.66)	3.67 (.48)	3.43 (.63)	2.17 (.54)	2.05 (.59)
6 (N=19)	3.36 (.51)	3.40 (.70)	3.16 (.57)	3.09 (.73)	3.51 (.53)	3.60 (.62)	2.34 (.41)	2.26 (.49)
7 (N=20)	3.23 (.49)	3.10 (.51)	2.73 (.54)	2.57 (.68)	3.63 (.53)	3.31 (.59)	1.85 (.31)	1.81 (.36)
8 (N=17)	3.71 (.76)	3.71 (.50)	3.37 (.78)	3.18 (.60)	3.93 (.60)	3.80 (.54)	2.42 (.54)	2.42 (.52)
9 (N=18)	3.15 (.84)	2.94 (.80)	2.91 (.85)	2.53 (.78)	3.42 (.59)	3.37 (.56)	2.25 (.48)	2.03 (.53)
10 (N=23)	3.88 (.58)	3.65 (.55)	3.45 (.73)	3.22 (.73)	3.69 (.67)	3.65 (.77)	2.49 (.60)	2.36 (.56)
11 (N=19)	3.68 (.61)	3.58 (.61)	3.18 (.69)	2.98 (.86)	3.87 (.67)	3.62 (.61)	2.34 (.60)	2.10 (.67)
Total (N=213)	3.56 (.61)	3.42 (.67)	3.19 (.68)	2.99 (.72)	3.68 (.56)	3.55 (.60)	2.25 (.51)	2.20 (.54)

Note: A total of 4 points was possible on Parts 1, 2, and 3 of this survey; a total of 3 points was possible on Part 4.

Table 5.4. Intercorrelations Among Measures on the Student Pretest and Posttest Batteries (N=213)

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Pretest Part 1 Feelings	.632	.559	.450	.207	.173	.219	.218	.211	.171	.570	.369	.350	.414	.279	.179	.140
2. Pretest Part 2 Feelings		.540	.615	.231	.176	.233	.315	.192	.186	.479	.583	.377	.463	.311	.161	.153
3. Pretest Part 3 Feelings			.409	.221	.202	.243	.249	.228	.243	.363	.277	.527	.262	.247	.114	.249
4. Pretest Part 4 Feelings				.251	.250	.288	.344	.221	.237	.414	.413	.397	.658	.364	.164	.214
5. Pretest Word Meanings.					.515	.870	.722	.473	.649	.288	.328	.360	.292	.652	.484	.663
6. Pretest Pattern Completion						.870	.528	.398	.519	.286	.318	.366	.262	.477	.333	.497
7. Ability Composite							.718	.501	.671	.330	.371	.418	.318	.649	.469	.666
8. Pretest Life Science								.499	.645	.364	.443	.504	.413	.740	.515	.624
9. Pretest Nature of Science									.437	.215	.300	.295	.297	.399	.458	.453
10. Pretest Science Process										.269	.299	.392	.271	.590	.505	.677
11. Posttest Part 1 Feelings											.619	.580	.558	.393	.320	.320
12. Posttest Part 2 Feelings												.590	.617	.427	.312	.345
13. Posttest Part 3 Feelings													.443	.471	.324	.461
14. Posttest Part 4 Feelings														.456	.311	.333
15. Posttest Life Science															.578	.681
16. Posttest Nature of Science																.598
17. Posttest Science Process																

ranging from .409 to .532. Also, the four pretest subscales have moderately high correlations with their posttest counterparts, with rs of .570, .583, .527, and .658 for Parts 1, 2, 3, and 4, respectively. As expected, these attitude subscales have relatively low correlations with the ability measures, even though it is interesting to note that the posttest subscales are more strongly related to entering ability than are the pretest subscales. This suggests that students' attitudes toward science were more closely aligned with their general ability at the end of the year than at the beginning of the year. A similar kind of pattern is detectable by looking at the relationships between the pretest "Feelings" and cognitive science measures and comparing them with the same posttest relationships. At pretest, the correlations between these noncognitive and cognitive measures are relatively low, ranging from .171 to .344. By posttest, the relationships have strengthened some, with correlations ranging from .311 to .471. Again, this suggests a closer alignment between attitudes and performance at the end of the year than at the beginning. Here, the chain of causality may be operating in either direction. Within these sets of relationships, it also is worth noting that the Life Science measure correlates more highly with the "Feelings" subscales than either the Nature of Science or Science Process measures. One can speculate that since the Life Science measure reflects what is most typically taught and valued in school (i.e., the accumulation of factual knowledge), students' attitudes toward the subject matter of science are most closely associated with this performance realm.

The second set of relationships worth examining is that of the ability measures--that is, Word Meanings, Pattern Completion, and the Ability Composite. The correlation between Word Meanings and Pattern Completion is .515, indicating related but sufficiently unique measures. This is consistent with theory on the crystallized and fluid components of ability. Turning to the relationship between the Ability Composite and the pretest cognitive science measures, the table shows a fairly strong correlation between pretest Life Science and ability (r = .718), suggesting that general ability has an important role in determining one's initial knowledge of life science. The correlation between ability and Science Process is somewhat less (r = .671) and that between ability and Nature of Science is lower yet (r = .501). Looking at the relationship between ability and the same measures at posttest, the general pattern is that of correlations that are slightly lower than they were at pretest, the largest reduction occurring for Life Science. This indicates, then, that there were factors other than ability that influenced students' progress over the year.

The third set of relationships deserving separate comment is that among the pretest and posttest cognitive science measures by themselves. At pretest, it is worth noting that the strongest relationship is between Life Science and Science Process (r = .645). The Nature of Science measure has moderate but weaker relationships with these two measures (rs = .499 and .437, respectively). The relationship among these three measures at posttest is similar in pattern, but increased in strength. This suggests that whatever students learned during the year, it increased their capacity to perform well on all three measures. Examining the correlations between pretest and posttest, the coefficients for Life Science, Nature of Science, and Science Process are .740, .458, and .677, respectively. While these are moderate to strong correlations, they still indicate substantial proportions of variance that could be accounted for by other factors. This, of course, is a question that will be explored throughout the remainder of the report.

Growth on Student Outcomes

Patterns of student growth on outcomes are examined more fully in this section. Several means of exploring student growth were employed in order to present the fullest picture possible. First, post-on-pre slopes were examined for each outcome measure. Second, as an initial step, a decision was made to analyze student change scores as an indicator of growth. While there has been much controversy in the past regarding the advisability of using straight gain scores, new considerations point to these scores as preferable to other more complex methods (e.g., Rogosa, Brandt, & Zimowski, 1982). Thus, the growth scores were examined descriptively for patterns across measures and classes. Third, the relationships between growth scores and students' entering ability and pretest performance were examined. The purpose of this examination was to check for any possible confoundings that might exist.

Post-on-Pre Slopes

Figures 5.1-5.7 present the post-on-pre slopes for the seven outcome measures (the four "Feelings" subscales and three cognitive measures). In each figure, there are 11 regression lines, one for each of the sample classes. Each line is tagged at the left end by its class number. The length of each regression line was drawn to correspond to the entire range of each class' pretest scores. The standard errors of estimate for these lines were small to moderate, with the following ranges for each respective measure: .246 - .729 for Part 1 Feelings, .377 - .694 for Part 2 Feelings, .371 to .591 for Part 3 Feelings, .327 - .660 for Part 4 Feelings, 2.059 - 4.815 for Life Science, 1.616 - 3.451 for Nature of Science, and 1.141 - 3.314 for Science Process.

Without going into great detail, there are several general observations to make about the slopes in the seven figures. First, relative to slopes for the cognitive measures, slopes for the "Feelings" subscales show more variation in placement across classes and across subscales. Particularly for the first three subscales, the degree of slope varies widely among classes with some classes having sharply positive slopes and others having much flatter, or even negative, slopes. This suggests that

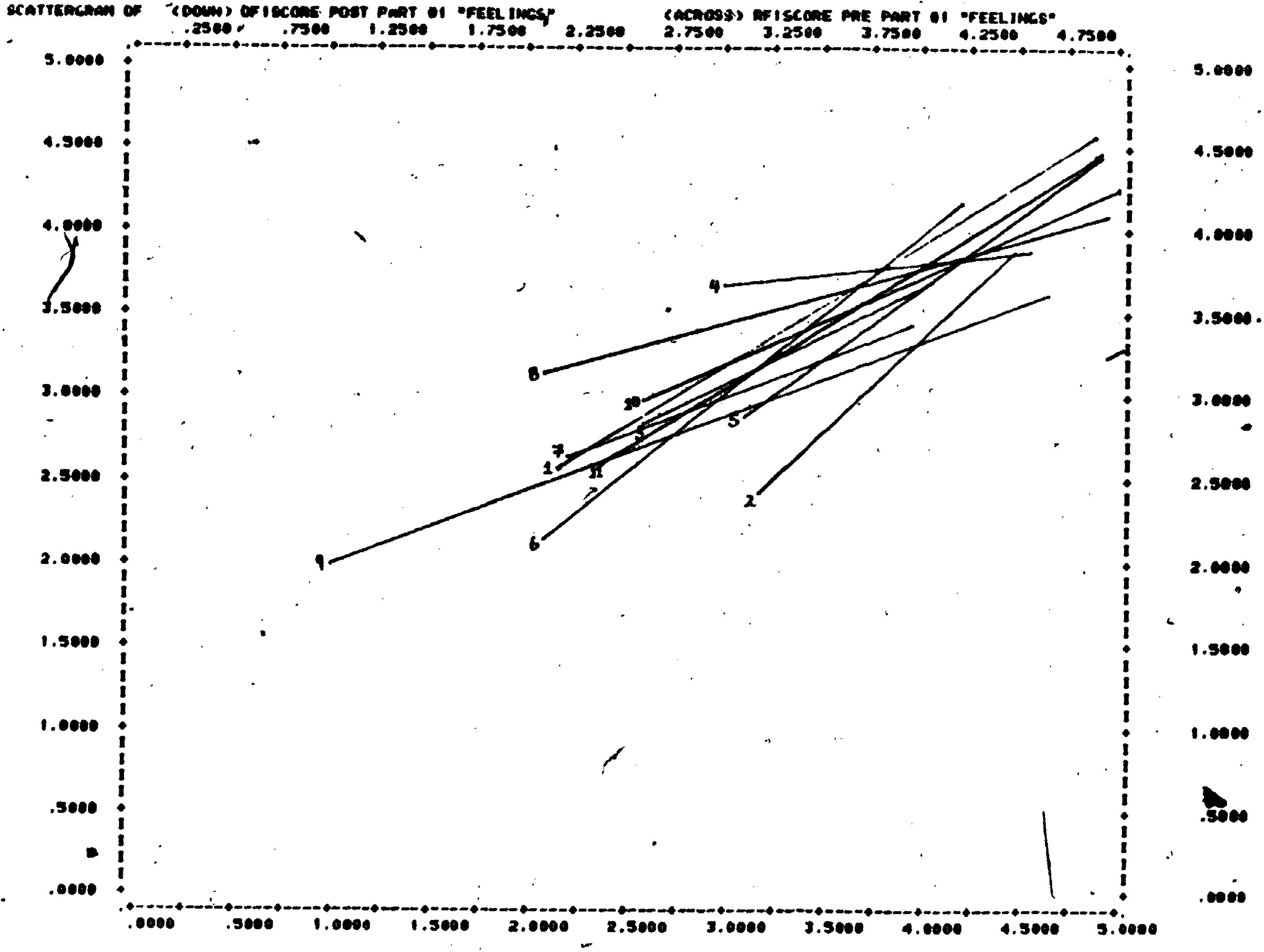

Figure 5.1. Post-on-pre slopes for eleven classes on Feelings, Part 1

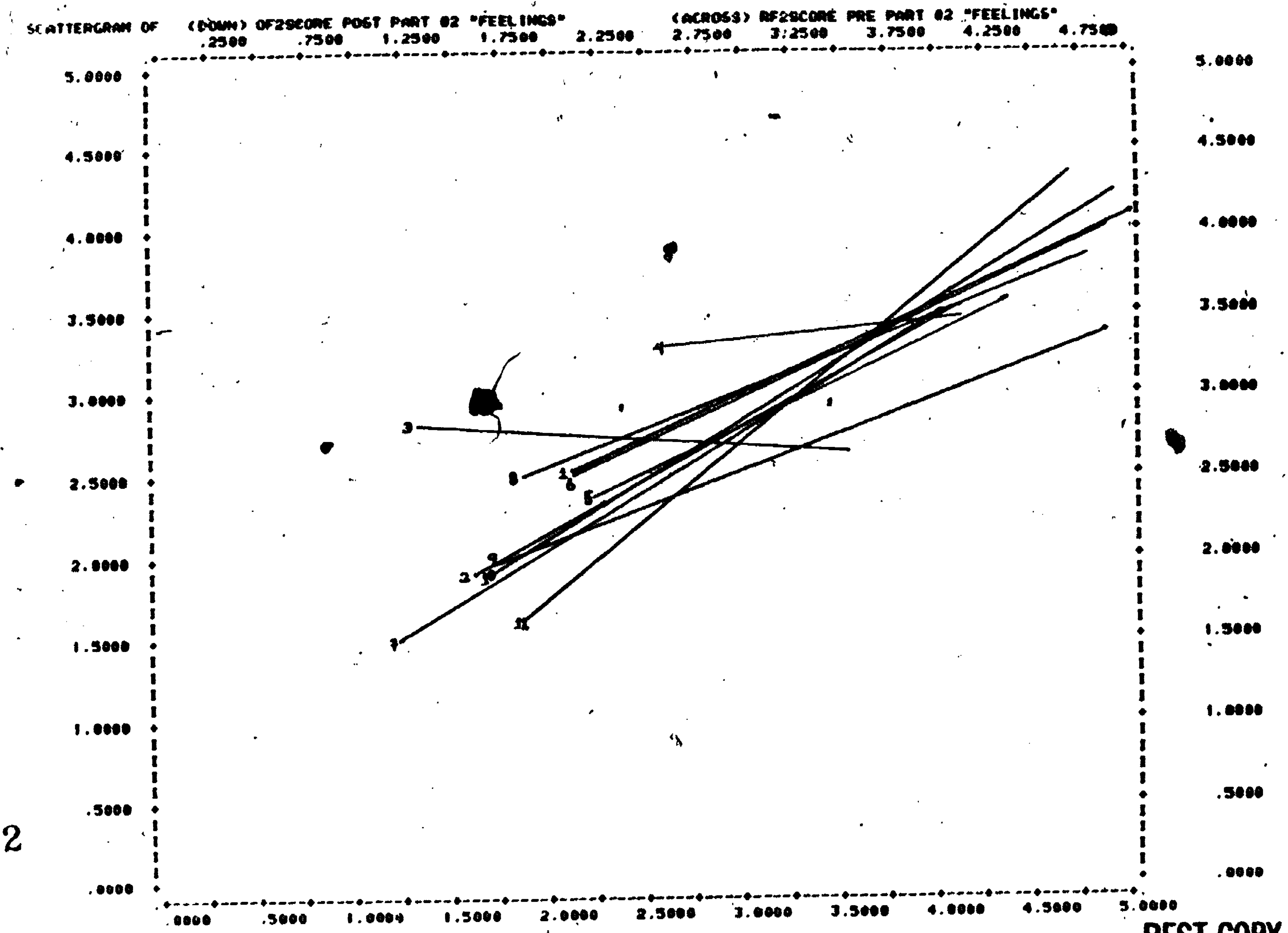

Figure 5.2. Post-on-pre slopes for eleven classes on Feelings, Part 2

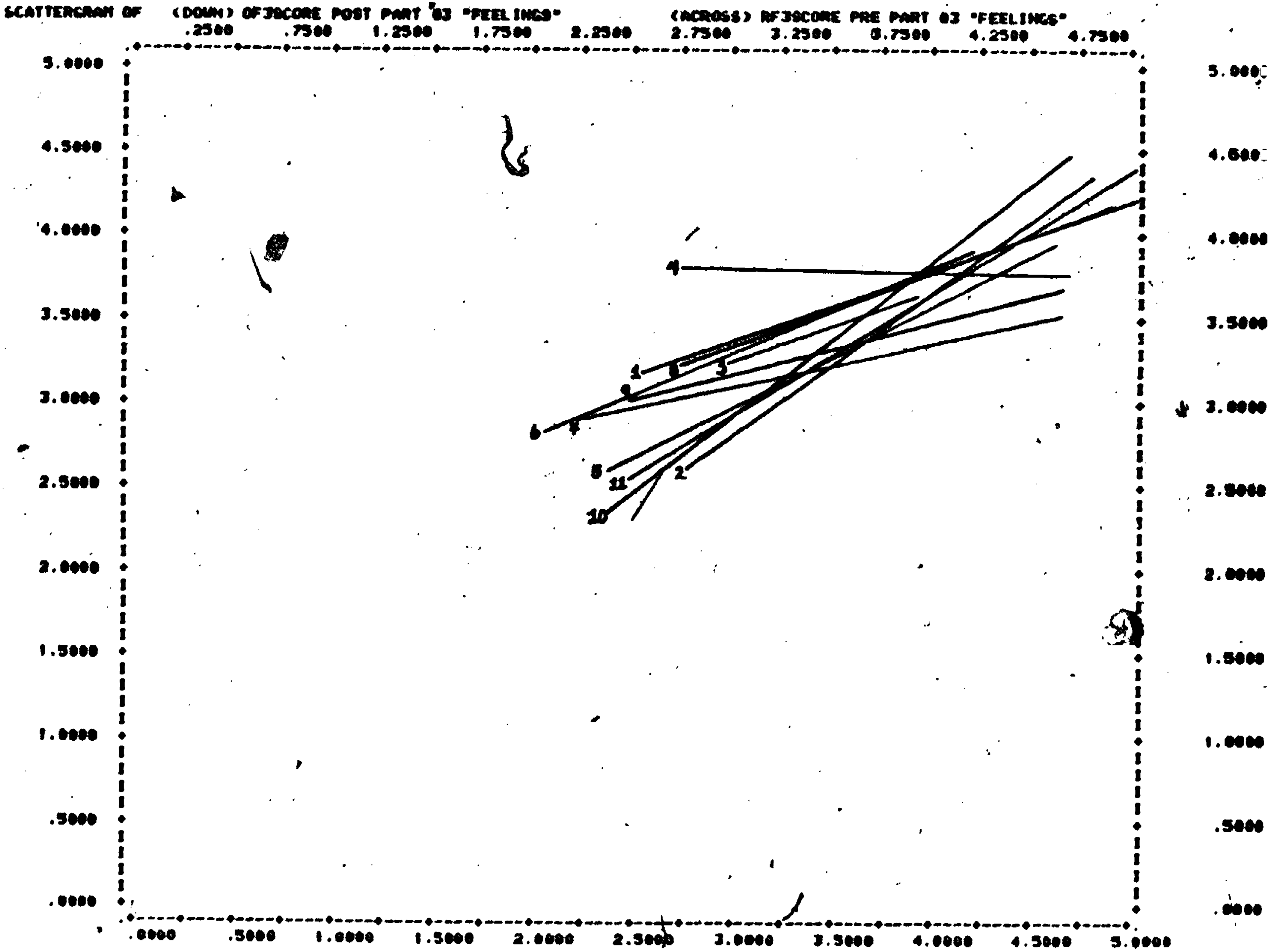

Figure 5.3. Post-on-pre slopes for eleven classes on Feelings, Part 3

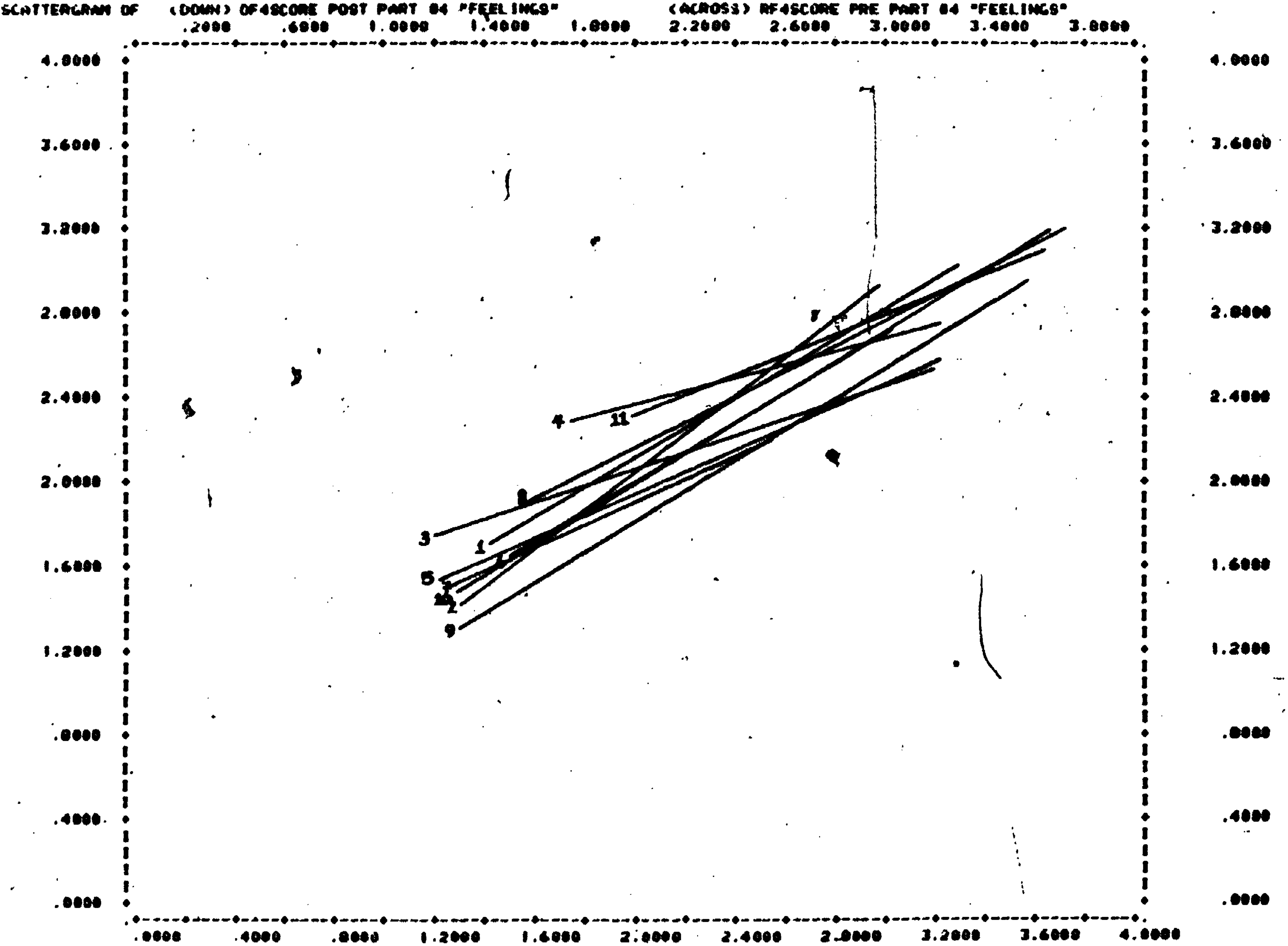

Figure 5.4. Post-on-pre slopes for eleven classes on Feelings, Part 4

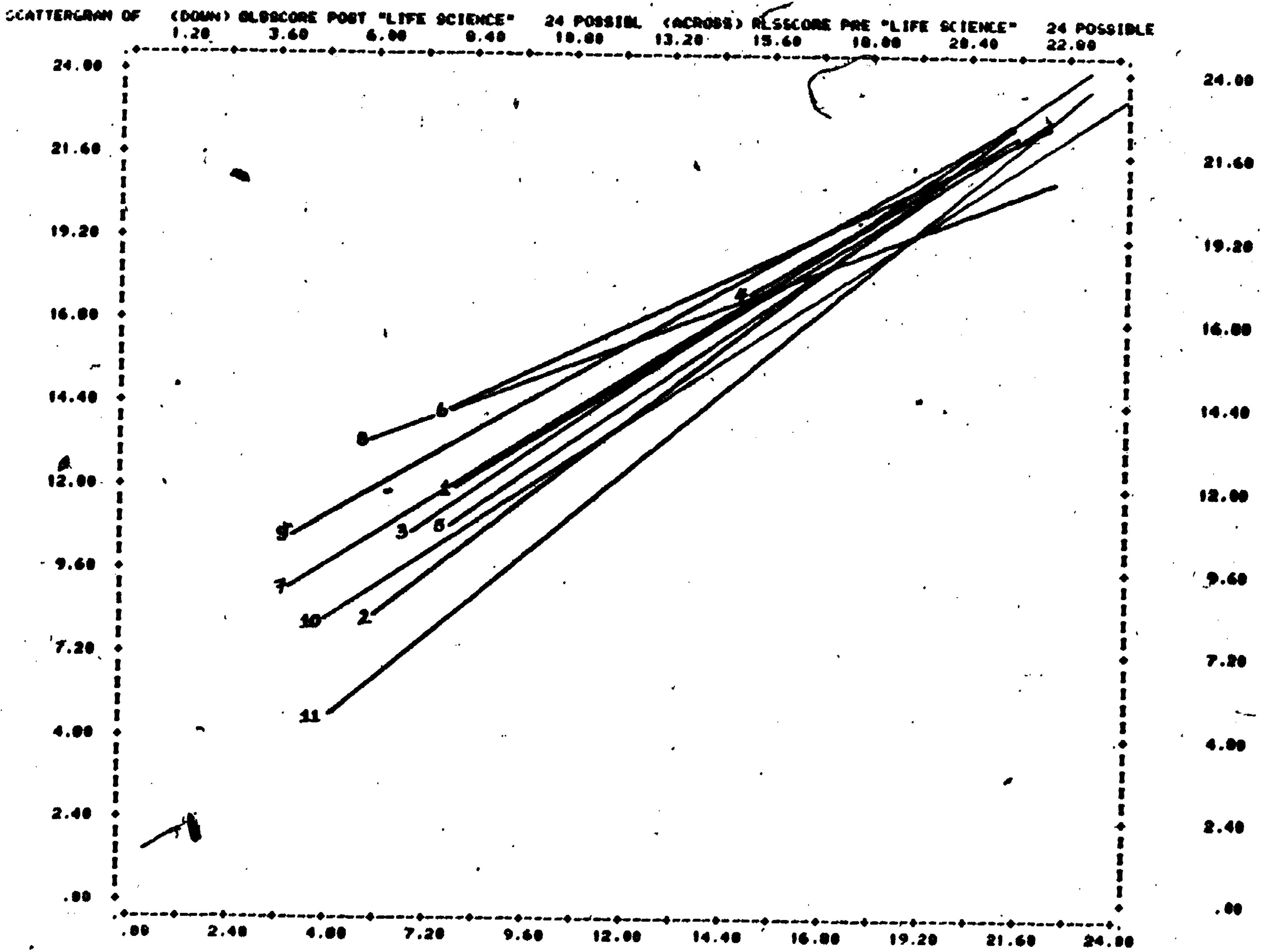

Figure 5.5. Post-on-pre slopes for eleven classes on Life Science

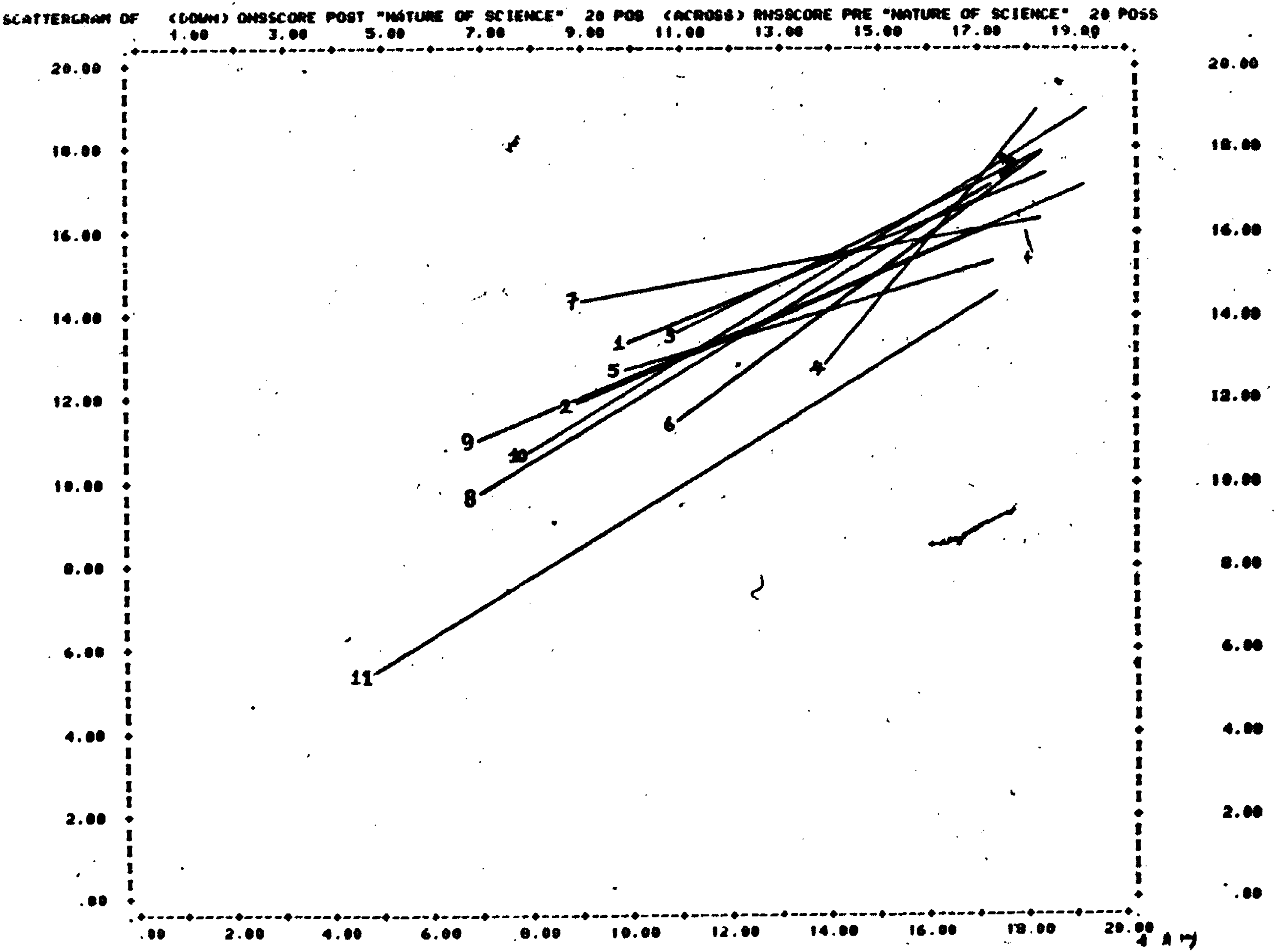

Figure 5.6. Post-on-pre slopes for eleven classes on Nature of Science

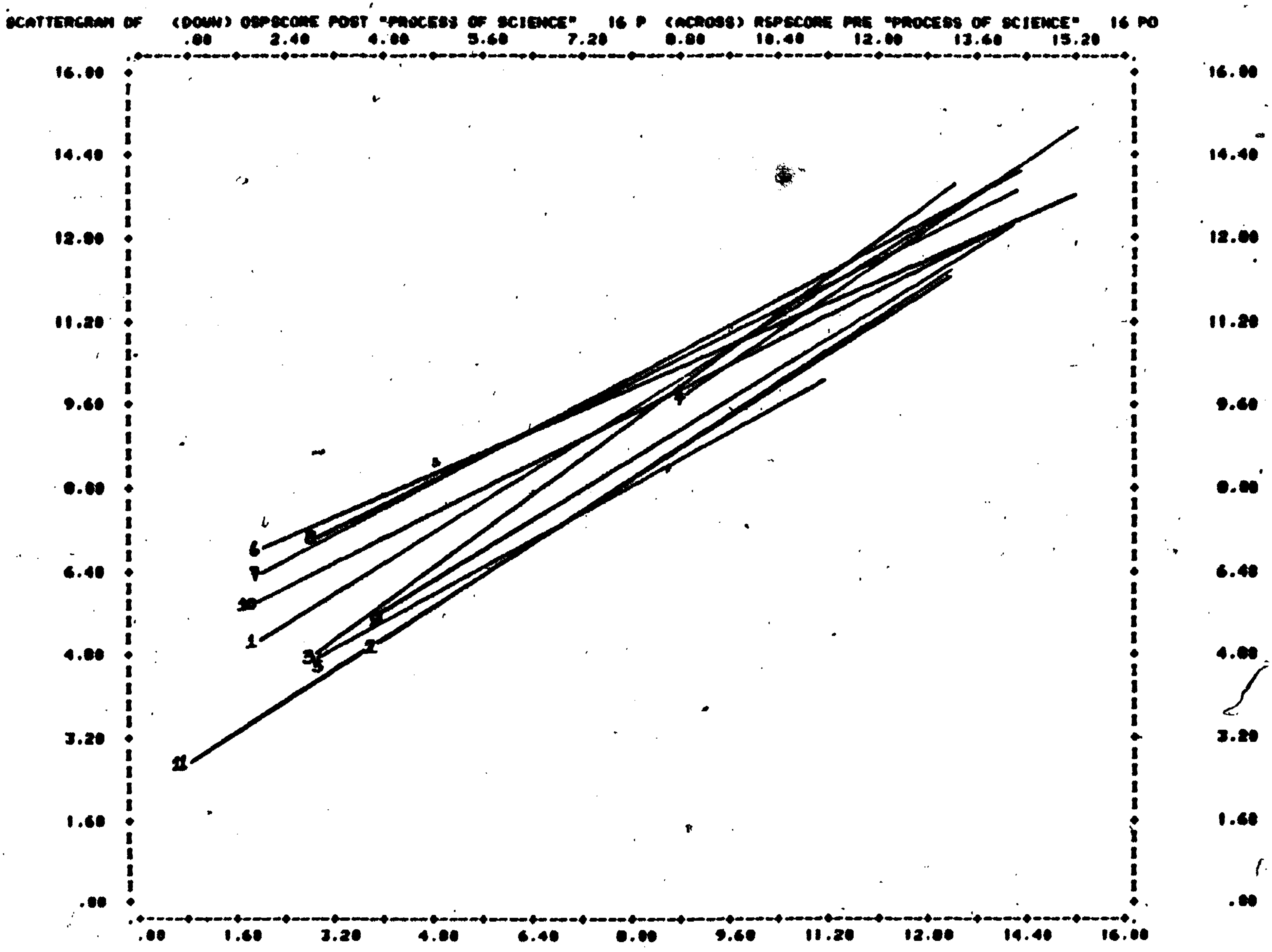

Figure 5.7. Post-on-pre slopes for eleven classes on Process of Science

change in feelings of students who started the year with more positive feelings relative to students who started the year with less positive feelings fluctuated from class to class. Also, it is difficult to take any one class and trace a fairly similar slope pattern across the "Feelings" subscales. The only obvious exception to this is the slope for Teacher 4, which has a high intercept and is relatively flat for all four subscales. It appears that while students in Teacher 4's class had relatively higher "Feelings" scores to begin with (i.e., at pretest), pretest variability was diminished by the end of the year, with all students having fairly similar posttest scores. Indeed, this is corroborated by the decrease in standard deviations for posttest scores for Teacher 4 in Table 5.3.

Another point worth noting is the relationship among slopes for the cognitive measures, those shown in Figures 5.5-5.7. Here, slopes for both the Life Science and Science Process measures appear quite similar. Not only are all the slopes fairly parallel and positive in nature, but the relative positioning of classes across the two measures is similar. Slopes for the Nature of Science measure are more scattered with less similarity of relative positioning among classes.

Finally, among slopes for the cognitive measures, a couple classes stand out. Slopes for Teacher 4 are distinct for all three measures because of their relatively restricted range at pretest -- that is, students started out as relatively high performers. Part of this trend may be explained by the small sample size for this class that was due to attrition (i.e. reassignment) of students at midyear. Also, Teacher 4's slope on Nature of Science is unique in that it is very steep. This would suggest that high pretest performers improved more relative to low pretest performers. Slopes for Teacher 11 also stand out in Figures 5.5-5.7. While the degree of Teacher 11's slopes is consistent with other classes, these slopes have wide pretest ranges and appear low relative to other classes. This suggests lower gains for this class, a matter that is addressed more directly below.

Descriptive Examination of Change Scores

Tables 5.5 and 5.6 present the class averages on student growth scores for the seven outcome measures. Rankings among classes on growth for each measure also are shown. In fact, these tables present extensions of Tables 5.2 and 5.3, which showed pretest and posttest scores, but not the calculated gains.

Examining Table 5.5 first, the trends for overall negative growth are identical to those discussed for Table 5.3. What is notable in Table 5.5 are differences in magnitude of growth and patterns of rankings among classes. Turning to magnitude of growth, the total scores at the bottom of the table show that decline was most substantial for Part 2 (intentions for future involvement with science), followed by Part 1 (attitudes toward

Table 5.5

Change Scores and Rank by Class on Four Subscales of Student Noncognitive Measure

TEACHER	FEELINGS, Part 1	Rank	FEELINGS, Part 2	Rank	FEELINGS, Part 3	Rank	FEELINGS, Part 4	Rank
1	.101 (.530)	1	.071 (.672)	2	-.039 (.587)	4	.060 (.384)	2
2	-.609 (.682)	11	-.238 (.627)	9	-.305 (.469)	10	.017 (.334)	3
3	-.068 (.450)	5	-.093 (.821)	3	.008 (.457)	3	-.027 (.498)	5
4	.045 (.441)	2	-.103 (.552)	4	.012 (.641)	2	.179 (.432)	1
5	-.270 (.65)	10	-.349 (.49)	10	-.239 (.97)	8	-.117 (.95)	8
6	.042 (.491)	3	-.064 (.710)	1	-.083 (.613)	1	-.081 (.404)	7
7	-.127 (.514)	7	-.168 (.577)	5	-.312 (.694)	11	-.033 (.349)	6
8	-.001 (.665)	4	-.192 (.647)	6	-.133 (.585)	7	-.006 (.455)	4
9	-.208 (.847)	8	-.382 (.820)	11	-.049 (.664)	6	-.221 (.419)	10
10	-.221 (.530)	9	-.232 (.533)	8	-.045 (.459)	5	-.130 (.385)	9
11	-.090 (.420)	6	-.197 (.565)	7	-.252 (.401)	9	-.242 (.528)	11
Total	-.141 (.597)		-.193 (.643)		-.126 (.567)		-.058 (.436)	

science classes), Part 3 (attitudes toward science in general), and Part 4 (interest in science outside class). Paired sample t-tests between pretest and posttest scores, indeed, indicated that these average levels of decline were statistically significant for Parts 1, 2, and 3 (ts = -3.46, -4.39, and -3.23, respectively), with Part 4 approaching significance (t = -1.93, p = .055). Assessing the practical importance of the overall levels of decline is, of course, more difficult. While declines of one-tenth to two-tenths of a point are not great on a four- or five-point scale, it is the consistency of the decline across measures and for most classes that seems most worrisome. Also, while average declines by class are typically moderate in range (from slightly positive to about -.25), there are a few classes that stand out. Teacher 2's class, for example, has an especially large decline on Part 1 (-.609), as well as a greater than average decline on Part 3 (-.305). On Part 2, the classes of Teachers 5 and 9 stand out, with declines of -.349 and -.382, respectively. Finally, on Part 3, Teacher 7's class is noteworthy, with an average decline of -.312.

The rankings in Table 5.5 suggest somewhat varied patterns of growth across classes and measures. Visual comparisons suggest that for Parts 1, 2, and 3, there are some fairly strong similarities in rank orderings among classes: those classes that tended to have more positive (or less negative) growth on one part also had more positive growth on other parts. Indeed, rank-order correlations support this: the correlation between Parts 1 and 2 equals .836, between Parts 1 and 3 equals .655, and between Parts 2 and 3 equals .600. The rank ordering for Part 4 shows less correspondence with the other subscales, with some major changes in position for classes (e.g., Teachers 2 and 6). Here, correlations confirm weaker, although still substantial relationships: correlations of Part 4 with Parts 1, 2, and 3, are .473, .491, and .264, respectively. In short, Part 4 seems to operate more distinctly as a measure than Parts 1 through 3. Perhaps this is attributable to the fact that items on Part 4 are those least associated with schools and the formal educational process, focusing on science activities outside of class.

Table 5.6 presents the growth scores for the three cognitive measures. The trends of overall positive growth on these measures have been discussed earlier in this chapter. Here, in addition, it can be noted that the magnitude of change for each of these measures, as tested by paired, pre-post comparisons, was highly significant (ts = 9.36, 3.83, and 5.05 for Life Science, Nature of Science, and Process of Science, respectively). (Comparisons of change scores across measures are not meaningful, however, because the three measures have substantially different scales.

Turning to the ranks in Table 5.6, it appears that while there is some correspondance of ranks across the three measures, it is not especially strong. Indeed, rank order correlations indicate low to moderate relationships. Ranks for Life Science have correlations of .382 and .282 with ranks for Nature of

Table 5.6

Change Scores and Rank by Class on Three Student Cognitive Measures

TEACHER	LIFE SCIENCE	Rank	NATURE OF SCIENCE	Rank	SCIENCE PROCESS	Rank
1	2.370 (2.292)	6	1.222 (2.207)	3	1.519 (.587)	3
2	1.833 (3.535)	7	.750 (2.908)	7	.000 (2.638)	11
3	2.417 (2.999)	4	1.250 (1.865)	2	1.333 (1.723)	5
4	1.615 (2.063)	9	.385 (1.805)	8	.385 (1.938)	7
5	2.381 (3.025)	5	.333 (3.006)	9	.286 (2.493)	8
6	2.895 (3.160)	3	.158 (2.115)	10	1.474 (1.867)	4
7	3.200 (2.895)	2	1.750 (2.653)	1	2.150 (2.758)	1
8	1.647 (4.257)	8	.765 (2.078)	6	1.765 (2.333)	2
9	3.222 (3.040)	1	.889 (3.596)	5	.222 (3.228)	9
10	1.174 (2.855)	10	1.087 (3.059)	4	.870 (2.599)	6
11	.684 (4.679)	11	-1.053 (2.738)	11	.053 (3.341)	10
Total	2.127 (3.316)		.704 (2.685)		.911 (2.633)	

Science and Science Process, respectively. The correlation between Nature of Science and Science Process is somewhat higher at .541. In short, patterns of average class growth were such that classes showed moderately similar patterns of growth on Nature of Science and Science Process; classes' growth on Life Science, however, was fairly distinct from growth on the other two measures. This pattern makes sense to the extent that the observed teaching and tasks in the sample life science classes focused primarily on factual content, that which most closely corresponds to the skills tapped by the Life Science measure. In contrast, it seems that teachers rarely, if ever, "taught to" the skills tapped by the Nature of Science and Science Process measures. It is interesting to note that these patterns of growth were not obvious from the slopes in Figures 5.5 to 5.7, where Life Science and Science Process appeared more similar than Nature of Science. This may be attributable to the fact that average class growth is difficult to infer from slopes; indeed, slopes are most useful for detecting relative degrees of growth among students of different pretest aptitude.

Relationships between Growth and Entering Performance

Having examined student growth on outcomes at a general, descriptive level, it is now prudent to consider how growth was related to students' incoming performance. Table 5.7 presents student-level correlations between gain scores and initial ability and pretest scores.

Looking first at the correlations with the ability composite, Table 5.7 shows only a small (albeit significant) positive relationship between ability and gain on the first three subscales of the "Feelings" measure. This indicates that students of higher ability showed greater gains (or perhaps smaller declines) in their attitudes about science relative to lower ability students. What is considerably more pronounced in Table 5.7 are the correlations between gain and pretest scores. Here the correlations are all consistently negative and moderate in strength. This indicates that on every outcome measure, students who started out with higher scores gained less by the end of the year, while students who started out with lower scores gained more. This pattern has been commonly observed in gain data from other studies (see Linn & Slinde, 1977), but its cause and treatment are arguable. One possible explanation for the pattern might be ceiling effects for the measures. This seems an unsatisfactory explanation, however. Ceiling effects on noncognitive measures are difficult to contemplate, especially since the overall trend was for negative growth. Also, an examination of posttest means and standard deviations in Table 5.2 does not suggest that many students achieved near perfect scores on the cognitive measures -- in short, nearly all students had room to improve, even at posttest. Another explanation is that the pattern is attributable to the statistical artifacts of gain scores (Linn & Slinde, 1977), a reason often cited in favor of abandoning gain scores. This position is countered by Rogosa, et al. (1982), who suggest

Table 5.7

Correlations between Growth on Outcomes and Entering Ability and Pretest Performance (N=213)

Growth Measure	Correlation with Ability Composite	Correlation with Pretest Score
Feelings, Part 1	.148	-.380
Feelings, Part 2	.170	-.407
Feelings, Part 3	.204	-.427
Feelings, Part 4	.057	-.358
Life Science	-.049	-.300
Nature of Science	.041	-.410
Science Process	.046	-.336

that this pattern of negative relationship is not a fundamental problem; rather, it is overridden because the gain score remains the best unbiased estimate of true change.

In sum, Table 5.7 points out an important relationship between growth and initial performance that should be kept in mind when considering other results and potential analyses. It is a relationship that is potentially problematic to the extent that other instructional variables of interest are also correlated with pretest performance.

Student Growth and Its Relationship to Class, Student Gender, and Teachers' Use of Scientific Literacy

In this section, we examine the relationship of several independent variables to student growth on outcomes at the student level. In the first set of analyses, class was included as an independent variable in order to answer the major question of whether or not there were significant differences among classes in the degree of student growth (or decline). Gender also was included as one major student characteristic that conceivably might be involved in differential growth. Student ability was not included in the analyses reported here for reasons discussed below. In the second set of analyses, teachers' use of scientific literacy served as an independent variable. Here, despite teachers' low overall use of the relating components of scientific literacy, it seemed important to ask whether there was differential growth between classes where teachers used relating components more frequently and classes where teachers used relating components less frequently. In short, in addition to asking whether class membership by itself made a difference, teachers' use of scientific literacy provided another means for grouping students, one that reflected the central normative framework of the study.

Analyses with Class Membership and Student Gender

The selected method of statistical analysis was an analysis of variance (ANOVA). An ANOVA was run for each of the seven outcome variables (four noncognitive and three cognitive). For each run, difference scores (post minus pre), computed at the student level, served as the dependent variable with class and gender as independent variables. Both independent variables were treated as fixed.

Table 5.8 presents the ANOVA results for the four subscales of the Feelings Toward Science measure. The table indicates two statistically significant results. First, there is a highly significant class effect ($F = 2.74$, $p = .004$) for the Part 1 subscale. Because Part 1 was the subscale that specifically addressed students' attitudes toward science classes, it is perhaps not surprising that this measure was related to class

Table 5.8.

Analysis of Variance of Pretest to Posttest Change in Four Subscales of Student Noncognitive Measure

		Feelings Part 1 (N=213)		Feelings Part 2 (N=213)		Feelings Part 3 (N=213)		Feelings Part 4 (N=213)	
Source	df	F	p	F	p	F	p	F	p
Class	10	2.74	.004	.53	.871	1.19	.303	1.55	.126
Gender	1	1.45	.230	.34	.560	.00	.964	1.80	.182
Class x Gender	10	1.50	.141	.95	.491	1.10	.361	1.96	.039
Mean Square Error		.320		.425		.319		.178	

membership. Mean gain scores point to Teachers 1 and 4 as having the greatest gains (or smallest decreases) on this subscale; while Teachers 2 and 5 had the greatest declines.

The second significant result in Table 5.8 is the class by gender interaction for the Part 4 subscale. This subscale measured students' involvement in science activities outside class. The presence of an interaction suggests that there were differences favoring girls in some classes and boys in other classes. Mean gain scores, broken down by class and gender, suggest that males tended to be somewhat more favorable than females overall, although there were more classes (six) where the direction of means favored females. These means indicated that males were substantially more favorable in the classes of Teachers 1, 7, and 11. Females were notably more favorable than males in the class of Teacher 9. Here, it is not clear if gender of the teachers played a role. There were only four female teachers in the study; three taught classes where males were more favorable and one taught a class where females were more favorable. In short, with a relatively small sample, it is difficult to speculate on the source of this interaction. There is much past research to indicate that teachers sometimes give differential treatment to boys and girls (probably because of general behavior differences between the two sexes), but without observation data at the level of individual students, we cannot determine if teacher behavior was a possible source of the interaction (see Brophy & Good, 1974; Brophy & Evertson, 1981).

Summing up this table, it is interesting to note that effects were found for the Parts 1 and 4 subscales only. This makes some sense in that these subscales measured attitudes in realms fairly immediate to students (their science classes and science activities outside class). In contrast, Parts 2 and 3 measured student attitudes toward future involvement in science and toward science in general. These realms may have been too general to be affected by experiences students gained in a one-year life science class.

Table 5.9 presents the ANOVA results for the three cognitive science measures of Life Science, Nature of Science, and Science Process. While the class factor accounts for more variance than the gender factor throughout, there is only one class effect approaching significance--that for Science Process (F = 1.73, p = .076). Despite its weakness, this result is noteworthy because of all the cognitive measures, the Science Process measure tapped a realm of thinking that may be the most transferable to life situations -- namely, the ability to apply scientific reasoning. Of course, this also is a measure that teachers apparently did little to address directly in class. In this sense, a nearly significant class effect is surprising. Means for this measure indicate that students in the classes of Teachers 7 and 8 gained the most on this measure while students in the classes of Teachers 2 and 11 gained the least.

Table 5.9.

Analysis of Variance of Pretest to Posttest Change in Three Student Cognitive Measures

		Life Science (N=213)		Nature of Science (N=213)		Science Process (N=213)	
Source	df	F	p	F	p	F	p
Class	10	1.17	.315	1.42	.173	1.73	.076
Gender	1	.03	.873	.34	.561	.10	.759
Class x Gender	10	.78	.652	.87	.561	1.11	.357
Mean Square Error		11.077		7.113		6.696	

Altogether, the findings in Table 5.9 are disappointing because they fail to suggest significant differences in growth among classes that could be used as one clear indicator of differential teacher effectiveness. While there certainly were mean differences among classes, these differences apparently were not great enough (at least, relative to within-class variation) to reach significance.

Before concluding, it is worth addressing the role of the Ability Composite in growth on the cognitive measures. Conceptually, it seems reasonable to argue that ability would be an important predictor variable to control for in the analyses of growth on cognitive measures. This proved not to be the case, however. When the analyses of the cognitive measures were run with ability as a covariate, the results were virtually unchanged, with F values rarely increasing or decreasing by more than .02. The explanation for this may best be found in the intercorrelations of Table 5.4. Because ability was highly correlated with pretest Life Science, Nature of Science, and Science Process (rs = .718, .501, .671, respectively), it most likely was the case that ability was largely taken into account by the use of the pretest score in the calculation of the dependent measure. In short, it seems there was little of a unique nature that ability contributed to these analyses.

Analyses with Teachers' Use of Scientific Literacy

For this set of analyses, teachers were grouped according to their overall use (across Topics 1 and 2) of the relating components of scientific literacy (see Chapter 3). When the percent of total presentation time devoted to the relating components was calculated for each teacher, two natural groupings suggested themselves. These are shown in Table 5.10. One group, referred to as the Lower Use group, had percentages ranging from 0 to 1.2. The second group, referred to as the Higher Use group, had percentages ranging from 3.5 to 11. With this grouping distinction as a two-level independent variable, t-tests were computed for each outcome, with student gain scores serving as the dependent variable.

Table 5.11 presents the results for the t-tests. With students in classes of Lower Use teachers serving as the first group, negative t values would be predicted by the hypothesis that students in Higher Use classes had greater gains. In fact, t values are negative for two outcomes only -- Parts 1 and 3 of the Feelings measure -- and these values do not approach significance. The remaining five t values are positive, suggesting a trend where students in Lower Use classes gained more than students in Higher Use classes. While none of these values are significant, note that the two values that come closest are for Nature of Science and Science Process ($t = 1.44$, $p = .152$, and $t = 1.69$, $p = .092$, respectively). These, indeed, are the measures we might expect to be most influenced by teachers' use of scientific literacy. The trend suggesting that these outcomes

Table 5.10

Teachers' Total Percentage (Across Topics) of Scientific Literacy Use, Grouped by Lower and Higher Use

Group	Teacher	% of Presentation Time Devoted to Relating Components
Lower Use (0 - 1.2%)	2	0
	3	.2
	6	.7
	7	.5
	8	.5
	10	1.2
Higher Use (3.5-11%)	1	11.0
	4	3.8
	5	4.0
	9	4.0
	11	3.5

Table 5.11

T-test Results Comparing Students in Classes with Lower versus Higher use of Scientific Literacy

Outcome	Lower Use Mean	Higher Use Mean	*t* value	*p* value
Feelings, Part 1	- .194	- .080	-1.40	.163
Feelings, Part 2	- .174	- .216	.48	.632
Feelings, Part 3	- .132	- .118	- .18	.861
Feelings, Part 4	- .045	- .072	.44	.657
Life Science	2.148	2.102	.10	.920
Nature of Science	.948	.418	1.44	.152
Science Process	1.191	.582	1.69	.092

might have been influenced in a way opposite to that anticipated warrants some attention. Perhaps the most obvious explanation for such a trend rests with the quality of teachers' use of the relating components that was discussed in the latter part of Chapter Three. Recall that the conclusion from this chapter was that when teachers did make reference to the relating components of scientific literacy, these references often were confusing and sometimes even inaccurate. Thus, it is possible that teachers who made more use of the relating components actually did a disservice to students, planting the seeds of further misconceptions in students' minds; this, in turn, might lead to lower student performance and measures designed to directly test students' understanding of relating components.

In sum, the results in this section suggest that teachers' use of scientific literacy was not a powerful explanatory variable for student growth on outcomes. Perhaps this is not surprising given that teachers' overall use of the relating components of scientific literacy was so minimal. While one can conceive of some low-frequency variables that might have a marked impact on students (e.g., use of personal criticism), this may have been a case where there simply were not enough occurrences to produce meaningful variance -- thus, good tests of relationships were precluded. Also, as emphasized in Chapter Three, the use of the relating components may only have measurable, positive value if done consistently within and across topics, as an organizing framework for factual content. Anything short of this may actually prove counterproductive, as trends in these data suggest.

Summary

The results of this chapter indicate that there were substantial differences among classes in their performance on both cognitive and noncognitive science measures at the beginning of the school year. Also, the relationships among the different variables appeared largely as expected, although students' general ability played a larger role in accounting for pretest performance on cognitive science measures than might have been anticipated. When both pretest and posttest class means on the student outcomes were examined, there was a general trend such that students' attitudes toward science declined over the school year while their performance on measures of science knowledge, understanding, and process increased. When student gains on the outcomes were examined in more detail, classes showed similar patterns of average growth across three of the four attitude measures. On the cognitive measures, average class growth on Nature of Science and Science Process had similar patterns, with growth for Life Science being more distinct. Another important feature of student gains was their moderate negative correlation with student pretest scores, such that students with higher pretest scores gained less than students with lower pretest scores on all outcomes.

The last part of the chapter examined the role of several independent variables in explaining student gain on outcomes. When the role of class membership and student gender on student outcome change over the year was examined, significant effects were limited to two subscales tapping students' attitudes toward science classes and science activities outside of class. These probably were the most proximal of all the outcome measures administered. There also was a nearly significant effect for class membership on the measure of students' ability to engage in scientific reasoning. When teachers' use of scientific literacy was examined as an explanatory variable, results indicated no significant differences in growth for students who where in classes where teachers made more use of the relating components of scientific literacy compared to students in classes where teachers made less use of these relating components. Teachers' frequency of use simply may have been too low to allow meaningful tests. However, there actually was a slight trend suggesting that students' growth on the Nature of Science and Science Process measures may have been injured by teachers' greater use of the relating components, possibly because the use was inconsistent and of poor quality.

CHAPTER SIX

THE QUALITY OF TEACHING BEHAVIOR

This chapter describes observers' ratings of the quality of teaching behavior in the eleven classes. Here, the focus is on teaching behaviors that have been linked to student growth on outcomes in studies of general teaching effectiveness, i.e., behaviors that are not specific to the teaching of life science. In this study, we gathered higher-inference data on the quality of teaching behavior because it was anticipated that quality would be an important element in explaining student change on outcome measures. It was expected that a basic repertoire of generic effective teaching behaviors would be a necessary -- although perhaps not sufficient -- condition for a relatively successful class, even in a specific subject area like life science. Unfortunately, for reasons described below, it was not possible to examine the direct relationship between quality of teaching and student growth on outcomes. Nonetheless, we think it is useful to present a descriptive account of the data on teaching quality.

Data Source and Analyses

The quality of teaching behavior was measured with 27 rating items on the Science Class Description (SCD) form. A copy of this instrument appears in Section Six of Appendix A. All items were in a five-point Likert-scale format, with the a "5" designating the most desirable response, and a "1" the least desirable response. Two of the 27 items came from Part 1 of the SCD, focusing on the degree of teachers' academic task orientation and the number of students generally paying attention in class. The remaining 25 items came from Part 3 of the SCD, covering a spectrum of managerial, instructional, and motivational concerns. As indicated in Chapter Two, observers completed the SCD ratings following every visit to a class; thus, the number of SCD ratings for a given teacher corresponds to the number of observed days for Topic 1 and Topic 2. Two SCD items were exceptions to this general procedure: on ratings of teachers' knowledge of subject matter and rapport with most students, observers were asked to complete these ratings only twice, once at the end of each topic.

For purposes of analyses, the SCD ratings were aggregated to the class level. This was accomplished by computing the average on each SCD item across all occasions for each teacher. Thus, the resulting data set consisted of 27 average rating scores per teacher. Before proceeding to use the ratings, the general ordering of teachers by the ratings was examined by the two first authors. This examination indicated one unexpected trend: one observer had rated his teacher (Teacher 8) consistently low on many of the SCD ratings, such that this teacher received the lowest average rating in many instances. This pattern was at odds with the researchers' general impression of Teacher 8's relative position among the teachers (two of the researchers had informally observed at least ten of the eleven teachers on one or more occasions). The researchers expected that Teacher 8 would receive ratings placing him no lower than the middle range of the teachers. Indeed, a follow-up conversation with the observer confirmed that he too viewed the teacher as being "in the middle of the pack." The observer also indicated that he often used the exact center point of the ratings scales (a "3") as a consequence. While this is understandable, it appears that other observers had a slightly higher center reference point. While there was no clear solution to this problem, some form of adjustment was considered necessary. The method selected was that of assigning Teacher 8 ratings representing the average of the other ten teachers on all the suspect items (items 8, 13, 14, 17, 18, 19, 21, 22, 23, 27, 28, and 31).

Descriptive Statistics

Table 6.1 presents the means and standard deviations by teacher for each of the 27 SCD rating variables. The variables are presented according to the ordering and numbering system in the instrument. While there is much information in the table, a good initial approach is to examine the total sample average ratings for variables that are unusually high or low. Focusing first on high items, the table shows three variables with average ratings above 4.0: relevance of questions asked (S19), accessibility to individuals (S25), and rapport with most students (S32). This indicates that relative to observers' experience with teachers in general, teachers in this sample were viewed as asking academic questions in recitation that were nearly always appropriate to the subject matter, as being easily available to assist students during seatwork or laboratories, and as being well-liked and respected by their students.

Turning to items with low average ratings, Table 6.1 indicates four variables with averages below 2.0: provides rationale for work (S12), suggests specific ways to learn (S16), type of questions asked (S18), and summarizes important points (S30). This indicates that teachers on the whole were rated as presenting no (or a very mundane) explicit rationale for assigned work, as rarely, if ever, suggesting specific learning strategies, as asking mostly lower-order (i.e. fact-recall) questions during recitation, and as rarely, if ever, summarizing the important points at the end of each period. It is interesting that three of these ratings (S12, S16, and S30) have to do with teachers' presentation of aids to learning (purpose, strategies, and summary). Two other similar variables -- provides overview initially (S10) and gives verbal markers (S15) -- also have relatively low ratings in Table 6.1 (with means of 2.31 and 2.57, respectively). The finding about lower-order questions is consistent with evidence about teachers' academic tasks -- i.e., that a low level of cognitive demand was placed upon students for

Table 6.1

Means and Standard Deviations on Science Class Description (SCD) Variables, by Class

TEACHER	1	2	3	4	5	6	7	8	9	10	11	TOTAL AVERAGE
S2 - Academic Task Orientation	3.95 (.71)	4.50 (.63)	3.65 (1.37)	4.50 (.63)	2.93 (1.21)	4.00 (.77)	4.33 (.77)	4.18 (.40)	4.06 (.85)	4.10 (.79)	3.64 (.92)	3.99 (.94)
S3 - Number of Students Attending	4.16 (.60)	3.25 (.68)	3.35 (1.17)	3.69 (.95)	3.43 (1.34)	3.18 (.75)	3.50 (.62)	4.27 (.47)	4.13 (.34)	4.45 (.51)	3.91 (.30)	3.76 (.86)
S8 - Overall Effectiveness	3.16 (.76)	4.63 (.72)	3.24 (1.52)	3.75 (.58)	3.29 (.73)	3.64 (.81)	3.89 (.76)	3.81 (.00)	4.31 (.60)	4.30 (.57)	3.82 (.75)	3.80 (.93)
S9 - Preparation for Instruction	3.95 (.78)	4.75 (.77)	3.06 (1.25)	3.81 (.66)	2.01 (1.07)	2.73 (1.19)	4.44 (.62)	3.36 (.50)	4.25 (.58)	4.70 (.47)	4.27 (.79)	3.76 (1.13)
S10 - Provides Overview Initially	2.95 (1.27)	1.88 (1.20)	2.76 (1.15)	1.87 (1.30)	2.50 (1.09)	1.36 (.92)	1.33 (.59)	1.82 (1.25)	3.56 (.89)	2.95 (1.23)	2.45 (1.13)	2.31 (1.28)
S11 - Relates Today's Activities	3.63 (.90)	2.06 (1.44)	2.53 (1.28)	2.53 (1.41)	1.14 (.53)	2.18 (1.25)	4.17 (.79)	3.64 (1.21)	4.00 (.82)	3.95 (.94)	2.73 (1.35)	2.96 (1.42)
S12 - Provides Rationale for Work	1.16 (.37)	2.00 (1.41)	2.65 (1.50)	1.53 (.92)	1.57 (1.02)	2.09 (1.45)	1.00 (.00)	1.18 (.60)	2.88 (.89)	1.55 (.76)	1.27 (.65)	1.72 (1.11)
S13 - Clarity of Directions	3.37 (1.01)	4.50 (.97)	3.29 (1.31)	4.31 (.70)	3.86 (1.17)	4.73 (.65)	3.00 (.69)	3.92 (.87)	4.75 (.45)	3.85 (.59)	4.09 (.54)	3.97 (1.05)
S14 - Content Presentation Logical	3.05 (.91)	4.78 (.67)	3.17 (.94)	3.79 (.58)	2.82 (.87)	3.67 (1.58)	3.11 (1.02)	3.57 (.50)	4.07 (.73)	3.94 (.56)	4.00 (.93)	3.63 (1.02)
S15 - Gives Verbal Markers	3.05 (1.47)	4.17 (1.60)	1.83 (1.34)	1.93 (.83)	2.09 (1.45)	3.56 (1.94)	1.39 (.70)	1.60 (1.08)	4.43 (.76)	2.41 (1.46)	1.78 (.97)	2.57 (1.55)
S16 - Suggests Specific Ways to Learn	1.47 (.96)	1.21 (.58)	2.23 (1.30)	1.54 (1.13)	1.00 (.00)	1.18 (.40)	1.00 (.00)	1.27 (.47)	1.79 (1.05)	1.41 (1.06)	1.40 (.97)	1.41 (.89)
S17 - Smoothness of Presentation	2.58 (1.02)	4.67 (.82)	3.42 (1.00)	3.86 (.66)	2.27 (.90)	2.78 (1.48)	3.11 (.68)	3.37 (.40)	3.86 (.53)	3.76 (.44)	4.20 (.63)	3.44 (1.05)
S18 - Type of Questions Asked	1.16 (.50)	1.43 (.79)	2.60 (.84)	2.60 (.74)	1.40 (.97)	1.88 (.99)	1.11 (.47)	1.74 (.89)	1.73 (1.01)	2.06 (.66)	1.75 (.89)	1.77 (.89)

Table 6.1 (cont.)

Means and Standard Deviations on Science Class Description (SCD) Variables, by Class

TEACHER	1	2	3	4	5	6	7	8	9	10	11	TOTAL AVERAGE
S19 - Relevance of Questions	4.53 (.51)	4.40 (.70)	4.10 (.57)	4.27 (.47)	3.71 (.49)	4.00 (.53)	4.56 (.51)	4.32 (.67)	4.64 (.50)	4.24 (.66)	4.13 (.64)	4.26 (.66)
S20 - Allows Time for Answers	1.05 (.23)	4.40 (.70)	2.55 (.82)	2.69 (1.32)	3.50 (1.07)	1.50 (.76)	1.44 (.51)	3.80 (.79)	3.09 (.54)	2.06 (.90)	1.29 (.49)	2.49 (1.28)
S21 - Feedback to Student Responses	3.42 (.69)	4.79 (.80)	4.42 (.67)	4.64 (.50)	4.00 (.82)	3.88 (.99)	2.22 (.65)	3.85 (.63)	3.92 (.95)	3.94 (.24)	4.14 (1.07)	3.93 (1.03)
S22 - Efficiency in Management	4.00 (.33)	4.19 (.66)	3.12 (.86)	4.00 (.82)	3.86 (.86)	3.18 (.87)	2.72 (.57)	3.73 (.40)	4.88 (.34)	3.70 (.80)	3.64 (.67)	3.73 (.90)
S23 - Effectiveness in Discipline	4.00 (.47)	3.50 (.63)	3.71 (1.05)	3.75 (1.57)	3.64 (1.50)	3.36 (.92)	2.78 (.65)	3.61 (1.04)	5.00 (.00)	3.05 (.60)	3.27 (1.01)	3.61 (1.11)
S24 - Monitors During Work	5.00 (.00)	4.73 (1.03)	3.08 (1.12)	3.85 (1.28)	2.64 (1.50)	3.50 (1.41)	3.41 (.80)	3.80 (.42)	5.00 (.00)	2.67 (1.40)	4.38 (.52)	3.82 (1.30)
S25 - Accessibility to Individuals	4.83 (.51)	4.73 (1.03)	3.00 (1.15)	3.42 (.90)	3.46 (.66)	4.00 (1.41)	3.88 (.49)	3.90 (.32)	5.00 (.00)	4.20 (.68)	5.00 (.00)	4.13 (.98)
S26 - Provides Unsolicited Feedback	3.22 (.81)	4.71 (1.07)	2.23 (1.01)	1.44 (.53)	1.23 (.60)	1.50 (1.41)	1.12 (.49)	2.10 (.32)	4.00 (.76)	1.53 (.52)	2.14 (1.46)	2.29 (1.42)
S27 - Fairness in Treatment	3.95 (.62)	4.75 (.68)	3.53 (.94)	4.31 (.70)	3.00 (1.11)	3.82 (.60)	3.17 (.62)	3.87 (.67)	3.75 (.58)	3.85 (.37)	4.82 (.60)	3.89 (.91)
S28 - Attitude About Learning	4.16 (.76)	4.75 (.68)	4.29 (.59)	4.31 (.60)	3.00 (.96)	3.73 (1.10)	2.78 (.43)	3.97 (.30)	4.81 (.40)	3.80 (.41)	4.00 (.77)	3.96 (.93)
S29 - Paces Period	2.79 (1.03)	4.63 (.72)	3.41 (1.28)	3.50 (1.59)	2.43 (1.45)	2.91 (1.64)	2.17 (1.04)	2.91 (1.30)	4.19 (.91)	4.50 (.51)	3.82 (1.40)	3.39 (1.40)
S30 - Summarizes Important Points	1.63 (1.16)	1.50 (1.15)	1.18 (.53)	1.19 (.75)	1.43 (.85)	1.36 (.81)	1.00 (.00)	1.36 (.81)	2.19 (1.37)	1.25 (.72)	1.36 (.81)	1.40 (.92)
S31 - Knowledge of Subject Matter[1]	4.00	5.00	4.00	4.00	3.00	3.50	4.00	4.00	5.00	4.00	3.00	3.95
S32 - Rapport with Most Students[1]	4.00	5.00	4.50	5.00	4.00	2.50	3.00	3.50	5.00	5.00	4.50	4.18

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[1] Standard deviations are not given for these variables because the average was based on only two occasions.

laboratory, worksheet, and exam assignments (see Chapter Four). Here, there is evidence that this lower-order climate extended to academic verbal exchanges between teacher and students as well.

The remaining ratings in Table 6.1 suggest that sample teachers generally were rated as slightly above average on most behaviors. In short, most teachers appeared strong in their academic orientation, management, and motivational skills. If there was any general weakness, it was in the area of presenting students with explicit learning aids during instruction.

One other variable deserving comment in Table 6.1 is S31, teachers' knowledge of subject matter. It can be seen that all but three teachers (Teachers 5, 6, and 11) were rated as having near or thorough mastery of the seventh grade life science curriculum. Perhaps this is not unexpected given a sample of volunteers who were comfortable with frequent observation. These ratings are thus probably higher than one would find for intermediate life science teachers in general. In short, the data here do not support the oft-mentioned view that most teachers of science at the secondary levels are deficient in subject matter knowledge.

The reader is left to explore Table 6.1 for the degree of variability among teachers on the SCD variables. Clearly there is important variability, as well as some consistency for teachers across variables. Teacher 5, for example, has generally low ratings, while Teacher 9 has generally high ratings.

The SCD variables also were examined for their interrelationships. Intercorrelations at the class and observation day levels, as well as a factor analysis (not shown here), were used to see if there might be a conceptually meaningful framework for organizing the variables. A synthesis of this exploration suggested that 18 of the 27 variables could be placed in five groups. These groups are shown in Table 6.2 and are termed Quality of Communication, Willingness to be a Resource, Positive Expectations, Classroom Management, and Explicit Learning Aids. The remaining 9 variables are listed as ungrouped. (The additional data in Table 6.2 are discussed below.)

The Relationship Between Teaching Quality and Student Performance

The purpose of collecting the Science Class Description (SCD) teaching quality ratings was to determine what role these behaviors played in explaining student outcomes. However, a couple of considerations impeded this investigation. These considerations are described next.

The first consideration was the relationship between student gain scores and student pretest scores. Recall from Chapter Five that this relationship was negative at the student level for all

Table 6.2

Correlations Between Science Class Description Variables and Student Pretest Cognitive Outcomes (N=11)

SCD Variables	Pretest Cognitive Outcomes		
	Life Science	Nature of Science	Science Process
I. Quality of Communication			
S8 - overall effectiveness	-.233	-.234	.230
S9 - preparation for instruction	-.123	-.124	.244
S13 - clarity of directions	.185	.110	.358
S14 - content presentation is logical	.055	.046	.391
S17 - smoothness of presentation	.018	.133	.437+
S29 - paces period	.259	.115	.425+
II. Willingness to be a Resource			
S24 - monitors during seat-lab work	.049	-.111	.116
S25 - accessibility to individuals	-.172	-.339	-.164
S26 - provides unsolicited feedback	-.094	-.363	-.014
III. Positive Expectations			
S21 - feedback to student responses	.464+	.425+	.495+
S27 - fairness in treatment	.191	.290	.407
S28 - attitude about learning	.299	.146	.478+
IV. Classroom Management			
S22 - efficiency in management	.071	-.149	.249
S23 - effectiveness in discipline	.031	-.159	.168
V. Explicit Learning Aids			
S10 - provides overview initially	.034	-.219	-.053
S12 - provides rationale for work	.083	-.094	.159
S15 - gives verbal markers	-.031	-.358	.043
S30 - summarizes important points	-.019	-.377	-.086
VI. Ungrouped Variables			
S2 - academic task orientation	.251	.199	.583*
S3 - number of students attending	.284	.041	.113
S11 - relates today's activities	-.049	-.180	.051
S16 - suggests specific ways to learn	.385	.290	.367
S18 - type of questions asked	.542*	.649*	.685**
S19 - relevance of questions asked	-.305	-.284	.155
S20 - allows enough time for answers	.016	-.140	.076
S31 - knowledge of subject matter	-.242	-.287	.106
S32 - rapport with most students	.219	.143	.452+

$^{+}p \le .10$

$^{*}p \le .05$

$^{**}p \le .01$

outcome measures. The same correlations at the class level (the unit of analysis necessary in this chapter) also proved to be negative for all outcomes: -.221, -.025, -.319, -.078, -.438, -.455, and -.247 for Parts 1, 2, 3, and 4 of Feelings, and Life Science, Nature of Science, and Science Process, respectively. The trend was for classes that had low average pretest scores to have high average gain, and vice versa, especially for the cognitive measures. While this relationship was not necessarily problematic in itself, it became so when viewed in connection with the second consideration.

The second consideration was the relationship between the teacher quality ratings and student pretest performance. Table 6.2 shows these class-level correlations with the cognitive outcomes. Several features of the correlations are worth noting. First, while the correlations are generally low in magnitude (as can be expected with such a small sample size), nearly two-thirds of them are in a positive direction. Second, the Science Process outcome has the greatest proportion of positive correlations. Third, of those correlations that do reach significance, all are in a positive direction. In short, this table suggests a trend for classes that had higher average pretest scores on cognitive measures, especially the Science Process measure, to have teachers who were rated more favorably on most of the teacher quality ratings. At least three different causal hypotheses for this relationship come to mind. One is that better teachers tended to be assigned to better classes. While none of the sample schools indicated that they practiced tracking, it is possible that inadvertent tracking occurred and that teacher assignments were not randomly distributed. Another hypothesis would be that better teachers were more selective in terms of the class they wanted observed for the study, and picked one of their higher-achieving classes. Yet a third hypothesis would be that teachers were more able (or inspired) to teach at higher levels of quality when they had a class of higher achieving students. Of course, it is impossible to sort out these causal explanations given the nature of the correlational data; one or all of them may have been at work.

While the trend towards a positive relationship between student pretest performance and quality of teaching makes sense, difficulties arise in its combination with the finding of a negative relationship between pretest performance and student gain. If classes with the higher average pretest score are those with the lower gains <u>and</u> those with the higher quality teaching, one can anticipate that the relationship between quality teaching and student gain will be negative. To state a negative relationship between quality of teaching and gain would be misleading because there is a third variable that is confounded with both quality of teaching and gain -- namely, pretest score. When we considered possible methods that might circumvent this confounding (e.g., dropping teachers with the most extreme scores, the use of partial correlations), the basic relationships remained unchanged. Thus, we conclude that there is no clear way to disentangle the confounding role of pretest score, particularly with such a small sample at the class level. While it is disappointing not to be able to examine teaching quality as a correlate of student growth, there are other relationships worth exploring in future work. Examining the relationship of student perceptions about their teacher and class to student outcomes and teaching quality is one such example.

Summary

Ratings of teacher quality indicated that observers perceived the participating teachers to be generally quite competent in generic aspects of instruction, classroom management, ability to motivate students, and subject-matter knowledge. However, nearly all teachers received low ratings on variables tapping their provision of explicit learning aids to students. The ratings of teaching quality tended to have positive correlations with student pretest performance on cognitive measures, meaning that higher quality teachers worked with initially higher-achieving classes. Since higher-achieving classes also had lower gains on student outcomes relative to lower-achieving classes, correlations between teaching quality and outcome gains are confounded by pretest variation. It is unlikely that this confounding can be disentangled.

CHAPTER SEVEN

STUDENTS' PERCEPTIONS OF SCIENCE CLASSES

From the initial conceptualization of this study, attention has been focused on the perceptions of students enrolled in the study classes. Our intent has been to move the "mediating process" research paradigm out of the laboratory and into the classroom to better understand how students' perceptions of their classroom experience and learning may be related to learning outcomes. This chapter is the first of three that begin to explore the perceptions of the students in this study.

Many aspects of students' perceptions of their science courses undoubtedly bear upon the main questions of this study. We have chosen to sharpen our focus and consider three categories of perception. The current chapter discusses students' general perceptions of their science courses and learning at the end of the school year. We report on their perceptions of the emphasis their teachers place on the components of scientific literacy; on their desire for changes in the instruction they received; on the strategies they report for learning and for getting right answers in their work; on their perceptions of the learning process itself; and of teachers' classroom grading systems. Finally we report on whether they regard understanding science or getting their classwork correct as the more important. We assume that these perceptions are constructed as students complete classroom activities throughout the year, and are relatively stable, normative assessments summarizing a year of classroom experiences.

Chapter Eight focuses on the characteristics of specific tasks and activities perceived by students as being quite different. Chapters Seven and Eight consider data which are "summative"; mean ratings of many students. Chapter Nine extends this discussion by considering the activities which target students found most engaging and from which they learned the most not only during the topic observations, but during the entire year.

Before turning to our exploration of student perceptions we should note that we can only present an initial, descriptive look at these data given the time constraints under which this report was produced. Further analyses using inferential methods will allow us to see more clearly the relationships between students' perceptions and students' learning.

Data Source and Analysis

The Ideas About Science Survey (IASS) was the source of the perception data discussed in this chapter. This measure was completed by students as part of the posttest assessment package, and replaced the Word Meanings and Pattern Completion measures given at pretest. The IASS is a complex questionnaire divided into three parts and containing a total 57 items. (A copy of the Ideas About Science Survey appears in Appendix B.)

Part I of the questionnaire attempts to record students' perceptions of the frequency with which teachers referred to the tenets of scientific literacy during class. A general stem, "In science class this year, how often did the teacher talk about . . ." appears at the top of the page. This is followed with 15 explicit examples of the ways the scientific literacy components could be used in class discussion (e.g., definitions of science words, how to do experiments, how science can be a fun hobby, etc.). These examples are keyed to the scientific literacy framework that has guided this study. Students were asked to respond to each example using a five point scale: (1) never, (2) seldom, (3) sometimes, (4) often, and (5) very often.

Part II of the questionnaire was designed to record students' perceptions of the teacher's instructional effectiveness. Twenty-two items describe behaviors identified in previous research on effective teaching as being associated with student learning. Examples of items include: "the teacher gives clear directions," "the same kids always talk," and "we often run out of things to do." Students were asked to indicate their level of agreement on a five point scale: (1) strongly disagree, (2) disagree, (3) no opinion, (4) agree, and (5) strongly agree. This part of the IASS was designed to provide a student analogue to the observers' judgments. It is not discussed in this report because of time constraints.

Part III of the Ideas about Science Survey consists of 20 items that record students' perceptions of numerous aspects of classroom life. Items present a general stem (e.g., "When I do worksheets, I get the right answers by"), followed by four or five statements that complete the stem (e.g., "looking them up in the textbook," "thinking about them," "asking the teacher," etc.). Students are asked to indicate their level of agreement with the completed stem on a four or five point scale. Responses to ten items from Part III and a ~~portion of an eleventh are~~ discussed in this chapter.

The number of students responding to the items discussed in this chapter ranged from 281 to 290. We include data from all students who completed part or all of the IASS, in order to maximize the data set for analyses that were primarily descriptive rather than inferential.

Responses to the IASS were analyzed by computing the mean response to each item by class and for the entire sample. In addition, for Part I of the questionnaire, students' responses to appropriate items were aggregated to create scores reflecting each component of the scientific literacy framework (i.e., content, social historical process, reasoning process, science and technology/society, and positive attitudes toward science). Chisquared analyses were conducted for each of the items in order to determine when the students in the eleven classes differed in their rating responses to an item. A total of 150 such comparisons were carried out. On 21 items the classes showed distributions of ratings which differed significantly at the $p < .001$ level. In addition, for 23 items the classes differed to a degree significant at the level $p < .01$. A further 35 items showed distributions of class ratings significant at the $p < .05$ level. These last 35 items must be regarded with a certain care, since one would expect to find 8 items showing significance at the .05 level simply by chance. These significance levels are indicated on the appropriate tables, and will be commented upon in the course of the chapter.

Perceived Scientific Literacy Emphasis

Table 7.1 presents an analysis of the ratings students made of the emphasis teachers gave to the scientific literacy components (Part I of the IASS). Mean ratings for each component appear in rows opposite the appropriate teachers. The ranking of the means for each component is also indicated. Standard deviations appear in parentheses. The data suggest both consistency and variation in students' perceptions of teachers' use of the scientific literacy framework.

First, there is relative consistency in the ordering of the emphases across the sample as a whole. Without exception, teachers were viewed as stressing content more than ~~the other~~ scientific literacy components. The majority of students indicated that their teacher gave emphasis next to scientific reasoning, followed by the relationship of science and technology to society, and the social historical process of science, and finally, positive attitudes toward science. Exceptions to this general trend are found for Teachers 1, 6, 9 and 11. The last three teachers were perceived as stressing science/technology and society more than scientific reasoning, and Teachers 1, 6, and 11 were seen as stressing positive attitudes toward science more than the social historical process of science.

Variation between teachers is suggested by the changes seen in teacher ranking within each scientific literacy component. For example, Teachers 1 and 4 are ranked as placing relatively high emphasis on all of the components, while Teacher 5 is ranked as placing low emphasis on all.

When these perceptual data are compared with the records of the use of scientific literacy components compiled during the topic observations (see Chapter Three), there is some consistency. The students, like the observers, perceived the major emphasis of the teacher to be on teaching scientific content. The observational records also corroborate students' perceptions that teachers' coverage of the attitudinal component of scientific literacy was infrequent: students placed these items on

Table 7.1

Students' Perceptions of Scientific Literacy Emphasis by Teacher

TEACHER	CONTENT	Rank	SOCIAL/ HISTORICAL PROCESS	Rank	REASONING	Rank	SCIENCE/ TECHNOLOGY AND SOCIETY	Rank	POSITIVE ATTITUDES	Rank
1 (N=29)	4.14 (.65)	4	2.92 (.62)	4	3.79 (.78)	2	3.51 (.82)	1	3.05 (.81)	1
2 (N=29)	3.83 (.91)	6	2.49 (.90)	9	3.32 (.80)	5	2.80 (.95)	11	2.40 (.90)	7
3 (N=31)	3.82 (.75)	7	2.20 (.85)	11	3.31 (.71)	6	2.81 (1.02)	10	2.05 (.81)	11
4 (N=14)	4.50 (.39)	1	3.05 (.43)	1	3.90 (.48)	1	3.24 (.59)	4	2.88 (.56)	3
5 (N=25)	3.65 (.89)	10	2.48 (.81)	10	3.00 (.82)	9	2.81 (.96)	10	2.28 (.66)	8
6 (N=31)	4.11 (.62)	5	2.92 (.80)	4	3.08 (.73)	8	3.47 (.77)	2	3.04 (.92)	2
7 (N=23)	3.61 (.91)	11	2.54 (.69)	6	3.30 (.67)	7	3.12 (.77)	5	2.25 (.71)	9
8 (N=23)	4.38 (.56)	2	2.53 (.75)	8	3.50 (.58)	3	3.28 (.62)	3	2.19 (.72)	10
9 (N=30)	3.81 (.94)	8	2.72 (.75)	5	2.91 (.64)	11	3.08 (.64)	6	2.49 (.72)	6
10 (N=27)	4.15 (.79)	3	2.96 (.84)	2	3.46 (.59)	4	3.04 (.98)	7	2.54 (.96)	5
11 (N=24)	3.76 (1.04)	9	2.53 (.88)	8	2.92 (.88)	10	2.93 (.97)	8	2.64 (.91)	4
All Classes (N=286)	3.96 (.83)		2.65 (.81)		3.29 (.76)		3.09 (.87)		2.52 (.86)	

<u>Note</u>. Scale points are: 5=Very Often, 4=Often, 3=Sometimes, 2=Seldom, 1=Never.

average between scale points of "sometimes" and "seldom." At this point, however, the accounts of students and of our observers diverge. Students perceived that teachers spent more time on scientific reasoning and science/technology and society than was actually observed. While students perceived that teachers talked about these components of scientific literacy at least "sometimes," examples of such explicit talk in the observational records were rare.

Desire for Instructional Changes

Table 7.2 presents data suggesting that students generally desired to participate more frequently in laboratory activities and wished that their daily diet of science activities was more varied (item 55). Students' used a five point scale ranging from "strongly agree" (5) to "strongly disagree" (1) to respond to the following items: "In this class I wish we did more laboratory activities" and "In this class I wish we did more different kinds of activities." Across the sample the mean response was 3.72 (SD = 1.11) to the first item, and 3.76 (SD = 1.03) to the second item. "Agree" was the median response to both items; 33 percent of the sample gave this response to the first item, and 41 percent to the second. Variation among classes in the strength of this agreement is not statistically significant for either of the items. Seen in the light of the analyses of tasks presented in Chapter Four, it is understandable why students might seek more variety in their daily tasks (i.e., in the cognitive level and response format of tasks) as well as additional exposure to laboratory activities.

Strategies for Science Learning

Recent research in cognitive psychology has called attention to the variety of cognitive and metacognitive strategies that play a part in learning. We turn now to students' reports of the generic learning strategies they used "to learn about science" as well as the specific strategies used "to get the right answer."

Autonomous vs. Mnemonic Strategies

Table 7.3 displays students' reports of the strategies they used "to learn about science" (item 41). The item stem and learning strategies presented to students in the Ideas About Science Survey appear at the left side of the table. Mean values for the entire sample and then for each of the classes appear in the row across from each learning strategy. Standard deviations are given in parentheses below the means.

Several trends are evident in these data. First, "thinking about the meaning of what you are studying" is considered impor-

Table 7.2

Students' Desire for Instructional Change

ITEM	ALL CLASSES (N=286)	TEACHER 1 (N=29)	2 (N=29)	3 (N=31)	4 (N=14)	5 (N=25)	6 (N=32)	7 (N=22)	8 (N=24)	9 (N=28)	10 (N=27)	11 (N=25)
In this class:												
I wish we did more laboratory activities	3.72[a] (1.11)	3.69 (1.07)	4.21 (.94)	3.55 (1.21)	3.31[b] (1.03)	3.76 (1.05)	4.09 (1.06)	4.05 (1.13)	3.96 (1.00)	3.54 (.96)	3.19 (1.21)	3.4 (1.12)
I wish we did more different kinds of activities	3.76 (1.03	3.83 (.97)	4.00 (.76)	4.00 (.86)	3.07 (1.07)	3.44 (1.19)	3.91 (1.00)	3.86 (1.17)	3.75 (1.03)	3.68 (1.02)	3.81 (1.03)	3.56 (1.19)

[a] n = 285

[b] n = 13

Note. Scale points are: 5=Strongly Agree, 4=Agree, 3=No Opinion, 2=Disagree, 1=Strongly Disagree.

Table 7.3

Students' Perceptions of the Importance of Autonomous and Mnemonic Strategies in Science Learning

ITEM	ALL CLASSES (N=288)	TEACHER										
		1 (N=29)	2 (N=28)	3 (N=31)	4 (N=14)	5 (N=25)	6 (N=33)	7 (N=23)	8 (N=24)	9 (N=30)	10 (N=27)	11 (N=24)
If you want to learn about science, how important are the following?												
asking yourself your own questions about what you are learning**	2.91 (.73)	2.97 (.78)	2.89 (.69)	2.94 (.73)	3.21 (.58)	2.84 (.47)	3.18 (.73)	2.61 (.66)	3.00 (.59)	2.43 (.86)	3.15 (.60)	2.92 (.88)
memorizing science vocabulary words**	3.05^{a} (.80)	3.48 (.69)	3.11^{b} (.58)	3.03 (.88)	3.21 (.70)	2.80 (.87)	2.97 (.68)	2.52 (.73)	3.33 (.76)	2.80 (.92)	3.30 (.78)	2.96 (.81)
thinking about the meaning of what you are studying*	3.20^{a} (.70)	3.38 (.62)	3.07 (.77)	3.06 (.51)	3.29 (.83)	3.36 (.57)	3.27 (.67)	2.70 (.82)	3.25 (.61)	3.17 (.83)	3.54^{c} (.51)	3.08 (.78)
memorizing science facts	3.05^{f} (.76)	3.10 (.72)	3.14 (.65)	3.03^{h} (.67)	3.14 (.77)	3.12 (.83)	2.91 (.72)	2.57 (.73)	3.25 (.74)	3.13 (.90)	3.23^{e} (.76)	2.96 (.81)
thinking about how you would solve problems if you were a scientist	2.63^{d} (.87)	2.93 (.70)	2.73^{c} (.96)	2.58 (.89)	2.86 (.66)	2.44 (.92)	3.00 (.71)	2.26 (.69)	2.63 (.97)	2.20 (.85)	2.65^{c} (.89)	2.70^{e} (.93)
remembering how to classify living things*	2.88^{f} (.81)	3.00 (.89)	2.71 (.76)	2.90 (.65)	3.29 (.73)	2.92^{g} (.83)	3.03 (.85)	2.48 (.79)	3.08 (.93)	2.83 (.83)	2.96 (.76)	2.52^{e} (.73)
thinking about the main ideas of a lesson	3.07^{f} (.78)	3.28 (.70)	2.74^{b} (.86)	3.06 (.57)	3.36 (.50)	2.92^{g} (.72)	3.33 (.74)	2.87 (.76)	3.00 (.93)	2.90 (.88)	3.22 (.70)	3.08 (.88)

$^{a}n = 287$
$^{b}n = 27$
$^{c}n = 26$
$^{d}n = 284$
$^{e}n = 23$
$^{f}n = 286$
$^{g}n = 24$
$^{h}n = 30$

Note. Scale points are: 4=Very Important, 3=Important, 2=Not Very Important, 1=Not At All Important.

***$p < .001$. **$p < .01$. *$p < .05$.

tant for the sample as a whole. Overall, it received a higher rating than any other item ($M = 3.20$, $SD = .70$), and for no class did it rank less than third in relative importance. Conversely, "thinking about how you would solve problems if you were a scientist" received the lowest rating for the sample as a whole ($M = 2.63$, $SD = .87$), and ranked no higher than fifth for any class. Three of the remaining learning strategies showed variation across the sample in the rating of their importance: Both "asking yourself your own questions about what you are learning" and "memorizing science vocabulary words" showed significant variation ($p < .01$) among the classes. The strategy of "remembering how to classify living things" showed suggestive variation ($p < .05$).

These data can be considered from a second, somewhat different, perspective. It seems reasonable to assume that teachers consistently assign tasks that require certain thinking strategies from students. Success or failure at these tasks then reinforces or discourages the continued use of these strategies by students. In constructing this portion of the IASS, we included learning strategies that attempted to capture both mnemonic and autonomous cognitive strategies. By "mnemonic" we refer to learning strategies that require no more than the exercise of memory. The mnemonic strategies included on the table are: memorizing science facts, remembering how to classify living things, and memorizing science vocabulary words. In contrast, "autonomous" strategies are those that require more complex and elaborated cognitive processes. Examples on the table include: asking yourself your own questions about what you are learning, thinking about the meaning of what you are studying, thinking about how you would solve problems if you were a scientist, and thinking about the main ideas of a lesson.

When one compares the rankings of autonomous and mnemonic learning strategies there appears to be a distinction between Teachers 6 and 7, and Teacher 8. The students in classes taught by Teachers 6 and 7 consistently indicated autonomous learning as being important by ranking them first, second and third. In contrast, students in the class taught by Teacher 8 consistently noted that mnemonic learning strategies were important by ranking them first, third, and fourth. Although these trends require further confirmation, they provide initial suggestions of differences in students' perceptions that may be corroborated by other data, and are possibly associated with differences in student outcomes.

Strategies for Getting the Right Answer

Tables 7.4, 7.5, and 7.6 display data regarding students' perceptions of the strategies most useful in getting the right answers in three instructional formats: homework (item 38), worksheets (item 39) and lab worksheets (item 40). The item stem and completion phrases appearing on the Ideas About Science Survey appear on the left of the table; the mean of students' responses

Table 7.4

Students' Perceptions of Strategies for Getting the Right Answer on Homework

ITEM	ALL CLASSES (N=290)	TEACHER 1 (N=29)	2 (N=29)	3 (N=31)	4 (N=14)	5 (N=25)	6 (N=33)	7 (N=23)	8 (N=24)	9 (N=30)	10 (N=27)	11 (N=25)
When I do homework, I get the right answers by:												
looking them up in the textbook***	3.44 (1.11)	3.62 (1.05)	3.62 (.82)	4.03 (.71)	3.93 (.83)	3.72 (1.06)	3.03 (1.13)	3.30 (.97)	3.88 (.74)	2.30 (1.20)	3.07 (1.07)	3.72 (1.24)
remembering them from class discussion	3.52 (.92)	3.69 (.76)	3.31 (.85)	3.42 (.96)	3.71 (.73)	3.44 (.92)	3.61 (.93)	3.13 (.92)	3.96 (.75)	3.37 (1.03)	3.59 (.89)	3.64 (1.11)
thinking about them**	3.24 (.98)	3.34 (.97)	2.86 (.83)	3.48 (.96)	3.71 (.47)	2.84 (.99)	3.61 (.79)	2.87 (.87)	3.63 (.92)	2.97 (1.00)	3.19 (1.11)	3.28 (1.17)
asking the teacher*	2.78 (1.14)	2.59 (1.15)	2.79 (.94)	2.39 (1.09)	3.14 (.77)	3.08 (1.22)	2.91 (1.13)	3.30 (1.18)	2.42 (1.28)	2.47 (1.04)	3.11 (1.01)	2.72 (1.31)
looking them up in my notes**	3.43[a] (1.28)	4.00 (1.13)	3.71[b] (1.05)	2.23 (1.09)	2.79 (.98)	3.00 (1.38)	3.94 (1.00)	2.91 (.95)	4.25 (.74)	4.03 (.96)	3.70 (1.14)	2.71[c] (1.30)
asking my friends*	2.85 (1.13)	2.69 (1.00)	3.31 (.93)	3.16 (.90)	2.29 (1.20)	3.28 (1.24)	2.42 (1.17)	3.13 (.97)	2.58 (1.18)	2.83 (1.29)	2.85 (1.06)	2.56 (1.12)

[a] n = 288
[b] n = 28
[c] n = 24

Note. Scale points are: 5=Always, 4=Often, 3=Sometimes, 2=Seldom, 1=Never.

***$p < .001$. **$p < .01$. *$p < .05$.

Table 7.5

Students' Perceptions of Strategies for Getting the Right Answer on Worksheets

ITEM	ALL CLASSES (N=290)	TEACHER 1 (N=29)	2 (N=29)	3 (N=31)	4 (N=14)	5 (N=25)	6 (N=33)	7 (N=23)	8 (N=24)	9 (N=30)	10 (N=27)	11 (N=25)
When I do worksheets, I get the right answers by:												
looking them up in the textbook***	3.45 (1.16)	3.90 (1.08)	3.69 (1.04)	3.97 (.60)	4.07 (.83)	3.56 (1.19)	3.70 (.88)	3.17 (.94)	3.58 (.97)	2.17 (1.18)	3.00 (1.21)	3.40 (1.41)
remembering them from class discussion	3.53 (.89)	3.62 (.83)	3.59 (.73)	3.23 (.72)	3.86 (.66)	3.52 (.82)	3.70 (.85)	3.35 (.88)	3.88 (.90)	3.17 (.91)	3.44 (1.01)	3.88 (1.13)
thinking about them	3.26^{a} (1.04)	3.24 (1.21)	3.17 (.97)	3.16 (.97)	3.79 (.43)	3.04 (1.10)	3.42 (1.00)	3.00 (1.13)	3.54 (1.06)	3.13 (.94)	3.26 (.98)	3.33^{b} (1.31)
asking the teacher	2.73^{a} (1.13)	2.62 (1.18)	2.83 (1.04)	2.45 (.99)	2.93 (.62)	2.84 (1.21)	2.82 (1.07)	3.05^{c} (1.21)	2.63 (1.38)	2.47 (1.11)	2.93 (1.07)	2.64 (1.29)
looking them up in my notes***	3.33^{d} (1.25)	3.66 (1.20)	3.57^{e} (1.07)	2.07^{f} (1.14)	2.93 (.92)	2.88 (1.24)	3.82 (1.04)	3.09^{c} (1.07)	4.04 (.86)	4.03 (1.10)	3.69^{g} (.97)	2.56 (1.29)
asking my friends	2.86 (1.18)	2.62 (1.01)	3.07 (1.10)	3.23 (1.02)	2.43 (1.22)	3.12 (1.36)	2.52 (1.18)	3.30 (.93)	2.83 (1.17)	2.93 (1.26)	2.63 (1.11)	2.60 (1.41)

a_n = 289
b_n = 24
c_n = 22
d_n = 286
e_n = 28
f_n = 30
g_n = 26

Note. Scale points are: 5=Always, 4=Often, 3=Sometimes, 2=Seldom, 1=Never.

$^{***}p < .001$. $^{**}p < .01$. $^{*}p < .05$.

Table 7.6

Students' Perceptions of Strategies for Getting the Right Answer on Laboratory Worksheets

ITEM	ALL CLASSES (N=288)	TEACHER 1 (N=29)	2 (N=29)	3 (N=31)	4 (N=14)	5 (N=25)	6 (N=33)	7 (N=23)	8 (N=24)	9 (N=28)	10 (N=27)	11 (N=25)
When I fill out lab worksheets, I get the right answers by:												
looking them up in the textbook	2.89 (1.19)	2.62 (1.12)	3.14 (1.18)	2.90 (1.19)	3.00 (.96)	3.12 (1.09)	2.48 (1.18)	2.61 (1.03)	2.96 (1.20)	2.07 (1.05)	3.63 (1.15)	3.40 (1.12)
remembering them from class discussion*	3.36 (.95)	3.03 (1.02)	3.21 (1.01)	3.61 (.76)	4.07 (.73)	3.16 (.69)	3.27 (.98)	2.87 (.87)	3.67 (1.13)	3.29 (.81)	3.30 (.91)	3.80 (.96)
thinking about what I saw during the lab activity	3.70^{a} (1.00)	4.07 (.80)	3.55 (.83)	3.65 (.84)	4.00 (.88)	3.56 (1.19)	3.82 (1.13)	3.30 (1.18)	3.92 (.93)	3.61 (.99)	3.48^{b} (.92)	3.79^{c} (1.18)
asking the teacher	2.80^{a} (1.10)	2.64^{d} (1.13)	2.62 (.98)	2.71 (1.10)	2.93 (.83)	2.88 (1.20)	2.91^{e} (1.15)	3.00 (1.04)	2.71 (1.37)	2.79 (.99)	2.88^{f} (1.11)	2.84 (1.14)
looking them up in my notes***	3.06^{g} (1.17)	3.24 (.99)	2.93 (1.00)	2.35 (1.28)	2.79 (1.05)	2.72 (.94)	3.28^{e} (1.40)	3.00 (.90)	3.33 (1.24)	3.93 (.94)	3.33 (1.04)	2.60 (1.19)
asking my friends or lab partners	3.30^{g} (1.10)	3.10 (1.01)	3.10 (1.08)	3.55 (.85)	2.64 (.93)	3.64 (1.04)	2.94^{e} (1.24)	3.65 (1.03)	3.04 (1.16)	3.36 (1.03)	3.70 (1.14)	3.40 (1.26)

^{a}n = 285
^{b}n = 25
^{c}n = 24
^{d}n = 28
^{e}n = 32
^{f}n = 26
^{g}n = 287

Note. Scale points are: 5=Always, 4=Often, 3=Sometimes, 2=Seldom, 1=Never.

***$p < .001$. **$p < .01$. *$p < .05$.

across the sample and by class appear in rows opposite the completion phrases. Standard deviations appear in parentheses below the means.

Looking at the data in Table 7.4, it appears that "remembering [answers] from class discussion" is the best candidate for the strategy students consistently use to complete their homework assignments. It received the highest overall mean rating (3.52), and variation among the eleven classes was not significant. For the remaining strategies, variation in emphases between teachers seems to be the rule. Three strategies show significant variation ($p < .01$) across classes: looking answers up in the textbook; thinking about answers; and looking answers up in my notes. In contrast, the data do suggest a commonality in what students tend to not do while completing their homework assignments: they do not ask their friends or the teacher. Given the logistical difficulties that these last two learning strategies would require for a homework assignment, it is hardly surprising that they are little used by students. However, the analysis reported in Chapter Four suggests that students rarely were assigned true homework.

Table 7.5 displays similar data regarding students' perceptions of the strategies they use to complete worksheets. The highest rated strategy is "looking them up in the textbook" (M = 3.53; SD = .89). Two strategies show significant variation ($p < .001$) across classes: looking answers up in the textbook; and looking them up in notes. Two of the remaining strategies are quite consistently ranked by students in the eleven classes: the strategy of "thinking about" the correct answers appears consistently in the middle of the range of means, while "asking the teacher" generally appears at the bottom of the range, indicating that it is a strategy employed relativly rarely. As with the preceding table, standard deviations are relatively large.

Table 7.6 presents data describing students' perceptions of the strategies they use to complete laboratory worksheets correctly. Here the strategy students report using most frequently is "thinking about what I saw during lab activity," (M = 3.70, SD = 1.0), while that reported least frequently is "asking the teacher" for the correct answer (M = 2.80, SD = 1.1). One strategy -- looking the answers up in notes -- shows significant variation ($p < .001$) among the classes, being rated most frequent in the classes of Teachers 8, 9 and 10, and least frequent in those of Teachers 3 and 11. This is largely consistent with data in Chapter Four indicating that Teachers 8 and 10 employed formal notebook systems while Teachers 3 and 11 did not.

Comparison of Tables 7.4 through 7.6 suggests that students reported using active cognitive learning strategies more frequently when completing laboratory worksheets than when completing worksheets assigned as part of seatwork or homework. For these latter assignments, students tended to report using strategies that demanded less cognitive engagement, such as remembering them from class discussion or looking answers up in the textbook or in notes (though reported use of these last strategies varied from class to class). For laboratory worksheets, looking up the answers received low mean ratings, and thinking about what had gone on in the lab activity was rated highly.

Perceptions of Science Learning

In the previous section we have explored the strategies students reported using to learn science. In this section we turn to their perceptions of their own thinking and learning, the difficulty of the different activity formats, and the degree of attention paid during each activity format.

Thinking Carefully About Science

Table 7.7 presents students' perceptions of how carefully they think about science during different activity formats (item 43). The Ideas About Science Survey item appears at the left of the table. Sample and class means are arrayed in rows opposite the completed item stem. Standard deviations appear in parentheses below the means.

The overall sample means suggest strongly that students reported thinking most carefully about science when they were taking quizzes or tests. This item ranked highest in all 11 classes. Thinking while engaged in lab activities was perceived by students to require slightly less thought; this is shown both by the overall mean rating and the ranking across classes: the item was ranked second in 7 classes. An interesting exception here is that of Teacher 4's class, where thinking during lab activities ranked seventh. In part this is a consequence of the high ratings these students gave to their thinking during quizzes (M = 4.0; SD = 0), during class recitations (M = 3.36; SD = .63), and while listening to the teacher talk about science (M = 3.14; SD = .53). (The ratings accord with these students' responses to the Student Class Survey; see Chapter Eight.) Finally, students' responses indicate that they think relatively less carefully when they are watching movies or filmstrips (ranked lowest in 7 classes) and listening to their teacher talk about science (ranked 6th in 6 classes).

Although it is no surprise that audiovisual presentations are not perceived as mindbenders, it is somewhat surprising that participation in teacher recitation is not seen as an occasion of thought. It may be that students perceive these activities as teacher performances where their role is largely passive. When they are called upon to produce an answer, they may feel that if the answer is not immediately apparent, there will not be enough time for any careful thought to produce it. As the common wisdom recounts, "either you know it or you don't."

Table 7.7

Students' Perceptions of Careful Thought in Different Activity Formats

ITEM	ALL CLASSES (N=289)	TEACHER 1 (N=29)	2 (N=29)	3 (N=31)	4 (N=14)	5 (N=25)	6 (N=33)	7 (N=23)	8 (N=24)	9 (N=30)	10 (N=27)	11 (N=25)
How carefully do you think about science when you:												
listen to the teacher talk about science**	2.73 (.78)	2.86 (.69)	2.46[b] (.64)	2.42 (.72)	3.14 (.53)	2.48 (.82)	2.79 (.78)	2.48 (.73)	3.17 (.56)	2.50 (.73)	3.04 (.76)	2.92 (1.04)
fill out worksheets	2.83 (.68)	3.03 (.68)	2.83 (.71)	2.90 (.54)	3.00 (.68)	2.72 (.68)	2.76 (.79)	2.52 (.59)	3.13 (.45)	2.55[g] (.69)	2.70 (.61)	3.04 (.73)
do lab activities**	2.99[a] (.74)	3.32[b] (.72)	3.04[b] (.69)	2.94 (.73)	2.64 (.63)	3.24 (.60)	3.00 (.75)	2.87 (.63)	3.08 (.65)	2.50 (.86)	3.07 (.68)	3.04[c] (.81)
fill out lab worksheets	2.81[d] (.72)	3.21 (.68)	2.86[b] (.59)	2.81 (.70)	2.71 (.81)	2.56 (.77)	2.84[e] (.73)	2.68[f] (.65)	3.08 (.65)	2.46[b] (.69)	2.85 (.82)	2.79 (.78)
watch movies or filmstrips	2.40[h] (.88)	2.44 (.87)	2.32[b] (.86)	1.97[i] (.85)	2.86 (.86)	2.16 (.85)	2.64 (.90)	2.48 (.79)	2.67 (.70)	2.36[b] (.95)	2.33 (.92)	2.44 (.92)
answer the teacher's questions during class discussion	2.91[j] (.83)	3.14 (.74)	3.00[b] (.86)	3.00 (.73)	3.36 (.63)	2.68 (.95)	3.00 (.83)	2.61 (.78)	2.87 (.80)	2.67 (.84)	2.96[k] (.92)	2.88 (.83)
take quizzes or tests	3.66[l] (.69)	3.72 (.70)	3.83 (.38)	3.81 (.48)	4.00 (.00)	3.76 (.66)	3.61 (.66)	3.43 (.73)	3.75 (.53)	3.60 (.81)	3.48 (.94)	3.40 (.91)

[a]n = 287
[b]n = 28
[c]n = 24
[d]n = 283
[e]n = 31
[f]n = 22
[g]n = 29
[h]n = 286
[i]n = 30
[j]n = 288
[k]n = 26
[l]n = 290

Note. Scale points are: 4=Very Carefully, 3=Carefully, 2=Not Too Carefully, 1=Not At All Carefully.

***p <.001. **p <.01. *p <.05.

Assessing Learning

Table 7.8 presents data, in the same format used in previous tables, regarding students' judgments of the amount of learning they perceived to occur in different activities (item 44). When asked to indicate how much they learned in different classroom activities, students were consistent in rating "taking quizzes or tests" as the activity most associated with learning. This activitity received the highest mean rating across the sample, ranking first or second in 9 of the 11 classes, and showing nonsignificant variation among classes ($p = .25$). "Listening to the teacher talk about science," and "doing lab activities" also received high ratings, though the second of these showed significant variation ($p < .01$) among classes. Filling out laboratory and class worksheets also showed variation among classes ($p < .001$ and $p < .01$ respectively). Watching movies or filmstrips tended to receive low ratings. Responses to the previous item indicated that students perceived themselves to think most carefully about science when taking tests or quizzes, and their responses to this item suggest that it is at just this time when students perceive themselves as learning the most.

Perceived Difficulty

Table 7.9 presents the judgments students made of the difficulty they attributed to each of the different academic activities (item 45). For the sample as a whole, quizzes and tests were judged most difficult by far, receiving a mean rating of 3.63 (SD = 1.08). The activity next in rated difficulty was "the things we read in science" (M = 2.99, SD = .86), while filmstrips and movies were the easiest (M = 1.99, SD = .96). Despite their high average score, quizzes and tests showed significant variation across classes ($p < .001$), due primarily to the responses to this item of the students in Teacher 5's class. While students in the ten other classes reported that quizzes and tests were most difficult, Teacher 5's students placed this item fifth in difficulty: harder only than the movies they saw. It should be pointed out that these students rated all the activities as relatively easy: the highest average rating -- given to lab activities -- was 2.76. It is not obvious why his students should find their tests unusually easy; like other students they reported that tests were the most important factor determining their grades, and so the perceived ease cannot stem from a perceived lack of importance.

Teacher 5's students aside, the general pattern of response to these items was to report quizzes and tests as most difficult, films and movies least difficult, with reading, worksheets and labs placed between, most frequently rated "just right."

Table 7.8

Students' Perceptions of the Amount of Learning Associated with Different Activities

ITEM	ALL CLASSES (N=290)	TEACHER 1 (N=29)	2 (N=29)	3 (N=31)	4 (N=14)	5 (N=25)	6 (N=33)	7 (N=23)	8 (N=24)	9 (N=30)	10 (N=27)	11 (N=25)
How much do you learn when you are:												
listening to the teacher talk about science	3.02 (.86)	3.31 (.85)	2.97 (.82)	2.84 (.90)	3.36 (.63)	2.72 (.79)	3.09 (.80)	2.48 (.85)	3.42 (.72)	2.90 (.88)	3.30 (.72)	3.00 (1.04)
filling out worksheets*	2.77^a (.76)	3.21 (.73)	2.72 (.65)	2.94 (.81)	2.79 (.80)	2.68 (.85)	2.91 (.72)	2.61 (.78)	2.83 (.76)	2.24^b (.69)	2.63 (.56)	2.88 (.73)
doing lab activities**	3.09^a (.77)	3.55 (.57)	3.00 (.76)	2.94 (.85)	3.14 (.77)	3.16 (.75)	3.06 (.86)	3.13 (.92)	3.29 (.62)	2.59^b (.73)	3.22 (.70)	2.96 (.01)
filling out lab worksheets**	2.78^c (.79)	3.31 (.66)	2.85^d (.78)	2.48 (.85)	2.79 (.58)	2.67^e (.96)	2.76 (.79)	2.57 (.73)	3.04 (.62)	2.37^f (.79)	2.93 (.62)	2.88 (.73
watching movies or filmstrips*	2.80^g (.88)	3.10 (.62)	2.57^h (.88)	2.29 (.94)	3.00 (.88)	2.76 (.88)	3.27 (.76)	2.65 (.88)	2.88 (.90)	2.67 (.84)	2.89 (.93)	2.79^e (.78)
taking quizzes or tests	3.17^a (.99)	3.52 (.83)	3.46^h (.92)	3.32 (.91)	2.93 (1.00)	3.20 (.91)	3.24 (1.00)	2.74 (1.05)	3.17 (1.00)	2.83 (1.18)	3.33 (.96)	2.88 (.93)

a_n = 289	e_n = 24
b_n = 29	f_n = 27
c_n = 283	g_n = 288
d_n = 26	h_n = 28

Note. Scale points are: 4=I Learn A Lot, 3=I Learn Some, 2=I Learn A Little, and 1=I Learn Nothing.

***$p < .001$. **$p < .01$. *$p < .05$.

Table 7.9

Students' Perceptions of the Difficulty of Different Activities

ITEM	ALL CLASSES (N=290)	TEACHER										
		1 (N=29)	2 (N=29)	3 (N=31)	4 (N=14)	5 (N=25)	6 (N=33)	7 (N=23)	8 (N=24)	9 (N=30)	10 (N=27)	11 (N=25)
In this science class:												
the things we read about science are:	2.99^{a} (.86)	3.03 (.73)	3.48 (.83)	2.74 (.73)	3.14 (.77)	2.68 (.69)	2.78^{b} (.87)	3.13 (.92)	2.83 (.87)	3.17 (.91)	3.07 (.73)	2.88 (1.09)
the worksheets we fill out are:*	2.92^{c} (.84)	3.03 (.68)	3.29^{d} (.85)	2.55 (.72)	3.64 (.50)	2.68 (.80)	2.94^{b} (.84)	3.22 (1.00)	2.79 (.59)	2.81^{c} (.96)	2.67 (.88)	2.87^{f} (.85)
the lab activities we do are:	2.82^{c} (.87)	3.14 (.83)	2.93^{d} (.94)	2.94 (.81)	3.14 (.66)	2.76 (.83)	2.53^{b} (.98)	2.83 (1.07)	2.62 (.65)	2.86^{d} (.71)	2.85 (.99)	2.48^{g} (.79)
the lab worksheets we fill out are:	2.90^{c} (.95)	3.07 (.80)	3.14^{d} (1.08)	2.97^{h} (.89)	3.36 (.74)	2.64 (1.04)	2.82 (1.10)	3.17 (1.03)	2.67 (.64)	3.00^{d} (.82)	2.67 (.92)	2.61^{g} (1.08)
the movies and filmstrips we watch are:	1.99 (.96)	2.10 (.77)	2.22^{c} (1.05)	1.55 (.67)	2.36 (.74)	2.00 (1.04)	2.03^{b} (.86)	2.17 (1.27)	2.21 (.98)	1.72^{j} (1.07)	1.81^{k} (.98)	2.05^{l} (.90)
the quizzes and tests we take are:***	3.63^{m} (1.08)	3.48 (.87)	4.07 (1.03)	3.48 (.77)	4.50 (.65)	2.36 (1.15)	3.70 (1.10)	3.78 (.85)	3.70^{g} (1.02)	4.13 (.94)	3.81^{k} (1.02)	3.21^{f} (1.02)

a_n = 289
b_n = 32
c_n = 284
d_n = 28
e_n = 27
f_n = 24

g_n = 23
h_n = 30
i_n = 282
j_n = 29
k_n = 26
l_n = 22
m_n = 287

Note. Scale points are: 5=Very Hard, 4=Hard, 3=Just Right, 2=Easy, and 1=Very Easy.

***p <.001. **p <.01. *p <.05.

Interest of the Activities

Students also rated the degree of interest of each of the class activities and an additional form of instruction: "answering the teacher's questions during class discussion" (item 46). Table 7.10 shows the summary statistics on their responses to these questions. Looking first at the mean ratings for the whole sample, it can be seen that lab activities were rated the most interesting (M = 2.70; SD = 1.05), while the least interesting activities were the filling out of worksheets (M = 2.70; SD = .92) and lab worksheets (M = 2.79; SD = .94). However, four alternatives showed highly significant variation across the classes: listening to the teacher talk about science ($p < .01$); filling out both worksheets and lab worksheets ($p < .001$); and watching movies and filmstrips ($p < .01$).

Teacher 4 received the highest ratings on the item concerning listening to the teacher (M = 3.86; SD = .66). All students in this teacher's class rated her "OK" or better. Teacher 7 received the lowest ratings on this item (M = 2.26; SD = .96). We shall see later, in Chapter 8, when we report the results of the Student Class Survey, that Teacher 4 did indeed use a challenging and engaging approach to recitation, introducing material at a rapid rate and expecting students to assimilate it. Teacher 7, in contrast, employed mainly routine and low-level activities that lost students' attention and interest.

Another interesting result is that in three classes (those of Teachers 4, 6 and 9) the highest ratings of interest were given to the watching of filmstrips and movies. This activity received the second highest overall ranking (M = 3.30; SD = 1.24), despite the fact that, as mentioned above, students frequently reported that they found this activity very easy and as requiring little careful thought. It seems that an easy activity is as likely to be found interesting as a more difficult one.

There is reason for concern because of the low level of interest students reported for the completion of worksheets, both regular and those that were part of their laboratory assignments. The labs themselves were rated as "interesting" or "very interesting" by 60 percent of students, while only 19 percent gave comparable ratings to lab worksheets. Again, the results in Chapter Four regarding the cognitive level and response format of worksheets suggests why students were disenchanted.

Perceptions of Attention

Table 7.11 presents data on the students' perceptions of the amount of attention paid to each of the academic actities (item 56). The stem to these items was as follows: "In this class, about how many students pay attention the whole time when they . . .," and the rating scale points were (5) everybody, (4) almost everybody, (3) about half, (2) almost nobody, and (1) nobody.

Table 7.10

Students' Perceptions of the Degree of Interest Associated with Different Activities

ITEM	ALL CLASSES (N=290)	TEACHER 1 (N=29)	2 (N=29)	3 (N=31)	4 (N=14)	5 (N=25)	6 (N=33)	7 (N=23)	8 (N=24)	9 (N=30)	10 (N=27)	11 (N=25)
How interesting are the following class activities:												
listening to the teacher talk about science**	2.98 (1.11)	3.28 (1.03)	2.76 (1.06)	2.64 (.95)	3.86 (.66)	3.00 (.96)	3.30 (1.24)	2.26 (.96)	3.25 (.94)	2.43 (.97)	3.18 (1.18)	3.24 (1.30)
filling out worksheets***	2.70^{a} (.92)	3.03 (.91)	2.65 (.86)	2.68 (.75)	2.77^{b} (.44)	2.68 (.85)	2.61 (.86)	2.39 (.94)	3.25 (.74)	1.96^{c} (.86)	2.63 (.84)	3.20 (1.15)
doing lab activities	3.68^{d} (1.05)	4.10 (.90)	3.86^{e} (1.04)	3.45 (.96)	3.93 (1.00)	3.92 (.91)	3.76 (1.20)	3.54^{f} (1.10)	3.87 (.74)	3.21^{c} (1.15)	3.63 (1.04)	3.29^{g} (1.20)
filling out lab worksheets***	2.79^{d} (.94)	3.10 (.77)	2.93^{e} (1.05)	2.77 (.80)	2.93 (.47)	2.80 (.87)	2.94 (1.06)	2.48 (.79)	3.08 (.93)	1.93^{e} (.72)	2.81^{h} (.85)	2.96 (1.17)
watching movies or filmstrips**	3.30^{d} (1.24)	3.66 (1.11)	2.57^{e} (1.14)	2.77 (.96)	4.15^{b} (.90)	2.72 (1.21)	3.88 (1.14)	3.43 (1.20)	3.29 (1.30)	3.53 (1.31)	3.62^{i} (1.17)	3.04^{g} (1.27)
answering the teacher's questions during class discussion*	2.93 (1.18)	3.31 (.97)	3.07^{e} (1.11)	2.90 (.87)	3.43 (1.16)	2.56 (1.00)	3.00 (1.25)	2.48 (.99)	2.92 (.93)	2.33 (.99)	3.37 (1.33)	3.08^{g} (1.14)
taking quizzes or tests*	2.87 (1.25)	3.17 (1.07)	2.97 (1.38)	2.94 (1.18)	3.29 (1.27)	3.16 (.94)	2.76 (1.15)	2.30 (1.02)	2.54 (1.22)	2.17 (1.34)	3.26 (1.32)	3.20 (1.35)

a_n = 288
b_n = 13
c_n = 29
d_n = 286
e_n = 28
f_n = 22
g_n = 24
h_n = 27
i_n = 26

<u>Note</u>. Scale points are: 5=Very Interesting, 4=Interesting, 3=OK, 2=Not Interesting, and 1=Not at all Interesting.

***$p < .001$. **$p < .01$. *$p < .05$.

Table 7.11

Students' Perceptions of the Attention Paid to Different Activities

ITEM	ALL CLASSES (N=290)	TEACHER 1 (N=29)	2 (N=29)	3 (N=31)	4 (N=14)	5 (N=25)	6 (N=33)	7 (N=23)	8 (N=24)	9 (N=30)	10 (N=27)	11 (N=25)
In this class, about how many students pay attention the whole time when they:												
listen to the teacher talk about science?	3.40^{a} (.87)	3.90 (.67)	3.31 (.93)	3.19 (.91)	3.71 (.61)	3.60 (.91)	3.37^{b} (.79)	3.00^{c} (.82)	3.25 (.74)	3.25^{d} (.80)	3.56 (.85)	3.28 (1.10)
fill out worksheets?*	3.52^{c} (.81)	3.96 (.63)	3.21 (.90)	3.74 (.81)	3.64 (.74)	3.44 (.77)	3.23^{f} (.56)	3.19^{g} (.87)	3.67 (.87)	3.54^{h} (.58)	3.59 (.84)	3.46^{i} (.98)
do lab activities?	3.87^{j} (.89)	4.07 (.59)	3.72 (.92)	3.97 (.87)	3.57 (.76)	4.36 (.76)	3.87^{b} (.98)	3.59^{c} (.91)	4.00 (.83)	3.85^{h} (.67)	3.73^{h} (.96)	3.60 (1.19)
fill out lab worksheets?	3.51^{e} (.96)	3.96 (.57)	3.24 (1.02)	3.50^{k} (.90)	3.36 (.74)	3.40 (1.00)	3.42^{f} (1.03)	3.20^{l} (.83)	3.92 (.93)	3.30^{m} (.91)	3.67 (1.04)	3.56 (1.16)
watch movies or filmstrips?	3.34^{j} (1.15)	3.83 (.97)	3.07^{d} (1.18)	2.81 (1.11)	3.15^{n} (.99)	3.32 (.94)	3.69^{c} (1.09)	3.36^{c} (1.22)	3.21 (1.28)	3.36^{d} (1.13)	3.67 (1.23)	3.12^{i} (1.23)
participate in class discussions?*	3.31^{o} (.98)	3.69 (.85)	3.22^{m} (1.01)	3.35 (.95)	3.50 (.85)	3.32 (.99)	3.59^{b} (.95)	2.82^{c} (1.01)	3.25 (.99)	2.73^{h} (.83)	3.59 (.89)	3.20 (1.12)
take quizzes or tests?	4.43^{p} (.96)	4.55 (.78)	4.18^{d} (1.22)	4.64 (.61)	4.29 (1.14)	4.52 (.87)	4.31^{b} (1.03)	4.14^{c} (1.28)	4.67 (.64)	4.29^{d} (.85)	4.78 (.51)	4.24 (1.30)

a_n = 286
b_n = 32
c_n = 22
d_n = 28
e_n = 281
f_n = 31
g_n = 21
h_n = 26
i_n = 24
j_n = 283
k_n = 30
l_n = 20
m_n = 27
n_n = 13
o_n = 282
p_n = 285

Note. Scale points are: 5=Everyone, 4=Almost Everyone, 3=About Half, 2=Almost Nobody, and 1=Nobody.

$^{***}p < .001$. $^{**}p < .01$. $^{*}p < .05$.

Not surprisingly, there was overall consensus that attention was greatest during quizzes and tests (M = 4.43; SD = .96). This item was rated highest in each of the eleven classes, and, overall, 84 percent of students reported that "everyone" or "almost everyone" paid attention during these activities.

Disturbingly, the activity which received the lowest ratings of attention was participation in class discussions (M = 3.31; SD = .98). Twenty-one percent of the students reported that "nobody" or "almost nobody" paid attention during this activity. The students in Teacher 9's class gave the lowest average rating to this item (M = 2.73; SD = .83); 13 of these students (50 percent of the class) reported that "almost nobody" paid attention.

Labs received the second highest overall mean score (M = 3.87; SD = .89), and they ranked second in each of the classes except that of Teacher 4. We noted earlier that Teacher 4 was noteable for the quality of her recitations and, indeed, the students placed listening to the teacher as the second most interesting activity (M = 3.71; SD = .61).

Receiving A Grade

In the next section we turn from students' perceptions of their classroom academic activities to consider their perceptions of teachers' classroom grading systems. We first discuss their conceptions of the relative emphasis given by teachers to different classroom activities when calculating a grade, and then look within the activities to examine what criteria teachers are perceived to use in assigning grades.

Contribution of Classroom Activities to Grade

Table 7.12 presents students' responses to the question, "What counts toward your grade in science?" (item 42). The completed item stem appears at the left of the table and sample and class means are listed in rows. Standard deviations appear in parentheses. The most striking result is that students overwhelmingly perceived that their performance on quizzes and tests contributed strongly to the grade they received in science. In every class, this activity was consistently highest in its ratings among the six options, with the lowest mean rating being 3.44 (Teacher 11) and the highest being 4.00 (Teacher 9). This finding is what one might expect given the results in Chapter Four indicating that exams often were the only tasks that teachers graded for accuracy, thus providing the main basis for individual grades.

It is worth noting, however, that the rating for quizzes and tests showed significant variation ($p < .001$) across classes. This was a consequence primarily of a certain number of students

Table 7.12

Students' Perceptions of Contributions of Classroom Activities to Grade

ITEM	ALL CLASSES (N=290)	TEACHER 1 (N=29)	2 (N=29)	3 (N=31)	4 (N=14)	5 (N=25)	6 (N=33)	7 (N=23)	8 (N=24)	9 (N=30)	10 (N=27)	11 (N=25)
What counts toward your grade in science?												
filling out worksheets**	2.90 (.79)	3.28 (.70)	2.79 (.94)	3.32 (.70)	2.71 (.99)	2.80 (.82)	2.91 (.72)	2.79 (.80)	2.67 (.56)	2,67 (.66)	2.78 (.64)	3.00 (.91)
doing lab activities**	2.96^{a} (.79)	3.62 (.49)	3.00^{b} (.61)	2.61 (.95)	2.79 (.80)	2.67^{c} (.87)	2.91 (.77)	3.13 (.87)	2.96 (.62)	2.83 (.65)	3.26 (.66)	2.68 (.80)
filling out lab worksheets**	2.98^{d} (.76)	3.52 (.57)	3.00 (.76)	3.16 (.69)	2.79 (.80)	2.83^{c} (.82)	2.85 (.91)	2.91 (.85)	2.79 (.59)	2.79^{b} (.69)	3.11 (.64)	2.83^{c} (.76)
watching movies or filmstrips***	1.87^{d} (.91)	2.38 (.78)	2.14^{b} (.93)	1.33^{e} (.61)	2.14 (.86)	1.96 (1.06)	1.70 (.98)	2.09 (.90)	1.75 (.74)	1.62^{f} (.62)	1.67 (.96)	2.08^{c} (1.02)
answering the teacher's questions during class discussion*	2.11^{g} (1.04)	2.25^{b} (1.11)	2.17 (1.04)	1.81 (.98)	1.86 (.86)	1.79^{c} (.88)	1.97^{h} (1.12)	1.65 (.83)	2.13 (.80)	2.66^{f} (1.11)	2.26 (1.20)	2.54^{c} (.98)
taking quizzes and tests***	3.84^{d} (.52)	3.97 (.19)	3.96^{b} (.19)	3.84 (.58)	3.79 (.80)	3.88^{c} (.45)	3.94^{h} (.35)	3.48 (.73)	3.96 (.20)	4.00^{f} (.00)	3.89 (.58)	3.44 (.82)

a_n = 288
b_n = 28
c_n = 24
d_n = 286
e_n = 30
f_n = 29
g_n = 285
h_n = 32

Note. Scale points are: 4=Counts A Lot, 3=Counts Some, 2=Counts A Little, 1=Doesn't Count At All.

***$p < .001$. **$p < .01$. *$p < .05$.

in the classes of both Teacher 7 and Teacher 11 rating the importance of quiz-taking for their grade lower than was the norm. Overall, 90 percent of the students gave the taking of quizzes and tests a rating of 4 ("counts a lot"). In Teacher 7's class, 9 students (39 percent) rated it 3 ("counts some"), while in Teacher 11's class 4 students (16 percent) rated this item 3, and 5 students (20 percent) rated it 2 ("counts a little"). Chapter Eight indicates that Teacher 11 assigned her students large amounts of seatwork and Chapter Four indicates that she also was unusual for grading the accuracy of all tasks. Thus, it seems likely that worksheets were at least as important at tests and quizzes for the determination of grades in this class. "Filling out worksheets" was indeed rated "counts a lot" by 8 of Teacher 11's students (32 percent), and received a mean rating of 3.00.

Table 7.12 indicates that all the remaining alternatives showed significant variation among classes (with the possible exception of "answering the teacher's questions during class discussion," where the significance of the variation is borderline). It seems that, at least as the students viewed it, teachers differed greatly in the relative importance they attach[illegible] to various classroom activities, for the purpose of assigning [illegible]des. At the same time, however, quizzes and tests generally topped the list of importance. For these students, it appears that tests were what counted. Thinking of the resource/task distinction made earlier in this report, it might be suggested that in students' eyes, all classroom activities were but resources for the tests they eventually had to complete.

Grading Criteria

Tables 7.13, 7.14, and 7.15 display students' responses to items asking about the relative importance of being neat, having the right answers, turning completed work in on time, or thinking carefully about what one is learning on grades for homework (item 51), class worksheets (item 52) and laboratory worksheets (item 53), respectively. Results are reported in the same format used in previous tables.

For both homework and worksheets, students generally perceived having the right answers as being the central criterion for their grade. Considering homework, this response has the highest overall mean (3.60), and the highest mean in 8 of the classes. Sixty-five percent of the entire sample rated this response "very important." Considering worksheets, the overall mean was again highest (3.54), and the mean for this response was highest in 7 of the classes. Sixty percent of the sample rated it "very important."

There is significant variation ($p < .01$) among classes on the importance for homework of neatness and of turning it in on time, and on the timeliness of worksheets, suggesting two further points. First, students in some classes appeared to consider

Table 7.13

Students' Perceptions of Grading Criteria for Homework

ITEM	ALL CLASSES (N=287)	TEACHER 1 (N=29)	2 (N=29)	3 (N=31)	4 (N=14)	5 (N=25)	6 (N=31)	7 (N=23)	8 (N=24)	9 (N=29)	10 (N=27)	11 (N=25)
On homework, how important is it:												
to be neat***	2.83[a] (.79)	3.24 (.58)	3.21 (.82)	2.39 (.72)	2.93 (.83)	2.68 (.75)	3.00 (.58)	2.83 (.89)	2.92 (.72)	2.52 (.95)	2.73[b] (.87)	2.71[c] (.62)
to have the right answers	3.60 (.60)	3.69 (.54)	3.66 (.72)	3.68 (.48)	3.93 (.27)	3.40 (.71)	3.65 (.55)	3.61 (.78)	3.54 (.66)	3.48 (.57)	3.63 (.56)	3.44 (.51)
to turn it in on time**	3.54[d] (.64)	3.93 (.26)	3.62 (.68)	3.65 (.49)	3.93 (.27)	3.36 (.70)	3.52 (.57)	3.43 (.73)	3.63 (.58)	3.24 (.64)	3.41 (.69)	3.33[c] (.82
to think carefully about what you are learning*	3.32[d] (.74)	3.55 (.51)	3.34 (.72)	3.29 (.69)	3.71 (.47)	3.04 (.84)	3.45 (.77)	2.87 (.87)	3.25 (.68)	3.14 (.88)	3.67 (.55)	3.25[c] (.68)

[a] n = 285
[b] n = 26
[c] n = 24
[d] n = 286

Note. Scale points are: 4=Very Important, 3=Important, 2=Not Very Important, 1=Not At All Important.

***p <.001. **p <.01. *p <.05.

Table 7.14

Students' Perceptions of Grading Criteria for Worksheets

ITEM	ALL CLASSES (N=285)	TEACHER 1 (N=29)	2 (N=29)	3 (N=31)	4 (N=14)	5 (N=25)	6 (N=31)	7 (N=22)	8 (N=24)	9 (N=28)	10 (N=27)	11 (N=25)
On worksheets, how important is it												
to be neat	2.86 (.79)	3.10 (.72)	3.24 (.79)	2.42 (.76)	3.00 (.68)	2.72 (.84)	3.00 (.58)	2.95 (.90)	2.79 (.72)	2.79 (.83)	2.78 (.85)	2.68 (.75)
to have the right answer	3.54[a] (.63)	3.61[b] (.50)	3.62 (.73)	3.65 (.49)	3.86 (.36)	3.25[c] (.74)	3.61 (.56)	3.64 (.73)	3.58 (.65)	3.36 (.62)	3.52 (.58)	3.38[c] (.71)
to turn it in on time***	3.45[d] (.69)	3.76 (.51)	3.52 (.74)	3.65 (.49)	3.93 (.27)	3.12 (.83)	3.45 (.57)	3.55 (.74)	3.63 (.58)	3.11[e] (.64)	3.27[f] (.67)	3.12 (.93)
to think carefully about what you are learning*	3.24[a] (.78)	3.48 (.63)	3.21 (.86)	3.23 (.62)	3.64 (.50)	2.92[c] (.93)	3.39 (.72)	2.91 (.81)	3.21 (.78)	3.19[e] (.79)	3.65[f] (.63)	2.92 (.86)

[a] n = 282
[b] n = 28
[c] n = 24
[d] n = 283
[e] n = 27
[f] n = 26

Note. Scale points are: 4=Very Important, 3=Important, 2=Not Very Important, 1=Not At All Important.

***$p < .001$. **$p < .01$. *$p < .05$.

Table 7.15

Students' Perceptions of Grading Criteria for Laboratory Worksheets

ITEM	ALL CLASSES (N=284)	TEACHER 1 (N=29)	2 (N=29)	3 (N=31)	4 (N=14)	5 (N=25)	6 (N=31)	7 (N=22)	8 (N=24)	9 (N=28)	10 (N=27)	11 (N=25)
On lab worksheets, how important is it												
to be neat	2.92 (.80)	3.14 (.69)	3.28 (.80)	2.55 (.77)	3.07 (.62)	2.80 (.96)	3.00 (.58)	2.95 (.90)	2.79 (.72)	2.70^h (.87)	3.00 (.88)	2.84 (.75)
to do the experiment right*	3.53^a (.65)	3.69 (.47)	3.69 (.71)	3.48 (.68)	3.86 (.36)	3.29^b (.69)	3.45 (.62)	3.59 (.73)	3.79 (.41)	3.33^h (.68)	3.56 (.51)	3.28 (.84)
to write down the right answers*	3.48^c (.67)	3.62 (.56)	3.54^d (.79)	3.68 (.48)	3.86 (.36)	3.08^b (.93)	3.48 (.51)	3.45 (.74)	3.63 (.58)	3.42^e (.58)	3.30 (.78)	3.32 (.69)
to turn it in on time**	3.44^f (.66)	3.62 (.49)	3.52 (.78)	3.65 (.49)	3.86 (.36)	3.04^b (.75)	3.45 (.57)	3.45 (.74)	3.54 (.66)	3.33^h (.62)	3.35^e (.56)	3.16 (.85)
to think carefully about what you are learning*	3.30^c (.74)	3.55 (.57)	3.28 (.84)	3.29 (.69)	3.64 (.50)	3.08^b (.97)	3.27^g (.78)	2.95 (.72)	3.29 (.62)	3.30^h (.67)	3.63 (.56)	3.00 (.83)

$^a n$ = 283 $^e n$ = 26
$^b n$ = 24 $^f n$ = 282
$^c n$ = 281 $^g n$ = 30
$^d n$ = 28 $^h n$ = 27

Note. Scale points are: 4=Very Important, 3=Important, 2=Not Very Important, 1=Not At All Important.

***p <.001. **p <.01. *p <.05.

turning work in on time to be more important than completing it correctly. Means indicating the importance of turning homework in on time were higher than they were for getting all the answers right in the classes of Teachers 1 and 8, and they were rated equally important in the class of Teacher 4. Timeliness was rated more important than correctness for class worksheets in the classes of Teachers 1, 4 and 8. Thus, in the classes of Teachers 1 and 8, students perceived being on time more important than getting the right answers for both homework and worksheets. Second, the mean rating that students in the class of Teacher 10 gave to the item "thinking carefully about what you are learning" was particularly high, for both homework and worksheets. Nineteen students (70 percent) rated this "very important" for homework, and an equal number rated it "very important" for worksheets. While this dffference may be attributable to chance, it does suggest an interesting avenue for future exploration.

Table 7.15 focuses on students' perceptions of lab worksheets, and presents a somewhat different story to students' perceptions of their homework and worksheets. Students tended to report that doing the experiment right was more important than any of the other alternatives. The overall mean rating of this item (3.53) was the highest, and its mean rating was the highest in 5 of the 11 classes. Once again the students in Teacher 10's class rated "thinking carefully about what you are learning" as the most important aspect of completing a laboratory worksheet. Turning the work in on time was the only item to show strongly significant variation ($p < .01$) among classes.

While having the right answer, or doing the experiment right, was generally placed highest in importance of the grading crteria, it is noteworthy that procedural and management concerns -- turning work in on time and being neat -- also received high ratings. In some classes these management concerns were given higher average ratings than correctness and accuracy. We are left with the somewhat disturbing picture that students consider their teachers to give greatest weight to test grades relative to other academic activities and that, when these activities are taken into account, their timeliness and neatness are often seen as being as important as the quality of work. This is consistent with the Chapter Four findings that teachers often evaluated tasks other than tests only on the basis of completion or failed to grade them at all. Indeed, it is almost surprising that students perceived the correctness of worksheets and homework to be as important as they did.

Understanding Science vs. Getting the Right Answers

Table 7.16 presents students' level of agreement with the statement "really understanding science is more important than getting the answers right" (item 55). As we are not making comparisons between alternative formulations of the same item, the definition of the scale points is crucial to understanding

Table 7.16

Students' Perceptions of the Importance of Really Understanding Science Versus Getting the Answers Right

ITEM	ALL CLASSES (N=286)	TEACHER 1 (N=29)	2 (N=29)	3 (N=31)	4 (N=14)	5 (N=25)	6 (N=32)	7 (N=22)	8 (N=24)	9 (N=28)	10 (N=27)	11 (N=25)
really understanding science is more important than getting the answers right	3.48[a] (1.19)	3.83 (1.14)	3.41 (1.09)	3.45 (1.21)	3.50 (1.51)	3.52 (1.08)	3.44 (1.19)	3.23 (1.11)	3.63 (1.28)	3.59[b] (1.08)	3.37 (1.45)	3.24 (1.16)

[a] n = 285
[b] n = 27

Note. Scale points are: 5=Strongly Agree, 4=Agree, 3=No Opinion, 2=Disagree, 1=Strongly Disagree.

students' responses. The item was presented with a five point response continuum: (5) Strongly Agree, (4) Agree, (3) No opinion, (2) Disagree, and (1) Strongly Disagree. The mean response for the sample as a whole was 3.48 (SD=1.19), ranging across classes from 3.24 to 3.83. Standard deviations ranged from 1.08 to 1.78. This item showed no significant variation across classes (p = .67).

Although this seems to be a somewhat controversial statement, with student opinion spanning the range from strong disagreement to strong agreement, more students agreed than disagreed with the item: 55 percent of the sample noted they either agreed (33.3 percent) or strongly agreed (21.4 percent) with the statement. Some students, however, perceived that right answers were the currency of classrooms: 20 percent of the sample expressed disagreement with the item. Unfortunately, at the time the IASS was written, we did not anticipate the possibility, indicated in Chapter Four, that neither higher-order understanding or accuracy of answers necessarily prevailed in the accountability systems of the classrooms. Thus, this item may have posed students with a confusing polarity.

Summary and Conclusions

The most salient findings to emerge in this chapter concern the role that quizzes and tests played in students' perceptions of their science classes. Students reported quizzes and tests as being the activities where they thought most carefully about science, and to which they paid the most attention. Surprisingly, the students also reported, in the main, that they learned the most while taking quizzes and tests, although they also perceived learning a lot about science while completing labs, relative to worksheets and audio-visual presentations. They also regarded lab activities as the most interesting.

These data are distressing when seen in conjunction with Chapter Four's analysis of academic tasks. We described there the low level of task difficulty most classroom tests actually manifested; yet students saw them as difficult. There is no evidence that tests were in reality any harder than other academic activities -- all were of low complexity and, if anything, the tests appeared to have been slightly easier than the worksheets.

We interpret the perceived link on students' part between tests and learning as an indication of the power of an assessment tool, especially when teachers make that tool the focus of their accountability system. Thus, class testing may generate a restricted definition of learning for students, -- i.e. they may perceive that they have "learned something" only if that learning is to be demonstrated by test performance. Given the low level of tests that students were required to complete, students probably found themselves repeatedly engaged in relatively superficial learning, which they may have come to take as the kind of thinking required for the discipline of life science.

It was possible to identify differences among the eleven classes in students' responses to the Ideas About Science Survey, and these differences frequently fit other data sources on the teachers, from both observational instruments and other perception instruments. For example, in Chapter Three we reported on teachers' use of the scientific literacy components; students' ratings here on their teachers' use of these components were in general accord, though they tended to overestimate the amount of use of the relating components.

The data from the IASS are also in general accord with data we shall report in Chapter Eight on students' ratings of the interest, difficulty, attention and learning associated with a specific day's activities, and in Chapter Nine on target student interviews concerning academic activities. This agreement will be discussed further in the concluding portion of Chapter Nine; it suggests the presence of convergent validity to these various measures of classroom activity and teacher behavior.

CHAPTER EIGHT

STUDENT CLASS SURVEY RESULTS AND THEIR RELATION TO CLASS ACTIVITIES AND TASKS

In this chapter we shall describe the results of the Student Class Survey. The Student Class Survey is a self-report measure of students' perceptions of their class on a specific day during each topic interval. In this chapter we shall examine four aspects of these self-report[illegible]he difficulty and interest of the day's activities, and the d[illegible] of attention and thinking they required. We shall examine [illegible] these aspects relate to observed features of classes, drawing on the narrative descriptions observers made of the classes.

Our aim in this chapter is to uncover links between class activities and student perceptions of them. We use the term "activity" to refer to any distinct segment of time characterized by a particular goal and structure of social interaction. Thus, an activity either can be academic or non-academic (e.g., a procedural segment such as roll call). Academic work is divided into tasks and resource use. The former entail students completing tangible work products (see Chapter 1); the latter are academic segments where students produce no product, but where they are gaining skills or knowledge which might be called upon in future tasks (e.g., a teacher's recitation on cell structure may prepare students for their unit exam).

Our rationale for undertaking an examination of the link between student perceptions and class activities and tasks is two-fold. First, there is a scarcity of research on early adolescents' perceptions of the tasks assigned them in science classes. A descriptive analysis cuts fresh turf here. Weinstein (1982) notes that research on instructional behavior has until recently focussed narrowly on the relationship between teaching behaviors and measures of student learning. The role of student behaviors and perceptions as intervening variables has only recently been appreciated (e.g., Stayrook, Corno & Winne, 1978; Winne and Marx, 1980). Those few studies which have examined the role of student perceptions suggest, however, that they are of central importance. A meta-analysis by Haertel, Walberg and Haertel (1979) found that perception of classroom environment accounted for more variance in learning outomes than did ability. Gains in learning were associated with perceptions of satisfaction, task difficulty, goal direction and organization, among others.

The second rationale for examining students' perceptions and self-report of their academic tasks is that we would like at least a partial understanding of the various connections between activity format, academic task, student perception and attitude, and cognitive and affective outcome. At this juncture, we can begin to describe only some of these linkages, with constraints imposed by the nature of our data. The Student Class Survey

(SCS) is a self-report instrument, given on a particular day during each topic. Like any measure which relies on subjects' self-report, it is prone to subjective distortions, and in the long term should be supplemented with observational data. Since it was administered on a single day, it cannot be taken as representative of the topic as a whole, let alone the entire school year, though student outcome obviously is the consequence of a year's schooling. Consequently, it would be potentially misleading to use the Student Class Survey results as intervening variables in any statistical assessment of the relationship between background variables (such as ability) and outcome variables (such as life science achievement).

Despite these cautions, the SCS scores can serve to inform us about the way students perceive and respond to different types of academic work. It should be possible to draw inferences about the particular kinds of activities most likely to result in an increase in students' motivation towards and learning in life science, and this is the focus of this chapter. An additional step would be to see if teachers showed differential use of these kinds of activities, to an extent that outcome differences could be predicted for their students. We are not currently at a point to take this second step, and this chapter will deal only with the identification of those activities which students perceived as interesting and difficult, involving both thought and attention, and those they saw as easy and dull, requiring little attention and thought.

Data Source

The Student Class Survey is a self-report instrument that was given to students on a day near the end of each of the two topics. Taking students about ten minutes to complete, it included questions on the amount of time students had been paying attention during the period, the amount of time spent thinking, the number of times students had been confused, the difficulty of the work, how interesting it was, whether the teacher connected the day's lesson to things studied before, whether students learned from their peers, whether they asked questions, and whether the class had been quiet enough for them to learn. In addition, the students gave short written answers to four open-ended questions, concerning what the teacher wanted them to remember from the lesson, the nature of links made with previous content, what they would do in their next class, and whether learning science was different from learning English. A copy of the instrument appears in Section Eight of Appendix A.

The data set used for analysis of the Student Class Survey consisted of all students who had responses for one or both of the two administrations of the survey. Thus, the sample size for this survey was larger and more inclusive than the sample size for the pre and post student outcomes (see Chapter Five). Also, the sample size fluctuated depending on topic and item. It was felt that the full use of all existing Student Class Survey data was appropriate given our desire to describe and interpret how all attending students felt about class on a specific day. Direct comparisons between responses for Topic 1 and Topic 2 and between the Student Class Survey and student outcomes were not viewed as a priority, and, in fact, might be misleading given differences in sample composition.

The analysis reported here is based on the four items (2, 3, 6, and 7) that took the form of five-point rating scales, where students rated the class in terms of (1) the percentage of time they were paying attention, (2) the percentage of time they were thinking, (3) the difficulty of the work, and (4) the interest level of the work. Students' responses to these items were considered proximal indicators of student learning. Items were coded so that a lower score indicated more attending, more thinking, more difficulty, and more interest. Students' open-ended responses to the Student Class Survey also are included in this chapter when they further interpretation of the rating items.

At this point in the analysis, we have not considered either student gender or ability as independent variables. There is some evidence from previous ~~studies that such variables are not of major importance.~~ For instance, Weinstein (1982) reported finding no effect of student gender and achievement on perceptions of teacher's treatment of high- and low-achieving students: she concluded that students in the class shared a common understanding of their teacher's instruction. It is possible, of course, that these findings cannot be generalized to perceptions of academic work, and gender differences will be a focus of future analyses.

Class Averages on Rating Items

Tables 8.1 and 8.2 show the average ratings on each of these four items for each of the eleven classes, for Topics 1 and 2, respectively. The upper left-hand number in each cell in each item's column (attending, thinking, difficulty, interest) is the class's mean score for the day; beneath it, in parentheses, is the standard deviation (SD). At the foot of each column is the total sample mean and its standard deviation. While classes are ranked on each item (right hand number in each cell), some of the ranking distinctions are based on differences of .01 or .02. Thus, the reader should not attribute much significance to distinctions based on so small a difference.

Examining Table 8.1 first, there appear to be moderate differences among some classes given the metric of 5-point ratings. The same holds true for Table 8.2. In order to address this issue of class differences statistically, one-way analyses of variance (ANOVAs) were conducted for all the items of the Student Class Survey, for Topic 1 and 2 separately. As Table 8.3 shows, on the four items of focal interest here, class was a significant

Table 8.1

Student Class Survey:

Mean Student Ratings by Classroom for Topic 1

TEACHER	ATTENDING	Rank	THINKING	Rank	DIFFICULTY	Rank	INTEREST	Rank
1 (N=28)	1.64 (.49)	2	1.89 (.63)	2	3.75 (.97)	8	1.71 (.76)	1
2 (N=29)	2.41 (1.12)	9	2.24 (1.18)	7	3.31 (1.10)	2	3.21 (1.18)	10
3 (N=31)	1.90 (.65)	6	2.13 (.85)	6	3.52 (.89)	5	2.81 (1.08)	7
4 (N=28)	1.79 (.88)	4	2.07 (.72)	5	3.71 (.98)	7	2.21 (1.10)	4
5 (N=26)	1.46 (.65)	1	2.00 (.49)	3	3.69 (.97)	6	2.23 (.95)	5
6 (N=22)	2.41 (1.18)	8	3.00 (1.27)	11	4.32 (.95)	11	3.64 (1.00)	11
7 (N=24)	2.54 (.93)	11	2.71 (1.08)	9	3.96 (.81)	10	2.87 (.95)	8
8 (N=20)	1.80 (.62)	5	2.05 (.95)	4	3.30 (1.03)	1	1.95 (.76)	2
9 (N=26)	2.31 (.88)	7	2.81 (1.13)	10	3.42 (1.17)	4	2.69 (1.05)	6
10 (N=29)	1.72 (.53)	3	1.76 (.79)	1	3.79 (1.05)	9	2.17 (.97)	3
11 (N=29)	2.52 (1.24)	10	2.45 (1.27)	8	3.31 (1.11)	2	3.03 (1.30)	9
Total (N=292)	2.04 (.93)		2.26 (1.02)		3.63 (1.03)		2.59 (1.15)	

Table 8.2

Student Class Survey:

Mean Student Ratings by Classroom for Topic 2

TEACHER	ATTENDING	Rank	THINKING	Rank	DIFFICULTY	Rank	INTEREST	Rank
1 (N=28)	1.86 (1.01)	3	2.25 (1.04)	5	3.32 (1.06)	3	2.68 (1.25)	6
2 (N=28)	2.29 (1.08)	7	2.39 (1.17)	6	3.43 (1.14)	5	3.04 (.96)	10
3 (N=23)	2.17 (.83)	5	2.70 (.76)	9	3.00 (.80)	2	2.65 (.98)	4
4 (N=35)	1.74 (.56)	1	1.86 (.73)	1	2.89 (1.05)	1	2.03 (.98)	2
5 (N=19)	1.86 (.88)	4	2.21 (.86)	4	3.42 (1.02)	4	2.68 (.82)	6
6 (N=30)	2.43 (1.19)	10	2.57 (1.28)	7	3.80 (.96)	8	3.00 (1.14)	9
7 (N=24)	2.71 (.81)	11	3.25 (.99)	11	4.08 (.83)	10	3.25 (.90)	11
8 (N=22)	1.77 (.69)	2	1.91 (.68)	2	3.55 (.91)	7	2.68 (1.04)	6
9 (N=32)	2.31 (1.09)	8	2.87 (1.31)	10	4.32* (.94)	11	2.52* (1.23)	3
10 (N=25)	2.28 (1.10)	6	2.20 (1.04)	3	3.84 (.90)	9	1.84 (.99)	1
11 (N=24)	2.33 (1.31)	9	2.62 (1.38)	8	3.54 (.98)	6	2.87 (1.08)	8
Total (N=290)	2.16 (1.01)		2.43 (1.11)		3.56 (1.05)		2.64 (1.11)	

*N=31

Table 8.3.

One-way Analyses of Variance of Class Differences on Four Student Class Survey Rating Scales

	Attention		Thinking		Difficulty		Interest	
	Topic 1 (N=198)	Topic 2 (N=196)	Topic 1 (N=198)	Topic 2 (N=196)	Topic 1 (N=198)	Topic 2 (N=195)	Topic 1 (N=198)	Topic 2 (N=195)
F	4.81	2.84	3.91	2.94	2.29	3.46	9.20	4.12
p	0.000**	0.003**	0.000**	0.002**	0.015*	0.000**	0.000**	0.000**

Note: There were 10 degrees of freedom in all cases.

* Significant at the .05 level.

** Significant at the .01 level.

factor at the $p < .01$ level or better on seven of the eight items, and class was still significant at the $p < .05$ level on the eighth item. This means that the variation among classes on each of the four five-point items is significantly greater than the variation within each class, despite the fact that for each rating scale, all the class means lie within one standard deviation of the scale's total sample mean. These results strongly suggest that there were real differences between some classes in students' perceptions of difficulty and interest and their self-reported levels of attention and thought.

Duncan range tests were also carried out in order to determine when the ratings received by two classes were significantly distinct. In short, this test identifies groups of classes, where the classes in each group are not significantly different from one another, but are significantly different from all other groups. The results of these tests will be reported on a class by class basis during this chapter.

A final feature of Tables 8.1 and 8.2 that should be noted is the relationships between rankings across the four measures. Examining Table 8.1, it appears that the rankings for attending, thinking, and interest are in fairly close correspondence. The rankings for difficulty match these rankings less well. This impression is confirmed by rank correlations for Topic 1, shown in Table 8.4. Students that ranked the class period as high (or low) on levels of attending for Topic 1 also were likely to rate it as high (or low) on thinking and interest. Furthermore, there was little or no relationship between perceived difficulty of the class and its interest, or the amount of thinking and attending that occurred. Turning to Table 8.2 (for Topic 2), the rankings between attending and thinking still seem closely matched. This is confirmed in Table 8.4 by a rank correlation of .80. The relationship of attending and thinking with interest is of lower magnitude than it was during Topic 1, however. Also, difficulty changes its relationship to the other three variables at Topic 2. It has moderate positive correlations with attending and thinking (rs = .68 and .45, respectively) and a smaller positive correlation with interest (r = .191). While this increase in relationship from Topic 1 to Topic 2 may be partly attributable to differences in sample composition between the two topics, it also is of enough magnitude to suggest that most students come to more closely associate a property of work (i.e., difficulty) and their own mental and behavioral processes (i.e., attending and thinking) by the end of the year. Comparing the stability of rankings across Topic 1 and Topic 2 also is worthwhile despite sample changes. Basically, it appears that there is relative stability across topics in terms of the lowest ranked classes (e.g., Teachers 6, 7, and 11) and more fluctuation among the middle to highest ranked classes.

Table 8.4

Rank Correlations Among Four Rating Scales (N=11)

	2	3	4
1. Attending	.818** .800**	-.159 .682*	.782** .582
2. Thinking		-.005 .446	.809** .455
3. Difficulty			-.005 .191
4. Interest			

Note: The top and bottom numbers represent correlations for Topics 1 and 2, respectively.

*p $\leq$ .05

**p $\leq$ .01

Comparisons of High and Low Ranked Classes

Class Selection

As mentioned, a ranking of 1 indicates that the students in that class rated the class the most interesting. A ranking of 11 indicated that the students rated it the least interesting of the eleven classes. These rankings highlighted patterns of similarity and difference among the classes. The rankings were examined across the four items, and certain classes selected for more detailed study, using the Class Narratives and the Narrative Record Summary Sheets. This selection was based in part on the extremeness of the classes' rankings. It seems likely that the activities most likely to foster motivation toward life science would be those students found interesting but difficult, requiring both attention and thought.

The second criterion for selecting a class for detailed analysis (and for inclusion in this chapter) was when a particularly interesting contrast developed between two classes. For example, in Topic 1, both Teachers 8 and 9 scheduled laboratory activities on the day the Student Class Survey was administered, but students rated these two similar activities very differently. Consequently, examining the different nature of the two laboratory activities that students were engaged in might prove insightful.

For Topic 1, five classes were selected for detailed examination: those of Teachers 6, 8, 9, 10 and 11. For Topic 2, four were selected: those of Teachers 4, 7, 9 and 10. Tables 8.5 and 8.6 show the rankings for the selected classes, together with the activity formats and the tasks operating during the class period when the Student Class Survey was given.

Topic 1

The mean ratings on the four items for all classroom during Topic 1 were as follows: attention, 2.04 (SD = .93); thinking, 2.26 (SD = 1.02); difficulty, 3.63 (SD = 1.03); and interest, 2.59 (SD = 1.15).

Teacher 9. The class of Teacher 9 was spent in a "hands on" laboratory practicum. The class period began with a 10-minute review of the phases of cell division, and then moved to a lab exercise in which the students attempted to identify cells going through the different stages of mitosis. Students' materials were microscopes and prepared slides of tissue from salamander tails. This was a typical day for this class; during the 10 days Teacher 9 spent on Topic 1, a laboratory practicum similar to this occurred on seven occasions. Altogether, there was a total of 112 minutes of practical laboratory work in addition to films, lab clean-up, reviews of lab procedure and, of course, lectures and reviews of lectures. There was also a single 30-minute exam

Table 8.5

Selected Teachers' Rankings for Topic 1

TEACHER	ACTIVITY	TASK	STUDENTS' RANKINGS			
			Attending	Thinking	Difficulty	Interest
8	Laboratory	Use Microscopes To Observe Protozoa	5th	4th	1st	2nd
9	Laboratory	Use Microscopes to Observe Stages of Mitosis	7th	10th	4th	6th
10	Teacher Recitation and Review	Answer Teacher Questions Orally	3rd	1st	9th	3rd
11	Seatwork	Answer Teacher Questions On Worksheets	10th	8th	2nd	9th
6	Seatwork	Correcting Test; Recording Grades	8th	11th	11th	11th

Table 8.6

Selected Teachers' Rankings for Topic 2

TEACHER	ACTIVITY	TASK	STUDENTS' RANKINGS			
			Attending	Thinking	Difficulty	Interest
4	Teacher Recitation	Take notes; Orally Answer Questions	1st	1st	1st	2nd
7	Recitation, Seatwork, & Review Game	Answer Questions on Worksheet	11th	11th	10th	11th
9	Laboratory	Blood Clotting Procedures	8th	10th	11th	3rd
10	Nine-Station Laboratory	Identify Parts of the Human Body	6th	3rd	9th	1st

on cytology.

The observer recorded the following notes. "The teacher's directions for the lab activity seemed very clear, and the students had little trouble following them. In addition, the students are already familiar with procedures for lab exercises, and things flowed very smoothly. During the lab exercise the teacher was very available as a resource for the students. He was constantly going around from group to group helping students focus in on a cell going through mitosis. I believe the teacher got around to helping each and every student look at the cells."

All seems well here at first glance, yet this class was ranked 6th in terms of interest (2.69). The students ranked it very low on the amount of time spent thinking (2.81) and attending (2.31) (10th and 7th, respectively). The class was rated as average (3.42) on difficulty, placing it 4th in rank. The Duncan range tests indicate that Teacher 9's class was less interesting than Teacher 8's class, though more interesting than Teacher 6's class. It was more difficult than Teacher 6's, and involved less thinking than either Teacher 8's or Teacher 10's classes. Students paid less attention than in Teacher 10's class. (All these differences are significant at the .05 level.)

Comments. One explanation for these unimpressive responses may lie in the cognitive level of the work that students were engaged in during their laboratory assignment. First, the students were familiar with the use of microscopes, so procedurally the work was not challenging. Second, the students used prepared slides--perhaps necessary given the topic--but, nevertheless, any interest, thought, or difficulty inherent in creating a slide was absent from this assignment. The assigment, then, was simply to identity examples of the five phases of mitosis--interphase, prophase, metaphase, anaphase, and telophase. Students had previously been taught these phases and had been tested on their ability to define them. The observer recorded that "the cognitive orientation of today's lab was mainly directed towards an understanding of how cells actually looked; in other words, mainly a comprehension task, although there was a small memory component." There were no specific problems to which the students had to address themselves; the methods were given to them in advance, and so were the answers.

The students, in their replies to the open-ended portions of the Student Class Survey, generally were clear that Teacher 9 wanted them to remember the phases of mitosis. "To know what the five phases are and look like" was a typical response to the question of what the teacher wanted them to remember for the day. Over a quarter of the students wrote, however, that the teacher had not connected the lesson to things studied earlier. Those who did find a connection often simply identified it as mitosis: "Have looked at mytosis wich we are now studing [sic]."

Teacher 8. The class of Teacher 8 also involved a laboratory practicum, but it was one which placed strikingly different task demands on students. This class was ranked the highest on difficulty among the 11 classes (3.30), but it was also ranked second in its interest to the students (1.95). The attention and thinking ratings were average (1.80 and 2.05, respectively). The Duncan range tests indicated that the class was significantly higher ($p < .05$) in interest than the classes of Teachers 9, 11 and 6. It was harder than Teacher 6's class, and required more thinking than the classes of Teachers 9 and 4. Attending was higher than in the classes of Teachers 9, 11 or 6.

The period began with a multiple-choice test on protozoa, and the teacher then reviewed a discussion on the previous day's laboratory assignment. After this, students returned to their microscopes for the purpose of trying to find various single-celled organisms in samples of pond water.

Teacher 8 made the following announcement during the introduction to the lab: "I want to call your attention to something I saw yesterday. . . that I have never seen before, and we've been doing this for about four years now. A boy called me over, and a lot of times people call me over, to see something and it's something I've seen before. But this thing was a single-celled organism--it was a protozoan--and this is the size that it was in comparison to all the others: it was huge. Not only was it huge, but it had a real ominous look to it--scary-like. It moved very slowly and it looked like. . . it was in charge. All the other organisms there were there to wait on this guy or protect this guy, and it was very dramatic looking, and I have never seen it before."

The students shared their teacher's enthusiasm. The observer noted that "every few seconds a different group is calling out, 'Mr. Bradford,' trying to get his attention so that he'll come over and tell them what they're seeing." The children were frequently described as "excited," and, when the teacher told them to clean up, several groups of students continued to look through their microscopes, unwilling to end the assignment. One pair of boys was observed competing for the last look at the organism they had just come across. Throughout the period, Teacher 8 did not maintain a low noise level, and on several occasions, he had to wait for students' talk to subside. Yet only 2 of the 40 students reported in their survey responses that the class was not quiet enough for them to learn.

The students' open-ended responses were more diverse than those of students in Teacher 8's class. When asked what they thought they were to remember, about half of the replies focussed on the purpose of the laboratory, e.g., "The different types of protazoa and how they work [sic]," or "He wanted us to remember the names and shapes and how the protoza move [sic]." Others referred to the subject matter in a vague sense (e.g., "learn about paramecium) or to procedural matters ("To be neat and to think about the project"). The variety of responses suggests that the task had greater ambiguity than the laboratory task assigned by Teacher 9.

Comments. At first glance, the classes of Teachers 9 and 8 had similar activities. However, there were marked underlying differences in the tasks that students were engaged in. Unlike the laboratory of Teacher 9, in Teacher 8's lab students were given a task which allowed for the unexpected and, possibly, some creative inquiry. In addition, students prepared their own slides, allowing them greater practical involvement and more responsibility for the task's outcome. Teacher 8 communicated considerable excitement while Teacher 9 did not. He made it clear that discoveries of some protozoa are rare and fortuitous, but possible at any time. He described the new protozoan in terms which, while somewhat anthropomorphized, were memorable. His comments graphically conveyed one interpretation of the relationship of the organism to the pondwater milieu, a key biological concept.

While observing live protozoa may be more interesting than observing the stages of mitosis in fixed slides, it seems likely that the students' active participation, both in preparing the materials and in the discovery of new organisms, made Teacher 8's lab a higher-order task, and both interesting and difficult.

A second pair of teachers--Teachers 10 and 11--differed in both the activity format and the task presented to students, though they dealt with similar content areas: both the classes were concerned with basic scientific vocabulary. The first class (Teacher 10's) focused on genetics. Vocabulary, such as "genotype, phenotype, dominant and recessive genes," was presented within an instructional mode of teacher recitation and demonstration. The second class (Teacher 11's) focused on geographical environments, with students engaged in individual seatwork--namely, completing study sheets and chapter review questions from their textbook.

Teacher 10. This teacher adopted the recitation and demonstration approach. His class was ranked high on interest (2.17), attending (1.72), and especially thinking (1.76), but relatively low on difficulty (3.79). The Duncan tests showed that levels of interest and attention were both significantly higher than those in the classes of Teachers 9, 11, and 6. Thinking also was higher in this class than in the classes of Teachers 9 and 6. The difficulty of this class, however, was rated greater only relative to that in Teacher 6's class. In short, students found the work easy, but reported that most of their time during class was spent thinking and attending.

During this teacher's recitation on genetics, he demonstrated tongue-curling, sensitivity to PTC, and several other phenotypic variations. Students apparently enjoyed participating in this activity. The period, which was reasonably representative of Teacher 10's classes during the topic, also included a review of genetics vocabulary and concepts. During the period students were constantly involved and participating. The teacher called on them to identify phenotypic variations in themselves and others, as well as to provide definitions of key terms for him. For the open-ended responses, about 60 percent of Teacher 10's students talked of "genes," "traits, "hereditary gene characteristics" and "genetic things" when they described what the teacher wanted them to remember from the period. One of them wrote that "there wasn't one main idea, just alot of dif. ones. We talked about traits and stuff." The remaining students gave very general answers (e.g., "study your notes") or no answer at all.

Comments. Students were kept on their toes by this form of presentation, and also by the participation demands imposed by that activity. Since they could be called upon at any point, they had to attend and think; when they were called upon, they had to rely upon their memory and reasoning to provide an answer, with no recourse to a text or other students. They were also, of course, publically accountable for their answers.

Teacher 11. This teacher assigned her students to work in their seats for over 30 minutes on the day of the Student Class Survey. The students completed review questions from the chapter on grasslands and coniferous forests they had read on previous days, and worked on study sheets. They rated this class as relatively hard (3.31), but as having little interest (3.03). On average, they reported attending and thinking only 50 percent of the time (2.52 and 2.45, respectively). The Duncan tests show that the degree of interest in this class was higher only than that in Teacher 6's class (which was perceived as very dull; see below). Difficulty was on a par with the classes of Teachers 8, 9, 10, and 11. The level of thinking was higher than Teacher 9 and 6's classes, while attending was not significantly different from the classes of Teachers 8, 9 or 6. The observer's notes confirm the students' reports: there was much conversation while the students ostensibly worked, and roughly a quarter of them were judged to be continually off-task.

In their open-ended responses to the Student Class Survey, the students seemed unsure what the teacher had wanted them to remember of the period. Thirteen children (45 percent) responded "Don't know," or left this question unanswered. Several others made remarks such as "The last chapter and to be quiet," or "Well she will dig into us intill we know it [sic]." Only six children (21 percent) mentioned the content of the lesson in their replies: "All about the different areas in North America," or "The different kinds of biomes." Furthermore, 40 percent of the children saw no connection to work done on previous days.

Comments. The task assigned for this class was such that only minimal cognitive demands were placed on the students. The response format of the assigned work required mostly filling in information missing from large factual statements, and students generally completed the assignment by searching through their textbooks until they found the appropriate passage. Students may have rated this class as relatively hard as a consequence of the minimal motivation they had to complete their work, or because they found it hard to find the material in their texts. It seemed that they found it easy to carry out the procedures necessary to complete ~~their~~ assignment. Parenthetically, this indicates that perceived difficulty is an ambiguous proximal indicator of learning.

The students were not publically accountable; indeed, no clear instructions were given about how the assignment would be graded, or when it was due. As a consequence, there were no incentives for students to attend for any length of time.* The degree of thought involved was negligible, since the best score could be gained by copying answers from the book. In any case, the questions required factual answers rather than any analysis or conceptualization, so the assignment was at best a test of memory.

Interim Summary. We have now described two pairs of classes from Topic I, where in each case one member of the pair was ranked high by students and the other ranked low. We have suggested that these differences in student perception were a consequence of the different demands which were operating in the four classes. Considering the ratings for attending, thinking, difficulty and interest respectively, Teacher 8 received high rankings throughout, while Teacher 9's rankings were low, low, average, and low. Teacher 10 was ranked high, except on difficulty, while Teacher 11 was low throughout, save for a high ranking on difficulty.

Teachers 8 and 9 used a similar activity format and instructional mode: the traditional laboratory -- but the nature of the assignments within this format were distinct. The task in Teacher 8's class had a greater degree of ambiguity to it, and involved students in discovery rather than simply recognition. It is encouraging that the students responded with enthusiasm and interest to this task, and did not try to negotiate with the teacher in order to lower the degree of ambiguity. Possibly this is because there was no great risk attached to their assignment, in terms of grade or status. Any students spotting a rare protozoan would gain kudos among their peers, but failure to make such an observation would not result in loss of face or in any differential grading by the teacher.

Teachers 10 and 11 both taught classes where the acquisition of vocabulary was paramount. In Teacher 10's class, there was an interaction between students and teacher, in which students were publically accountable. Teacher 11 employed seatwork, and students generally completed it by searching for the answers in their textbook. Students reported that the former class was interesting, and captured their thought and attention, while the latter was a mirror image: difficult, but dull, and generating minimal thought and attention.

It would appear that students' interest was captured, and their thinking and attention stimulated, when they were given an opportunity for practical activity and participation, or when they were drawn into an active and productive interaction with their teacher. On the other hand, when they were assigned straightforward procedural or routine work, they experienced a lack of challenge and interest. This preliminary generalization receives some confirmation from the case of a fifth teacher, Teacher 6, whose SCS ratings for Topic 1 were the lowest of any teacher on three of the four items.

Teacher 6. This class was ranked lowest among the 11 classes on interest, difficulty, and thinking, and also very low in student attention (in 8th place). The students considered it somewhere between average and uninteresting (3.64), and it was rated as very easy (4.32). The Duncan range tests showed that Teacher 6's class was significantly lower than all others in the degree of student interest, and lower than the classes of Teachers 8, 10 and 11 in student thinking. It was significantly lower in its difficulty than Teacher 9's class, and also lower in the degree of student attention than Teacher 10's class. On these last two items--difficulty and attention--Teacher 6's class received lower ratings than most other classes, but the differences were not statistically significant at the .05 level.

These student responses suggest that the class was uneventful, and examination of the observer's narrative suggests why. The class period was taken up by a 5-minute roll call, then an 11-minute segment was spent correcting the "end of unit" test which had been given the previous day; finally, a further 10 minutes were spent recording the students' grades on this test. Thus, the teacher filled the period with routine and procedural activities.

Unfortunately, a period such as this was typical for this teacher. During the 7 days spent on the topic, there were only 15 minutes when students engaged in a cognitively complex learning activity -- namely, observing the characteristics of bacterial colonies. On the other hand, they spent a total of 40 minutes copying material from the board, 53 minutes listening to the teacher lecture, 25 reading, and 10 watching a movie.

In their written responses concerning what the teacher had wanted them to remember, Teacher 6's students tended to focus on procedural and disciplinary matters. Nineteen students (86 percent) referred to classroom behavior (e.g., "Not to bring gum to class," "I think he wanted us to be quiet and be respectful to others") or to procedures (e.g., "To be a good corector [sic]," "He wanted us to check the test"). Only four students (18 percent) made reference to the content of the lesson (e.g., "About bacteria," "How to correct papers and to remember about bacteria").

Comments. The observer's impression of the class, as recorded in informal notes, was similar to that of the students. She indicated that the class was "uninspired. The content is there, but there's a lack of excitement. The teacher, in conversations before and after class, seems really concerned and excited about teaching science, but the students don't appear very excited. Their behavior is neutral. The teacher knows his stuff, but as a new teacher, he is rather at a loss for things he could do with a class that really turns them on. There were times when I was watching the class that I was really bored. The activities given the kids are ones such that they are passive instead of active learners."

The observer added, "The teacher is discouraged about the number of students he is reaching. I think he realizes the kids are bored but doesn't know how to change that. He has told me many times that this is his last year of teaching; it is too much for him to give of himself with so little return."

This teacher, thus, was apparently well-intentioned, informed about his subject matter, and aware that he was not succeding in the task of educating his students. Yet he was unable to communicate any enthusiasm to students or to change his practices to make them more effective. This teacher had major problems in classroom management; it would seem that he lacked the requisite skills to assign his students engaging and challenging tasks.

Topic 2

In Topic 2, the overall ratings which students made on the four items showed slight increases in numerical value on three of the four items, indicating that students generally found their classes slightly less interesting, requiring slightly less thought and attention. Attention received a mean rating of 2.16 (SD = 1.01); thinking a mean rating of 2.43 (SD = 1.11); and interest a mean rating of 2.64 (SD = 1.11). Difficulty received a mean rating of 3.56 (SD = 1.05), down a little from its Topic 1 value. These differences should be interpreted with caution, since a change in sample composition, subject matter, or time in the school year could be their cause. Also, when one examines individual class scores, several classes received lower (i. e., more favorable) ratings for the second topic than they did for the first, moving against the overall trend.

The following teachers were selected based on their patterns of ratings: Teachers 4, 7, 9, and 10. The criteria for selection were the same as for Topic 1.

<u>Teacher 4</u>. The day of the administration of the Student Class Survey for Topic 2 was rated high by students in all four areas: attention (1.74), thinking (1.86), difficulty (2.89) and interest (2.03). It was ranked most favorably among all 11 classes on the first three items and second on the fourth. The Duncan range tests demonstrated that Teacher 4's class was significantly higher in student attention than Teacher 7's class and higher in student thinking than both Teacher 7 and 9's classes.

in difficulty it was statistically distinct from all three classes, and in interest it was higher than the classes of Teachers 7 and 9.

The class was devoted almost entirely to the presentation of content by the teacher. Eighty percent of time was spent in recitation, and most of this was a summary and review of meiosis, with a great deal of additional information provided to supplement what had been covered in previous days' classes. The observer described it as "a heavy duty day," and added that the entire topic had been this way. Teacher 4 employed a teacher presentation of this type on four of the topic's eight days.

The teacher began the lesson with a review of content that had been covered by a student teacher the previous week. She called on students to answer questions like "Where does meiosis occur?" and "Which is larger, egg cells or sperm cells?" The observer noted, fifteen minutes into the review, that "the instructor is definitely covering new information and the students appear to be struggling to provide the answers she is looking for." Teacher 4 is a tough task-master, as the following exchange shows:

> The teacher asks the class, "define fertilization, somebody... anybody." No one volunteers, so she calls on Greg, who says, "I don't know, I wasn't here on Friday." The teacher replies, "I don't care, you should still know this stuff." Greg mumbles under his breath. Teacher 4 says, "Go ahead, Greg. I think you've said it." Greg repeats more loudly, "Um... when the sperm meets up with the egg." Teacher 4 responds, "When the sperm meets up with the egg, and they become one. So..."

The students' task during the teacher's presentation was to take notes. Most of them appeared to be doing this as Teacher 4 instructed and wrote information on the chalkboard. The observer remarked on the quantity of material written out and added that "the students need to be applauded today for staying with it as long as they did."

In their open-ended responses to the survey, Teacher 4's students were able to give accurate, if brief, descriptions of what the teacher wanted them to remember. All but four students (11 percent) mentioned some aspect of meiosis ("How genes divide or reproduce," "mitosis and meiosis," "how cromasons with sperm and egg cells fitlize and reproduce [sic]"). Only four students claimed that the lesson had not been linked to previous work, and all students but two were aware that the next day they would be taking a test.

Comments. It appears that the students found this class a challenging and engaging one. The activity format for this class is reminiscent of that used by Teacher 10 in Topic 1. Students were involved and participating in a teacher recitation. The difference in student ratings is that while Teacher 10's students rated his class as high in interest, attending and thinking, but low on difficulty, Teacher 4's students rated it high throughout. The difference in difficulty ratings probably is due to the different form that student involvement took: in Teacher 10's Topic 1 class, students were called upon to identify phenotypic variations and provide definitions of key terms. These definitions were already familiar to them. Teacher 4, in contrast, was quizzing students on a good deal of novel material, and the students, not surprisingly, rated this as harder. The recitation and questioning moved along at a rapid pace, and so students were not allowed to become bored.

<u>Teacher 7</u>. The Student Class Survey was administered on Day 8 of Topic 2 for this teacher. Students rated their class low on each of the four focal items; it was ranked lowest (11th) on attention (2.71), thinking (3.25) and interest (3.25), and tenth on difficulty (4.08). The Duncan tests showed that the class was lower in student interest than any of the other three picked for detailed examination. In both student attention and difficulty, it was significantly lower than the class of Teacher 4, while in student thinking it was lower than both Teacher 4 and Teacher 10's classes. On no item was it significantly higher than any of the other three classes.

Again, these student ratings make sense when one looks at the nature of the activities they were engaged in during the period. There were a total of ten distinct activity segments during the class. The teacher began with a brief opening transition to the day's activites, spent four minutes calling roll, then gave directions for the day. Next, he spent a minute reading a section in the textbook on "incomplete dominance," while the students read along quietly. This was followed by a nine-minute recitation and reading on the same subject matter, followed by seatwork consisting of a handout on genetics. After this, the teacher introduced a review game which involved the teacher calling out a definition and then a number indicating a student in each row. Selected students had to run up to the front of the class, hit a bell, and give the term corresponding to the definition. The observer remarked that the students seemed most concerned about getting to the front of the room first, whether or not they knew an answer. They became caught up by demands which were tangential to the teacher's intentions for the activity, but which were a direct consequence of the way he had structured it. The requirement that they race to reach the bell became the students' focus, and the planned cognitive benefit of the work fell into the background. Since the game was intended to function as a preparatory review for the unit test the following day, the students were poorly served by the teacher's thoughtless organization of the activity.

In their written responses, students showed a lack of consensus when identifying what the teacher wanted them to remember. Many responses were vague (e.g., "Well about cromoaons and sex cells [sic]," "How a cow get differt colors [sic]," and "Incomplete dominance"). Nine students (39 percent) saw no connection between the lesson and work done on previous days. Eight students (33 percent) said they didn't know what would be done the next day, and the rest had varied opinions (e.g., "Take a test," "Probably study more about chromosomes and traits," and "Do science").

Comments. Students reported that this class was easy, that it required little thinking and attention, and that it generally lacked interest. In terms of the students ratings, this class of Teacher 7 resembles most closely Teacher 6's class during Topic 1. In both cases, routine and procedural activities occupied a large proportion of the class time.

Teacher 9. Students in this class completed the Student Class Survey at the end of the sixth and final day of Topic 2. After approximately seven minutes of teacher announcements and roll call, the majority of students were occupied by laboratory work on the Rhesus blood factor. This class was ranked 8th in terms of time attending, very low on thinking and difficulty (10th and 11th, respectively), but relatively high (3rd) on interest. It thus differed somewhat from the laboratory conducted by this same teacher during Topic 1. Recall that for Topic 1, students gave low ratings across the board to the laboratory exercise on the identification of phases of mitosis. For Topic 2, the Duncan range tests placed this class lower than the class of Teacher 4 in its difficulty and degree of student thinking; lower than the class of Teacher 10 but higher than the class of Teacher 7 in interest; and not statistically distinct from the other classes in the degree of student attention.

For Topic 2, the laboratory work required that students lance a finger in order to obtain a drop of blood. Then this blood was mixed with serum and observed for clotting, which would indicate the presense of the rhesus factor. The previous day, students had undertaken a similar laboratory in which they had tested for their blood antigens. Thus the procedures were familiar to them.

The students were in general agreement in identifying what Teacher 9 wanted them to remember from their lesson. Eighty-seven percent of their open-ended responses referred to blood types, or specifically to the Rhesus factor (e. g., "What our Rh factor is," "That there is a protein in your blood, and you either have it or you don't," and "How to type blood"). Only four students (12 percent) saw no connection with previous days' work, and 26 (81 percent) were aware that there would be a test next day.

Comments. The attention and thinking ratings for this class were almost identical to those the students gave for Topic 1: 2.31 and 2.87, respectively. The difficulty rating changed from 3.42 to 4.32, while the interest rating changed from 2.69 to 2.52. The blood laboratory was, then, easier but more interesting than the mitosis lab had been. The decrease in perceived difficulty most likely stems from the fact that students were familiar with the procedures they were employing. Higher interest probably is due to the fact that students were learning information about their own blood.

Teacher 10. In this class, the Student Class Survey was completed on Day 7 of the nine day long second topic. On this day, the students took a brief test on human systems, and then spent the remainder of the period in a laboratory, rotating through nine activity stations on human systems. The class ranked sixth in attention (2.28), third in thinking (2.20), ninth in difficulty (3.84) and first in interest (1.84). The Duncan range tests placed this class significantly higher in interest than the classes of Teachers 7 and 9, as easier than the class of Teacher 1, as involving more thinking than the class of Teacher 7, and as not statistically distinct from the others in levels of student attention.

The laboratory stations were concerned with the human skeletal, digestive, and circulatory systems. The last station was for blood typing. The observer noted that most of the students at one station were "off task and just fooling around." The teacher was unable to monitor the activities, since he was working at the blood-typing station, piercing fingers for those students who needed help. (The observer remarked that this was unusual; that Teacher 10 usually monitored in both seatwork and laboratory situations.) The students began to move from station to station without waiting for the teacher's directions to do so.

Sixty-eight percent of the students referred to one or another of the systems of the body when describing for the Survey what Teacher 10 wanted them to remember. Their descriptions were frequently vague (e. g., "He wanted us to learn the systems of a human body," and "About the jobs of the different systems"). One student explained the lesson in these terms: "There wasn't one idea I don't think. I think there were alot of things he wanted us to remember. I think our activities main purpose was for a study helper." All but three of the students (12 percent) found connections between the lesson and previous work, but seven students (28 percent) did not know what they would be doing when their science class next met.

Comments. The students rated this activity as interesting and easy. This was the first time during either of the observed topics that the teacher used a rotating station structure--with multiple activities during a single period--and this in itself may have caught student interest. The observer noted that student engagement was fairly low, and this is reflected in the students' own ratings of their attention: the mean rating was 2.28, which placed this class sixth among the eleven.

Conclusions

We have attempted in this chapter to use students' perceptions of their classes in order to identify kinds of academic activities and tasks which are likely to facilitate motivation and achievement in intermediate life science classes. We have described several academic tasks that were associated with greater or lesser student thought and attention, difficulty and interest. In Topic 1, Teacher 6 presented his students with routine and procedural activities; students described the day as very easy and uninteresting. Teacher 9's laboratory functioned smoothly; however, his students reported little interest, little thought, and little attention. The relatively low level of student involvement, the use of pre-prepared slides, the fact that the students had already taken a test on mitosis, and, perhaps, the subject of mitosis itself, probably contributed to the students assigning low ratings to the class.

Teacher 8 would not perhaps be considered a good teacher by those who value discipline and a classroom which runs without hitches. The laboratory work he assigned his students in Topic 1, however, had an air of discovery and excitement to it. Nor was this restricted to the particular day our questionnaire was given; Teacher 8's students were involved throughout Topic 1 in their own individual projects and experiments. Students reported that they found their work with this teacher interesting, challenging and that they were thinking and attending over 75 percent of the time.

Teachers 10 and 11 were rated by their students in an almost opposite manner. Teacher 10 employed traditonal recitation and demonstration, including forms of student participation (observing phenotypic variations) which the students evidently enjoyed. Teacher 11 assigned tedious routine seatwork to her students, which they found relatively hard but dull.

In Topic 2, Teacher 7's use of mostly routine and low-level activities lost students' attention and interest, despite the 'review game.' Although the game motivated students, it did so in a manner which interfered with rather than fostering academic goals. Students became so concerned with getting to the front of the classroom that they were distracted from the need to come up with correct answers. Teacher 9 ran a fairly familiar laboratory, as in Topic 1, but student interest was a little higher this time, probably because the subject matter of human blood had more personal relevance than did the phases of mitosis. Teacher 10 captured student interest, but at the cost of engaging them in activities (the nine-station laboratory) where they were engaged for very brief periods, and where they found the work easy.

Teacher 4's was the class rated consistently high on all four items. This teacher had an assertive approach to recitation, including question-and-answer segments. She introduced new material at a rapid rate and expected that students could deal with it. Thus, Teacher 4's class was perceived as difficult and challenging by the students but at the same time as holding their interest and attention. Research on the correlates of successful teaching has shown that rapidly paced presentation is associated with higher student achievement in reading and mathematics, and it is possible that a similar approach may work for science (Fisher et al., 1980; Rosenshine, 1976).

The results from the Student Class Survey, both from Topic 1 and Topic 2, suggest that students are interested and engaged when they are assigned work requiring active involvement. Merely structuring the classroom so that they are permitted such involvement is not enough, as Teacher 10's class illustrates. In the examples we have discussed, it appears that students must either be held to their work (e.g., Teacher 4) or motivated by an enthusiastic and personally involved instructor (e.g., Teacher 9). What these examples also point out is that the same class activity can be more or less successful (as perceived by students) depending on the more detailed features of the academic work which students are assigned. Specifically, this chapter has included descriptions of recitation that were more and less successful and descriptions of laboratories that were more and less successful. This suggests, contrary to some rhetoric, that there is nothing inherently more interesting about doing a lab than sitting through a recitation. Even recitation can be a powerful tool for getting students involved cognitively and motivationally. The position of another common activity, seatwork, is less clear. Both selected examples of this activity (Teachers 6 and 11 in Topic 1) were rated relatively unfavorably by students. It is difficulty to say whether this is inherent in seatwork or whether it was due to the low cognitive orientation of the seatwork (e.g., copying answers out of the book) that was observed throughout all sample classes (see Chapter 4).

The conclusions of this chapter must be qualified by stating that it is unclear to what extent student responses to the Student Class Survey were affected by daily fluctuations in teachers' activities and tasks. It may be the case that their responses were sensitive to these fluctuations, and, thus, these responses may not reflect their average perceptions of their classes. Furthermore, it is not clear how these perceptions may have influenced students' long-term motivation and learning in science.

Nonetheless, we feel that the Student Class Survey has demonstrated its usefulness for examining specific class periods of instruction. It shows a sensitivity to differences among classes, as well as showing reasonable consistency among students within each class. Our future refinements of the SCS and the techniques for its use will probably include requesting students to focus on specific activities during a class period, rather than on the period as a whole.

We have seen that students respond positively to academic activities which involve resource use: laboratory assignments and teacher recitation. They apparently find academic tasks, like seatwork, where they must produce a product, considerably less engaging. Students give positive reports (where "positive" means reactions which we believe are likely to lead to increased achievement in life science) about activities which are intended to prepare them for tasks where products will be produced, but negative reports about those tasks themselves.

It is not altogether clear whether this is a result of the intrinsic nature of academic tasks--perhaps to the producing of a product, with its attendant hazards of grading and accountability--or to the particular nature of the tasks these teachers assigned. The analysis of assigned tasks in Chapter Four lends weight to the second of these possibilities: most tasks were of minimal cognitive complexity, and contained little which might challenge and stimulate the students.

CHAPTER NINE

TARGET STUDENT INTERVIEWS

Interviews were conducted with individual target students at the end of each of the two topics. These interviews served to elicit students' perceptions of the past week's lessons, their understanding of the lesson material, and their response to the entire semester's lessons. In this chapter we focus on the activities that target students indicated were most interesting, and in which they reported they had learned the most, both for the current topic and for the semester as a whole. The target students' responses to our interviews provide further information on the kind of activities most likely to foster achievement and motivation in life science. They provide more detail than the Student Class Survey, though, of course, the sample size is smaller.

Procedures and the Instrument

Each interview was conducted after school, in an office or classroom. No other students or adults were present, and the student was guaranteed confidentiality of his or her remarks. The interview was audiotaped, with the student's permission. The audiotape of the interview was transcribed.

Target students were selected to represent a range of achievement levels, balanced for student gender. Six students were recruited as targets in each class: three of each sex at each of three achievement levels (low, middle and high), determined from their pretest life science achievement scores. After potential students were identified by their test scores, their parents were contacted by mail and asked for permission for their child to be interviewed. The target students were assigned identification letters which specified their gender and ability level: in each class, Student A is the high ability female, Student B the middle ability female, Student C the low ability female, Student D the high ability male, Student E the middle ability male, and Student F the low ability male.

The interviewer worked with a ten-page interview schedule, which listed fourteen distinct sets of questions, together with three items the interviewer completed in summary evaluation. The schedule served to ensure that no area of questioning was omitted, and also included two five-point rating scales which were shown to the student during the course of the interview. It also provided the interviewer with a format to record summary information on the student's replies. The interviewer was free to move within the structure of the schedule, however -- that is, to probe and rephrase questions as deemed necessary. The form of the interview schedule differed for Topics 1 and 2. The differences mainly concerned the manner in which the student's memory was jogged at the start of the interview, and the form that probing took on the reasons an activity was interesting. Copies of both the interview schedules appear in Section Nine of Appendix A.

The interviewer began with an introductory statement orienting the student to the purpose of the interview, and then brought out a Lesson Summary Chart, which presented in graphic form the classroom activities which had taken place during the past five class days. For the Topic 1 interview, the interviewer then went through the activities, day by day, to ensure that the student remembered each of them. For the Topic 2 interview, the student was asked to describe what had happened in class day by day. This introductory section was ended by checking the student's memory with a brief question about one of the days. If the student showed evidence of lack of memory, the interviewer continued to probe, trying to build up the student's recollection of the week's activities.

The next section of the interview dealt with the student's perceptions of the past week. Eight questions were asked of the student in this section, focussing first on what activity had been the most interesting, what aspects had made it interesting, and which of these was most important in making it so. The student was asked to rate "exactly how interesting [it] was." Questioning continued concerning whether learning had occurred during this activity, and when during the week the most learning had occurred. The student was then asked to rate "exactly how much you learned." The last question of this section asked whether what had been done during the week was similar or different to what was usually done.

The third section concerned understanding of the past week's material. The student was asked first to describe one of the week's activites where the teacher had explained science content, and then an activity -- if any -- where the teacher had engaged in relating behavior. These activities had previously been identified by the interviewer.

The fourth section of the interview concerned the student's reactions to the whole semester's lessons. The format of questioning paralleled that of the first section. Four questions were asked: Which day had been the most interesting, and what aspects had made it so, which of these aspects was most important in making it interesting, and finally, what would the student do if he or she were the teacher, and wanted to teach a science class that students would find interesting?

After the interview was over, the interviewer made summary five-point ratings of the student's understanding of the explaining activity and of the relating activity, and a three-point rating of the quality of the interview.

Results

For purposes of data-reduction, and to tie this chapter to the previous ones, especially Chapter Eight, we shall consider in detail here only target student responses concerning those teachers who were selected for detailed study in Chapter Eight on the basis of their Student Class Survey ratings. It will be recalled that for Topic 1 these were the classes of Teachers 6, 8, 9, 10 and 11, and for Topic 2, the classes of Teachers 4, 7, 9 and 10. Chapter Eight was concerned with the way all the students in the class perceived the particular activities of the survey day. This chapter examines the way our target students picked interesting and significant activities from an entire week of the topic, and from the semester as a whole. We focus on the students' selection of activities from the week of the topic which were interesting and in which learning occurred, and of an activity from the entire semester which they had found the most interesting. We also examine their responses to the question concerning what they would do if they were a science teacher. At the end of this chapter we examine numerically the responses from all 66 target students, from the classes of all 11 teachers.

Topic 1

Teacher 9. On several days during Topic 1, Teacher 9 conducted a laboratory on single-celled organisms, and all the target students referred to this when naming the activity they had found the most interesting. Different students named different organisms: two mentioned the euglena, two the amoeba, one the paramecium and one the volvox. It is noteworthy that none of the students named the laboratory which Teacher 9 introduced on the day the Student Class Survey was carried out: the identification of stages of mitosis. This fact corroborates the low survey ratings which that laboratory received; it also indicates that Teacher 9 did not always assign work which his students found dull. (At the same time, we shall report below that the target students found the protozoan laboratory an unusual event.)

This protozoan lab received an average interest rating from the target students of 3.8. Most of them mentioned the novelty of what they had seen when asked what had been most important in making the lab interesting. All six students said that they felt they had learned in the course of the laboratory work.

When asked in which activity in the past week they had learned the most, there was more divergence of opinion. Three students again named the protozoan lab, while two others named a lecture by the teacher on the structure of a leaf, where Teacher 9 had drawn a cross-sectional diagram of the leaf and explained its micro-structure. The sixth student talked in general of the teacher's lecturing as resulting in the most learning. The average learning rating was 4.0.

Asked which activity during the first semester had been the most interesting, the students showed diverse views. Four students each named a separate laboratory activity: litmus testing for alkali and acids; generating hydrogen gas (and then exploding it!); making models of atomic structures; and the protozoan lab. The remaining two students identified class presentations on the skeletal system and mitosis respectively.

In answer to the question concerning what they would do if they were a teacher, all six students mentioned laboratory work and demonstrations. Four of them seemed to feel that they would employ laboratory work exclusively; one said he would have "bizarre experiments with strange results." The other two students saw more importance in a balance of forms of presentation. Student A, for example, replied in the following terms:

> I wouldn't lecture them because I don't like being lectured. I guess that's all. I don't know. Because I know lecturing is boring. The class, they just kind of sit there.
>
> WHAT SORT OF THINGS WOULD YOU HAVE THE STUDENTS DO?
>
> Oh, I'd like show 'em movies and you know slides, and I'd explain to them, and I'd show them, you know, bones, real bones and how they work and stuff.
>
> WHY DO YOU THINK YOU'D DO THAT?
>
> Because it would be interesting instead of boring. It's not just lecturing them and telling them what it is instead of showing them. It's more interesting if you show people what things are instead of just telling them about it.

Student B also had a complex view of what a science class should involve:

> WHAT SORTS OF THINGS WOULD YOU DO?
>
> Oh boy. I always think about this . . . Well, I would lecture as well as experimenting and doing things. One thing that would be important to me is having a right mixture.
>
> OF?
>
> Of having labs and field trips if they're possible and lecturing and doing work out of a book or . . . and having discussions . . . well that would probably be good, but not in a science class . . . Having the right amount of everything.

Comments. These remarks suggest that Teacher 9 had some problems keeping the students involved and motivated. The mitosis lab was an example of an activity which students found dull and uninteresting. It is noteworthy that the activities which students described as interesting were generally laboratories, while those in which they felt they had learned the most included also teacher recitation. We shall see that this pattern holds generally across classes: students report finding labs more interesting than other academic activities, while they report learning occurring in other activities, which were not necessarily found interesting.

Teacher 8. The five days of Teacher 8's first topic began with two class periods of teacher recitation and seatwork on protozoa, their characteristics and types. On the third day the students worked on individual seatwork, and then the teacher had a brief question and answer period. On the next day the students were assigned a laboratory exercise, observing protozoa in pond-water. They finished this exercise on the last day.

Five of the six target students in Teacher 8's class were in agreement that the protozoan lab had been the most interesting activity of the first topic. The reader will recall that the Student Class Survey was distributed on the day of the protozoan lab, and it is described in some detail in Chapter Eight. The sixth student, Student D, chose instead the teacher's presentation on the characteristics of protozoa that took place on the first day of the topic. The average interest rating was 4.5.

Asked to identify the activity when the most learning took place, Student A again named the protozoan lab. Student F insisted that the lab and a filmstrip on protozoa were equally important. The other students all selected the teacher's presentation at the beginning of the topic. The average rating for learning during these activities was 4.5.

Three of the students named the protozoan laboratory as also being the most interesting activity of the semester. Two of the other three students named other laboratories: Student A named a lab on yeast, examining its action with and without nutrient sugar; Student B named a lab on the action of light on plant growth. Student D referred to a period of two to three weeks on animal cells and organelles, and was unwilling to select a particular activity from within this period.

When describing how they would run an interesting science class, the students were appreciative of Teacher 8's methods. Student D remarked that "Mr. Bradford always makes pretty good explanations I guess." Student E said, "Well, I'd pretty much do it like Mr. Bradford is doing it," and also made the following comments:

> DISCUSSING PROTOZOA AND NOTE-TAKING, YOU FELT YOU WERE LEARNING THE MOST. WHY WAS THAT?
>
> Well, because discussing, when Mr. Bradford talks, sometimes, um, he says something funny or something, so no one, or no one

> at my table, really, doesn't pay attention. And I always listen to him and he always says that, kind of like it's not important, you know? So you need to listen to him, he says that in a neat way, and like when he was describing -- I don't think it was during <u>this</u> certain discussion -- but he was describing a protozoa and it was, somebody had just found it and it was huge, and he says, "It just looks like it had an ominous look and all the others were waiting on him." Really interesting to listen to him.

Student A was also satisfied with the current organization of activities:

> I'd just have the kids do labs and things like Mr. Bradford does with us, and... I don't know.
>
> WOULD YOU DO DIFFERENT KINDS OF LABS, OR MORE LABS, OR FEWER LABS?
>
> Just about the same because we usually have one once a week or twice a week.
>
> YOU'D KEEP IT EXACTLY THE SAME AS HOW HE'S DOING IT?
>
> Yep. I think it's pretty good, the way he's doing it.

<u>Comments</u>. The target students' remarks are very much in accord with the Student Class Survey results, where Teacher 8 received high ratings for the four focal items. The target students confirm that his classes combined interest with a challenging level of difficulty. When asked what they would do if they were teacher, they tended to use Teacher 8 as a model or example of teaching practices they found admirable.

Most of the students again found laboratory assignments most interesting, both during the topic and for the semester as a whole, while most learning was reported as occurring in teacher recitiations and viewing a filmstrip.

<u>Teacher 10</u>. Teacher 10 conducted two activities during Topic 1 which students referred to. The first was a presentation on inherited traits. (This activity was discussed in Chapter Eight; it was on the day of this presentation that the Student Class Survey was given.) The second activity was a 'Gene Monster Packet': students were required to 'design' a monster, by specifying key genetic traits. They were then to mate it with another monster, and see what characteristics the offspring had, determined by probabilities of inheritance and dominance relationships. This package took several days for the students to complete. Topic 1 took a total of 13 days. In addition to the activities mentioned, the teacher gave several class recitations on cell division, chromosomes and the phases of mitosis, the phases of meiosis, and on genetics vocabulary words. The students saw films on X and Y chromosomes and on cell division. They also read an article on Barbara McClintock, in addition to

preparing for their end of unit test.

Four target students identified the teacher's presentation on traits as the most interesting activity of Topic 1 (giving it an average rating of 4.6), while the other two, Students D and E, identified the Gene Monster Packet (rating it an average of 4.0). All six students said they had learned from the activity they named.

Asked in which activity they had learned the most during the topic, the students disagreed. Two, Students C and E, again mentioned the traits presentation. Student A named the Gene Monster Packet. Two students named a vocabulary-word task. Student F named a film on X and Y chromosomes. Student A explained her choice in the following way:

> WHEN DID YOU FEEL YOU WERE LEARNING THE MOST?
>
> Actually, I have to say the gene monster, but it doesn't seem like I'd be learning much, but see I always thought . , . like at first I always thought . . . I mean everything's pretty new to me, but like the big-B little-B, big-B big-B? I would have never expected to have a blue-eyed kid from big-B little-B, big-B big-B. When I was first presented with the thing I thought that if one parent had brown eyes, forget blue-eyed kids, you know? So I learned a little more about the chances and that, you know. I always wondered why some kids look exactly like their parents and some are just totally different. Now I know because I've seen some of our gene monsters. You have a whole line of purplish-grey hair and then you get a baldy with no warning. So I think that's probably the most learning part of that week. This week was kind of a fun week, actually.

The target students assigned an average learning rating of 4.3 to the various activities they had named.

Asked which activity during the semester had been the most interesting, four of the students agreed that their first microscope laboratory won the award. They had examined cells from a layer of onion skin, and cells scraped from the inside of the cheek. Student F recalled the occasion they had made hydrogen gas, then trapped it in soap bubbles and exploded them. Student A responded that the most interesting activity had been one she remembered as 'Planet X.' Teacher 10 had presented the students with a mysterious material, which he told them was the surface matter of Planet X. The material was a liquid when undisturbed, but while squeezed it would turn solid (unknown to the students, it was a solution of cornstarch in water). The students' task was to make observations of the material's properties and thereby deduce its composition.

Student A told the interviewer why this activity had been so interesting for her:

> It was weird because it was like something fun to do. It was like he was giving us a break, but we weren't, we were still learning stuff at the same time. It's kind of subconscious; we weren't learning on purpose, we just did it. That sounds weird doesn't it? I mean he knew what it [the constarch solution] was, but we were thinking, "oh good." But actually we did learn something, and that was kind of neat -- the way he got us to learn and we didn't know it.

Several students echoed Student A's appreciative comments on Teacher 10's teaching when they were asked what they would do if they were teacher. Student E replied "give them a lot of fun packets. I'd probably do similar to what Mr. Bentley does, because that's the best class I have, that I like the best." Student D said much the same. Students F and B both insisted that they would have laboratories. Student F justified this:

> WHY WOULD YOU DO A LOT OF LABS AND EXPERIMENTS?
>
> Well, because I think that when you do like a lab or an experiment, that the kids can see it happening. They'd think more about it, and they remember it more.

Student B also valued laboratory work:

> Oh, I'd use a lot of the time for labs. Because I think it's important learning about the things first and then after you've learned them then you get to do little projects with it and I'd like to do little demonstrations and then I'd go "Here's some equipment, be sure you use it wisely," and let them learn about it. Like I'd walk around the class and say "Yes, may I help you" and stuff like that. But labs are really important. Because you learn. Like, I never knew about microns. I never knew about microns until we did that lab about them.

Comments. Teacher 10 got high ratings for attention, thinking and interest in the Topic 1 Student Class Survey, but lower ratings for the difficulty of the teacher-led recitation and review which took place that day. The target students seemed to feel that the teacher did a good job in general, assigning interesting laboratories and giving informative lectures. They referred to his instructional practices when describing the way they themselves would teach. Unlike the target students who described the classes of Teachers 8 and 9, these students identified a teacher recitation as being the most interesting activity of the topic, though the activities selected from the whole semester tended to be labs.

Teacher 11. The first topic focussed on forms of environmental milieu. This six-day topic mixed reading and questioning segments on tundra, deserts, grasslands and forests, with written seatwork and audiovisual presentations. Of the five target students interviewed, four identified as the most interesting activity one on the third day, where the students took turns to give characteristics of different environments they had garnered from the book and then call on fellow student volunteers to name the correct environment. The fifth student (Student D) named working on a study sheet as the most interesting activity. These two activities were given an average interest rating of 4.5 by the students.

The students picked a number of aspects of the week's work when asked to identify the activity during which they had learned the most. Student C said that all the class discussions during the topic were equally important in this respect; two named working on their study sheets; two mentioned the review on the last day of the topic. The average learning rating given was 4.2.

Three of the students said that the most interesting activity of the semester had been when they used microscopes to view a variety of microscopic structures: onion skin, salt, pepper and sugar grains. The fourth (Student B) named the class question and answer session on types of land, and the fifth (Student D) said that all the time spent learning about the body had been interesting, and he was unwilling to pick a single activity that stood out.

Asked how they would teach an interesting class, the students seemed content with the way Teacher 11 organized her instruction. Two students (Students B and E) explicitly said they would do as she did. Student E went on to describe what he found best about Teacher 11's class:

> "I think the best thing is when we don't mess around and we get right to the point and do our work, and if we have extra time, then we read more from the text or we go ahead and we do the other work and understand what happens because you know the questions that we have, she can answer them for us. She doesn't just push us away and say, well I can't do this because I have to go put on my make-up or something like that."

Comments. The target students' comments differed somewhat from the picture of Teacher 11 one obtains from the Student Class Survey. There, her class was rated as low on attention, thinking and interest, and high on difficulty. The main activity on the day of the Student Class Survey was seatwork, and this activity was not representative of the topic as a whole. The most frequent type of activity during the topic was teacher recitation based on the textbook.

The students referred to their teacher's practices when asked how they would teach a class. There was no laboratory assignment during Teacher 11's first topic, and the students named a variety of activities as most interesting for the topic. Three of them, however, named labs as the most interesting activity of the semester. The activities in which learning was seen as greatest were a mixture of teacher recitation and seatwork.

Teacher 6. The eight-day topic concerned bacteria and viruses. Teacher recitations occurred on four days, intermingled with seatwork on study guides taken from the text, note-taking, and the copying of diagrams of the nitrogen cycle and of bacterial shapes. The students were assigned a laboratory activity of viewing bacterial colonies and estimating their population size. They also viewed a videotape and took a unit test.

The target students in Teacher 6's class all felt that the Topic 1 week had been different from their previous work: they had taken more notes, seen movies, and done laboratory work. Asked which of the week's activities was most interesting, five of the students named the laboratory on cells, and the sixth picked a movie on bacteria that included a presentation on Pasteur. The average interest rating was 4.3.

Turning their attention to the occasion when they felt they had learned the most, the students mentioned a variety of activities: taking notes from the teacher's board work; taking the unit test; working with the study guide; and Teacher 6's recitation on the nitrogen cycle. The average rating here was 4.0.

The activities the students picked as the most interesting in the entire semester were again varied. Three students picked a laboratory, and two of these agreed that it had been their first microscope practicum. Two others, Students B and F, talked of a presentation students had given, while Student C claimed that no one day stood out in her mind.

Hypothesizing about what they would do if they were teacher, all six students mentioned laboratory work, though some were more specific than others. Student F said he would "do the same as Mr. Jenkins," while Student E proposed that students do "labs, take notes a little, [and] use the books a little," explaining that "you can learn more if you do stuff yourself."

Comments. The target students were more appreciative of their teacher than the Student Class Survey ratings would lead one to expect. In the Survey, Teacher 6's class was rated low on the four items of focal interest (see Chapter Eight.) The class was rated as boring, though the target students' responses suggest that the teacher actually went out of his way to try to provide interesting activities for this topic, perhaps because of the observer's presence.

Laboratories were the activity most frequently picked as most interesting, while recitation, seatwork and test-taking were all named as being occasions of the most learning.

Topic 2

Teacher 4. This teacher spent eight days teaching a topic entitled "heredity and change." Teacher recitation was the major instructional form. Students did classwork and homework on Punnett squares and dominance characteristics, checked themselves for PTC senstivity, and took an end-of-unit test.

Two target students--Students C and F--did not appear for the interview, so our data for Topic 2 are drawn from four interviews. When asked what was most interesting during the past week, two of the students, Students B and A, named the teacher's presentation on miosis. Student E named a lecture on the relationship between phenotype and genotype. Last, Student D named problems the teacher gave the class -- drawing Punnett squares and calculating phenotype ratios. The four students gave these activities an average interest rating of 4.2.

Similar activities were named as the ones where the most learning took place. Two students named the lecture on phenotypes and genotypes, and one the lecture on miosis. The fourth named the Punnett square problems. The average learning rating here was 4.7.

Two of the target students, Students A and B, identified a frog dissection laboratory as the most interesting activity of the semester. Student E recalled observing microorganisms under the microscope, and Student D named a presentation by Teacher 4 on the circulatory system.

Asked what they would do if they were a science teacher, both Student A and Student B mentioned dissecting. Student E said:

> "Do labs every week, and I'd explain to the class the assignments. I'd give the class homework most nights, because I feel like when you have homework, and you do it, then you learn more. It's different when you're home, because you're not all thinking about school and stuff, and you're more calm. I'd give the class a test on each unit, and it'd be about a week or a week and a half long. I'd do most of the things Mrs. Stahl does. She's a pretty good teacher."

Student A responded to the question by saying:

> I don't think I'd use the book hardly at all . . . I just don't think that it's as interesting to read it. Even though I like to read, I think it's a lot more interesting to have somebody explain it to you . . . Mrs. Stahl tried quite a few different things on us, and so I think I'd try and do different things. Just don't keep doing the same thing.

Comments. These target students' remarks seem to reflect the way Teacher 4 was rated in the Student Class Survey. There, her class was rated high throughout, on attention, thinking, difficulty and interest. The target students gave this teacher unusually high ratings for learning: an average of 4.7.

Going against the norm, Teacher 4's target students named teacher recitations and seatwork as the most interesting activities. Unlike other classes, the same topic activities were identified as most interesting and as the occasions of most learning. This suggests that Teacher 4 was able to invest activities not often amenable to interesting content with an unusual degree of elan.

Teacher 7. The topic concerned heredity and genetics, and took place over nine days of instruction. There was less use of laboratory activities than in this teacher's first topic; teacher recitations took place on most of the days. Students also did seatwork consisting of worksheets, learning vocabulary, and writing in their journals. There was a test at the end of the unit, with a review game the day before. (This review game was described in Chapter Eight.)

Only four target students (Students A, D, E and F) were interviewed at the end of Teacher 7's second topic. Three of the four said that the most interesting activity during the week had been a presentation by the teacher on twins, by way of introducing heredity and genetic variation. The fourth student, Student D, named the review game which took place on the last day of the topic. These two activities received an average rating on interest of 4.3.

Identifying the activity which occasioned most learning, the students differed. Student E named a teacher recitation on DNA and chromosomes, Student A a test for color blindness the students had carried out, Student F named the review game, and Student D was able to pick no specific activity from the topic. They assigned an average learning rating of 4.0.

Turning to the activity which had been most interesting during the entire semester, the student's responses showed an unusual pattern. Two students were able to name activities: Student E a film on techniques of meat preservation, and Student F a lab where animal specimens were identified and classified. But the remaining two target students were unable to identify any activity from the entire semester which struck them as memorably interesting. Student A replied:

> I don't know.
>
> ANYTHING STAND OUT? A LAB OR A DISCUSSION OR A FILM, OR SOMETHING?
>
> Un huh [negative].
>
> NOT MUCH INTERESTING? HOW INTERESTED ARE YOU IN SCIENCE?

> I don't know. It's not my best subject.

Student F responded to the interviewer in a similar manner:

> CAN YOU REMEMBER DAYS WHERE YOU DID SOMETHING THAT WAS REAL INTERESTING TO YOU?
>
> No. I don't know... he just mostly... when other people are around we do fun things, but usually we just study. We've done some things. Like, we've had labs and stuff.
>
> DO YOU REMEMBER ANY OF THE LABS THAT WERE GOOD?
>
> No.

Comments. On the Student Class Survey, Teacher 7 received low ratings across the board for the last day of his Topic 2 class. The target students' responses, particularly when asked to pick the most interesting activity of the semester, suggest that Teacher 7 had persistent problems capturing his students' interest and attention. The students reported that the topic had been unusual in having recitations and laboratory work;* more usually, they would find themselves engaged in seatwork. Not surprisingly, they named the recitation and the heredity game as the most interesting activities which had occurred. The inability of two of the students to recall any particularly interesting activity from the semester as a whole is a sad testament to the teacher's lack of skill or imagination.

Teacher 9. In the second topic, Teacher 9 spent five days on the circulatory system and blood typing. He lectured on the circulation of blood through the heart, held a review on this material the next day, had students take an oral exam, and then lectured on blood typing. Students saw a film on the circulatory system, and then took part in a blood-smear laboratory, which was followed by a review of blood typing. On the last day (which was also the day of the Student Class Survey), students took part in a blood-typing laboratory, which was followed by a lecture on the rhesus factor.

One of the target students was absent on the day of the second laboratory; the other five students all named this blood-typing lab as the most interesting activity of the week, and three of them also named it as the most interesting activity of the semester. They rated it an average of 4.3, and all said they had learned from it.

However, when asked when they had learned the most, four of the students named the teacher's lecture on the circulatory system, and the other two named the film they had seen on the same topic. They were very aware that new information had been presented to them in both these activities, and gave ratings on learning of 4 or 5 (the overall average for all the activities was 4.5).

Asked to identify the most interesting activity of the semester, three students, as mentioned, named the second lab on blood-typing again. A fourth student named the teacher's lecture on the circulatory system. The remaining two students referred to a laboratory where seeds were planted, and to a lecture on the parts of a flower. Describing the latter, Student E said that it had been interesting "because I never knew. I just saw a flower as a flower. I never knew about leaves and I never knew about how it gets its food and how it reproduces and all that stuff."

Students showed a certain concord in their discussion of the way they would run things if they were teacher. Five of them stressed that they would have variety; "something different every day" (Student E). Student B went into some detail:

> I'd do a lot more of class activities. I remember last time when I said that. I still think it's got to be the right combination. You've got to have just the right amount of everything, and I've had teachers who have hit upon that, but obviously Mr. Ferber hasn't. I'm a lot of times turned off in his class and everything.
>
> OH, WHY?
>
> Well, the only reason I pay attention at all is because I like science and because I like getting good grades . . . you have to have the right combination.
>
> SO IT'S A DELICATE BALANCE BETWEEN EVERYTHING?
>
> Well not necessarily delicate. I don't think it has to be perfect or anything. It's just you don't want to have three-fourths of the time lecturing and one-fourth of the time tests. You know that's a very obviously bad combination. The kids are going to be totally 'bleahh' . . . Now this is what a good experiment would be for your laboratory next year: let's find out what kids like to study. Like our class really liked to study the skeletal system. Circulatory system . . . aahh! Atoms and things . . . bleahh!
>
> WHAT SORT OF ACTIVITIES WOULD YOU EMPHASIZE?
>
> Probably I would . . . discussions. Because science is a discussing matter. We never discuss, we just learn. Nobody knows for sure. Like there's a lot of controversial matters in science. It would be so fun to talk about them. "Why do you think this is true?" "Why do you now think this is true?" Then do an experiment and find out . . . But we never do it. We do it in social studies, which is really neat.

This articulate account of Teacher 9's way of teaching science was largely in agreement with what other students said. Student D noted that the week of Topic 2 was different from other weeks because they had done an "experiment" (the blood typing lab), and "we haven't really done an experiment since chemistry," and also "we did it on ourselves. Most of the time he just shows it on a model." This suggests the possibility that Teacher 9 put on a special show for the observer.

Comments. On the Student Class Survey, Teacher 9's blood-clotting lab was rated low in attention, thinking and difficulty. It was, however, rated high (3rd overall) in interest, and the target student responses describe it in the same way. It is striking that students can report an activity of being of great interest, yet as requiring little in the way of thought and attention. Four of the students, asked why the lab had been interesting, replied that its ease was a factor; three of them also said that doing well in the lab had made it interesting. Learning about oneself was, however, the reason most salient to students for the lab's interest. None of the students named the blood-clotting lab as the activity where most learning had taken place.

Teacher 10. Topic 2 dealt with the human skeletal and circulatory systems. After an introduction to all ten major body systems, Teacher 10 spent four days on the circulation of the blood. He conducted recitations, and a film was shown, with homunculi carrying out the various functions of the heart, blood vessels and lungs. For homework, Teacher 10 had the students cut out a ditto of the skeletal system, assemble it, and label it. He also lectured on the skeletal system, using a small model skeleton called Huey. On the seventh day of the topic students formed groups and rotated around the room to nine different activity stations. The remaining days involved reviewing and testing.

The parents of Student C requested that she be withdrawn from target student status, so our data are limited to interviews with five students. These students' responses in Topic 2 told a similar story to those of the first topic. A variety of activities were identified as the most interesting during the week. Two students, Students A and E, mentioned the film, and two, Students B and D, the skeleton lecture. Student F named the skeleton ditto. All said they had learned, and gave the various activities an average interest rating of 4.4.

The same activities were identified as those where the most learning had occurred during the week. Student F named the skeleton ditto; Students D and E the film, and Student A the skeleton lecture. Student B named a quiz the teacher had conducted on the circulatory system. The average learning rating given these activities was again 4.4.

Recalling the most interesting activity in the course of the semester, all five students named laboratory work. For three of them it was a day when they had dissected a frog. A fourth, Student F, recalled a related activity where students measured the length of a frog's leap, and calculated its ratio to the animal's length. Student A mentioned an occasion when students collected bacteria samples from various locations around the classroom -- the door handle, another student's tongue -- and cultivated them on agar.

Asked what they would do if they were teacher, several of the students made reference to their teacher. Student D said he would "explain things so that students would comprehend it, and, like, to make it interesting at the same time, like Mr. Bentley's Huey." Student E replied "Well I'd do it kind of like Mr. Bentley did." The other students all mentioned a range of activities: notes, dittoes, movies, field trips, quizzes and models. They talked as though these were all activities they themselves had been assigned.

Student A discussed the particular things which had gone on in the classroom during the topic which had helped her understand and learn the material. While her comments are perhaps indicative of unusually percipient self-monitoring, we suspect that the other students would agree:

> "The quizzing was good. That helps you study, get some studying done in class. You try and think of the answer before the person he calls on tells the answer, and I was trying to make mental notes of the things I needed to study. The lectures on the parts of the circulatory system I thought was funny. It stuck in my mind. The T-shirt he wore [showing the bones of the torso] helped because you could see it on him; then the way he told us to find it, like say feel the shoulder blade and stuff like that. And Huey was fun. (Laugh.) I liked Huey, and he helped. If he would have just written on the board or just told us it wouldn't have sunk in. I do better with a visual aid, and the skeleton helped a lot. The little extra things he added in about how you grow keeps it interesting. I think to keep the attention of the class he kind of has to kind of say little interesting things in between, and the shirt and Huey both helped a lot."

<u>Comments</u>. The portraits of Teacher 10's instruction which we obtain from the target students and from the Student Class Survey are similar in the two topics. If there is a common criticism of this teacher, it is that the work he assigned was not difficult enough. This is conveyed by the Student Class Survey ratings for both topics (the difficulty ranking was 9th on each topic), and by the target students' comments -- the movie on the flow of the blood, for example, was criticized for being interesting but childish.

Types of Activity Named by All Target Students

Examination of the activities named by the target students in reply to our questions shows that they generally reported that laboratory assignments were the academic activities they found the most interesting. However, these were not the activities in which they felt they had learned the most. Tables 9.1 and 9.2 show in summary form the target students' responses to these questions in all eleven classes, for Topic 1 and Topic 2, respectively. For Topic 1, 40 of the Target Students (63 percent) named laboratories as the most interesting activity of the topic. However, only 13 (22 percent) said that a lab had been the occasion of most learning. Nineteen students (32 percent) identified teacher recitations as the activity where they had learned the most, and 14 (23 percent) identified seatwork.

When these students reflected on interesting activities over the previous semester, the salience of laboratories was even more striking. Forty-six students (71 percent) named a laboratory, while only 6 (9 percent) named recitation, and only 1 (2 percent) named seatwork.

At the end of Topic 2, 36 target students (62 percent) named a lab as the most interesting activity of the semester, and only 6 (10 percent) named teacher recitation. This pattern of response was similar to that at the end of Topic 1. In their reports of Topic 2 itself, however, only 21 students (34 percent) named a laboratory activity as the most interesting, while 18 (30 percent) named recitation. The lower emphasis here on the interest of laboratory work is accounted for by the mention of other kinds of activity -- especially films (11 percent) -- as being most interesting. For example, although the target students in both Teacher 7 and Teacher 10's classes had lab work in Topic 2, none of them reported it as most interesting. One possibility is that the target students came to find different properties of academic activities of interest, but this explanation is countered by the fact that they tended still to report labs as the most interesting activities of the semester. A second explanation for the way students viewed the second topic is that teachers made an effort to introduce other interesting activities while their classes were being observed.

In Topic 2, recitation and seatwork were again the two activities regarded as occasioning most learning. Twenty students (34 percent) named recitation and 24 (41 percent) named seatwork, while only four (8 percent) named a lab activity.

Ratings of Interest and Learning

Tables 9.1 and 9.2 also show the average ratings of interest and learning in each of the classes. That there is no great variation among classes is not surprising when one recalls that we were asking the target students to rate activities which they had already selected as being "most interesting," and as the occasion of "most learning." Two numbers stand out, however. Both Teacher 3 and Teacher 9 received unusually low ratings for interest in Topic 1 (3.7 and 3.8 respectively). The numbers for both these teachers picked up for the second topic, however.

Table 9.1

Target Students' Responses for Topic 1

TEACHER	MOST INTEREST DURING TOPIC	RATING	MOST LEARNING DURING TOPIC	RATING	MOST INTEREST IN SEMESTER	TEACHER USED AS MODEL
1	Lab (4)[1] Recitation (2)	4.6	Lab (1) Film (1) Homework (1) "All days" (1)	4.2	Lab (5) First week(1)	Yes (2)
2	Lab (3) Seatwork (3)	4.3	Seatwork (5) Lab (1)	4.0	Lab (2) Film (1) T demonst.(1) Other (2)	Yes (1)
3	Lab (4) Recitation (1) Seatwork (1)	3.7	Test review(3) Seatwork (2)	4.0	Lab (5) Recitation(1)	Yes (3)
4	Lab (5) Seatwork (1)	4.7	Lab (2) Recitation(3) Video (1)	4.2	Lab (5) Seatwork (1)	No
5	Lab (5) Seatwork (1)	4.5	Lab (3) Seatwork (2) Film (1)	4.0	Lab (5) Recitation(1)	Yes (3)
6	Lab (5) Film (1)	4.3	Notetaking (2) Test (1) Seatwork (1) Recitation (2)	4.0	Lab (3) Student (2) presentation Nothing (1)	Yes
7	Lab (1) Recitation (2) Film (1)	4.3	Recitation (4)	4.5	Lab (2) Field trip(2)	Yes (1)
8	Recitation (1) Lab (5)	4.5	Lab (2) Recitation (4)	4.5	Topic (1) Lab (5)	Yes
9	Lab (6)	3.8	Lab (3) Recitation (3)	4.0	Lab (4) Recitation(2)	No
10	Recitation (4) Lab (2)	4.4	Recitation (2) Lab (1) Seatwork (2) Film (1)	4.3	Lab (6)	Yes
11	Recitation (4) Seatwork (1)	4.5	Recitation (1) Seatwork(2) Test Review(2)	4.2	Lab (3) Topic (1) Recitation(1)	Yes

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[1] Numbers in parentheses represent the number of target students giving each type of response.

Table 9.2

Target Students' Responses for Topic 2

TEACHER	MOST INTEREST DURING TOPIC	RATING	MOST LEARNING DURING TOPIC	RATING	MOST INTEREST IN SEMESTER	TEACHER USED AS MODEL
1	Lab (2)[1] Video (2) Seatwork (2)	4.3	Lab (1) Recitation(1) Seatwork (4)	4.0	Lab (5) Science fair (1)	Yes (1)
2	Lab (6)	4.3	Lab (1) Test (1) Seatwork (4)	4.2	Lab (3) Film (1) Test (1) Nothing (1)	Yes (1)
3	Lab (2) Recitation(3) Test (1)	4.2	Review (2) Recitation(4)	4.7	Lab (4) Science fair (2)	No
4	Recitation (3) Seatwork (1)	4.2	Recitation(3) Seatwork (1)	4.7	Lab (3) Recitation(1)	Yes
5	Recitation (1) Guest speaker (4)	4.2	Recitation(1) Seatwork (3) Test (1)	3.4	Recitation(1) Lab (2) Speaker (2)	Yes (3)
6	Recitation (2) Seatwork (1) Video (3)	4.0	Recitation(1) Seatwork (4) Discussion(1)	4.0	Lab (3) Recitation(2) Film (1)	Yes (1)
7	Recitation (3) Game (1)	4.3	Lab (1) Recitation(1) Game (1) Nothing (1)	4.0	Film (1) Lab (1) Nothing (2)	No
8	Lab (3) Recitation (3)	4.0	Recitation(2) Seatwork (2) Lab (1)	4.7	Lab (3) Reports (1)	--
9	Lab (5) Recitation (1)	4.3	Recitation(4) Film (2)	4.5	Lab (4) Recitation(2)	No
10	Recitation (2) Film (2) Seatwork (1)	4.4	Recitation(2) Film (2) Seatwork (1)	4.4	Lab (5)	Yes
11	Lab (3) Seatwork (2) Project (2)	4.0	Seatwork (5) Recitation(1)	4.0	Lab (3) Seatwork (2) Nothing (1)	Yes (3)

[1] Numbers in parentheses represent the number of target students giving each type of response.

The Teacher as Model

The last column of each table shows whether the target students, when asked what they would do if they were teacher, made positive reference to their teacher as a model of good teaching practice. The frequency with which they did this is encouraging: 9 of the 11 teachers were held up as models after Topic 1, and 7 of the teachers after Topic 2. Teachers 3 and 7 were refered to as models in the first topic, but not the second, while Teacher 4 showed the opposite pattern. However, Teacher 9 had the unfortunate position of being talked of negatively by the target students in both Topic 1 and Topic 2. This result is in accord with the low interest rating for Topic 1 and the low interest ratings on the Student Class Survey reported in the last chapter.

Conclusions

It is instructive to compare the data from all three of our student perception instruments: the Ideas About Science Survey (Chapter Seven), the Student Class Survey (Chapter Eight), and the target student interviews (this chapter). On all three instruments, particular teachers stood out as different in some way from the rest. For example, Teacher 4 stood out as having unusual presence in class recitations that generated student interest and involvement. Teacher 9, in contrast, was viewed as failing to provide a motivating atmosphere, despite his strongly academic orientation.

Students' perceptions of different kinds of activities also showed substantial agreement across the three instruments. Analysis of the SCS showed that students gave higher ratings of interest, difficulty, thought and attention to class periods where they had been engaged in resource activities -- laboratories and teacher recitations -- than to those which had been spent in seatwork and procedural tasks. The target students appeared to differentiate between laboratory activities (which they found most interesting) on the one hand, and recitation and seatwork (where they reported the most learning occurred) on the other. The IASS showed students reporting most learning and attention in quizzes and tests, followed by lab activities, but most interest in lab activities. Teacher recitations held an intermediate position: they were occasions of learning, and also interesting, though less so than laboratories. When the target students reflected back over the entire semester, laboratories showed a singular prominance, suggesting that they were more memorable than other kinds of classroom activity.

The variation in the activities which students report occasioned the most learning is explainable. In the IASS, tests were named, while in the target student interviews, students named seatwork and teacher recitation with almost equal frequency. However, the target student interviews were conducted just before the end of each topic, and most tests were given as an end-of-topic test on the last day. Consequently, when the target students were asked which activity during the topic had been the occasion of most learning, in most cases, tests were not a possible choice.

In sum, the different measures of students' perceptions give largely convergent results: a common understanding of the classroom, and of individual teacher's idiosyncrasies, appears to exist, and can be tapped via individual interviews, students' general ratings of their instruction, and ratings of a particular class period.

There remains the question of why students report learning taking place in their quizzes and tests. Of course, we are dealing here with students' perceptions of learning, and it may be that learning was not taking place where the students thought it was. Seventh grade students -- particularly those who spend their time in science classes like the ones we have described in this report -- may come to associate learning with the simple accrual of information and its subsequent retrieval, and so identify tests and, to a lesser extent, teacher recitation, as the kinds of activity where they think they are learning. It may even be the case that students come to see learning and interest as being mutually exclusive. Student A in Teacher 10's class, it will be recalled, was struck by an occasion when learning had been fun: "We weren't learning on purpose, we just did it. That sounds weird doesn't it?" Such a proposal does not, of course, sound "weird" to the teaching and research communities, and one of the purposes of engaging students in laboratory activities is that they should learn through their actions, and find enjoyment in learning. It is possible, though, that this notion is a novelty to the majority of seventh grade life science students, once they have become accustomed to being graded on low-level and undoubtedly tedious homework, worksheets, and tests.

CHAPTER TEN

CONCLUSION

This chapter presents a selective synthesis of the preceeding seven chapters of results from the Intermediate Life Science Study. Because the results' chapters end with summaries, we limit ourselves here to presenting our judgment about what the results point to by way of improving practice in intermediate life science classes. We interpret the findings to suggest the need for serious consideration and reform in two areas: scientific literacy and academic tasks. We address each of these areas in turn.

Scientific Literacy

The data from this study indicate a large discrepancy between what science educators strongly advocate as the structure of the discipline for the teaching of science and what actually is taught in life science classes. Our data show that even with a sample of teachers judged by observers as generally competent instructors with an adequate grasp of the subject matter, these teachers focused almost entirely on the presentation of factual content during their recitations, conveying this information in a segmented, topic-by-topic fashion. Thus, teachers rarely if ever made use of any of the relating components of scientific literacy. These relating components -- relating to science as a social historical process, relating to science as a reasoning process, relating science and society/technology, and positive attitudes toward science -- have the potential to serve as conceptual frameworks for science facts and enhance the meaning of content for students. Unfortunately, too few instances of the use of these components were observed for us to fairly assess this hypothesized linkage.

A thorough analysis of the impact of the relating components of scientific literacy also was hampered by the fact that when some teachers did make a rare reference to them in their recitations, these references often were logically confusing and misleading. Thus, there is the possibility that these references were counterproductive for students. One reason for the poor quality of teachers' use of the relating components may be that teachers do not have a systematic plan for employing the components. Instead, as it seems in this study, they may make reference to the components in a spontaneous and erratic fashion. This, in turn, may be the result of the fact that teachers feel pressure to cover a great number of factual science topics in a year's course at the expense of other concerns. It also may be the result of the general weakness teachers displayed in terms of providing students with explicit learning aids.

This view of the state of scientific literacy in classroom instruction was reinforced by two additional sources of data from the study. First, students themselves perceived that the presentation of factual content was the predominant focus of their teacher's recitations. Second, data on academic tasks indicated not only that the relating components were rarely addressed in tasks, but that there was little correspondance between instances of relating in recitation and instances of relating in tasks for any given teacher. This supports the conclusion that the relating components are not used purposefully as a tool for structuring the existing curricula of life science teachers. Our initial analysis of the textbooks used in the sample classes suggest that they contribute to this state of affairs.

If we are to assume that instilling students with an appreciation for all the components of scientific literacy remains the most important goal of science education, then it seems that a great deal of effort--using a variety of resources--is required. We suggest the following steps for improving the use of scientific literacy in life science classes:

- First, it seems important to ensure that teachers are fully aware of the scientific literacy framework. This implies the necessity of a widespread dissemination effort among teachers -- dissemination aimed at not only presenting them with working definitions and examples of the scientific literacy components, but also with a rationale for why and how the components should be used.

- Second, teachers will need training in how to plan their curriculum according to the framework of scientific literacy. Here, they need experience in developing their own scientific literacy resources and using these resources to select one or more of the relating themes of scientific literacy to organize each of their topics. These themes will then serve as unifying threads for the factual content. Teachers also need experience in planning their recitations and assigned work so that these themes are reflected on an explicit and consistent basis.

- Third, the above two recommendations can be facilitated if additional changes in science education take place. For example, a life science teacher's task at building scientific literacy into his or her curriculum would be aided if popular life science textbooks and other commercial materials also incorporated such a strategy. As it is, current textbooks at best may offer discrete chapters on scientific reasoning or science and technology. This segmentation only reinforces poor use of the relating components. Teachers probably could make better use of the scientific literacy components if there were less pressure to cover vast amounts of factual content. At least in the seventh grade, it seems much preferable that teachers spend a longer period of time (e.g., 3-4 weeks) on a selected topic, and use this topic as an occasion for having students explore the historical, reasoning, technological, and attitudinal implications of science.

Academic Tasks

Data from this study indicate that the most common type of academic task assigned to students in the sample classes was worksheets to be completed in class. Laboratory activities were used less frequently, usually when topics were amenable to microscope work. Finally, all teachers made use of exams as end-of-topic assessments. What all three of these task types shared in common was an overwhelming reliance on problems requiring low-level cognitive processing (i.e., rote or algorithmic) and verbally restricted response modes (i.e., matching, multiple-choice, fill-in the blank, and short answer). Thus, most students in our study probably passed through a year-long life science course without ever having to write so much as one paragraph of original information or interpretation. These findings on tasks are disappointing not only from the standpoint of promoting an understanding of science, but also in terms of fostering the problem-solving and verbal skills deemed desirable thoughout the entire school curricula.

Additional perspectives on the role of tasks come from our student perception data. First, it was noted that while students reported some instances of teacher recitation and laboratory activities as interesting and mentally engaging, they almost never characterized worksheets in these terms. Moreover, they perceived they learned less when completing worksheets than they did during recitations or laboratories. There are two potential reasons for this. One is that the nature of worksheets was as discouraging to students as it was to researchers. Another factor may be that teachers assigned few work products in direot connection with recitations and laboratories, and students may find these non-product activities more enjoyable.

A second relevant observation from the student perception data concerns students' views of learning. While some students espoused high goals when asked about the importance of learning about science, others recognized that what mattered was "making the grade." Their descriptions of learning in their classes reflected the mundane and tedious nature of their tasks. Indeed, when asked when they were learning the most, many students defined learning in terms of tasks when they were most engaged in obtaining the science facts that they would be accountable for on their topic exams. In short, it appears that students came to equate learning with successful preparation for and performance on lower-order and verbally restricted exam problems. This may have dire consequences for students' more generalized attitudes toward learning as their schooling progresses.

Given these findings, we recommend that educators and intermediate life science teachers work together to improve the quality of tasks they assign students. This improvement is quite feasible from the standpoint that teachers exercise considerable control over their tasks. While they may use tests and other commercial materials as sources for their tasks, the assignments themselves often are teacher-made. We suggest that in addition to the incorporation of scientific literacy into tasks (discussed in the previous section), that improvement efforts be directed in these areas:

- Teachers need guidance in increasing the problem level of their tasks. Primarily, this entails the inclusion of problems calling for inference, abstract reasoning, and reference to students' own daily experiences.

- Teachers need guidance in designing response formats that require extended verbal responses. While there is still a role for brief item formats, it is likely that higher-order problems will often require students to express themselves in one or more paragraphs.

- Teachers will need additional support to anticipate and deal with the consequences of assigning students more sophisticated work. This includes preparation for potential management problems, the systematic communication of higher expectations to students, and the establishment of appropriate grading procedures.

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APPENDIX A

INTERMEDIATE LIFE SCIENCE STUDY
OBSERVER MANUAL

Alexis Mitman and John Mergendoller

November, 1983

INTERMEDIATE LIFE SCIENCE STUDY OBSERVER MANUAL

TABLE OF CONTENTS

SECTION ONE: INTRODUCTION

This notebook is the observer manual for the Intermediate Science Study (ISS). This notebook provides the background and guidelines you will need in order to take responsibility for data collection in a teacher's class. It is important that you read the entire manual.

Purpose of the Study

The general purpose of the Intermediate Science Study (ISS) is to provide an up-to-date description of what life science instruction is like at the intermediate level. While a sample of volunteer teachers is unlikely to be representative of science teaching everywhere, it nonetheless is probable that we will see activities that typify much science teaching. Of course, we also hope to see among these activities examples of excellence in life science teaching. These examples can serve to guide both researchers and practitioners.

Educators, past and present, have spent considerable effort in thinking about what good science teaching consists of. They refer to their conceptions as definitions of "scientific literacy." In this study, we are using a generally accepted definition of scientific literacy to focus the study and its instrumentation. This definition consists of a number of areas that ideally should be addressed in the teaching of science. While not all instruments address all the areas of scientific literacy, there is considerable overlap. Figure 1.1 demonstrates the overlap of scientific literacy areas covered by three major sets of measures in the study.

Overview of Time Line and Instrumentation

Figure 1.2 presents the timeline for the Intermediate Science Study. The timeline indicates the approximate time of year when the study activities will occur. As shown, the first activity, student pretesting, already has occurred. After observer training, the next steps entail interviewing your teacher(s) and making introductory visits to familiarize yourself with the class(es). Then, a meeting among observers in each state will take place in order to discuss the visits and clarify issues. The next major activity will entail an analysis of each teacher's basic curriculum materials. While analysis of additional materials will occur throughout the year as these materials become available, it is important that observers analyze the basics before regular observation visits begin.

The core of the study's activities consists of making two sets of topic observations per teacher. It is anticipated that one of these sets will occur in Nov.-Dec. and one during Spring, although there may be exceptions. The exact timing and length of the visits

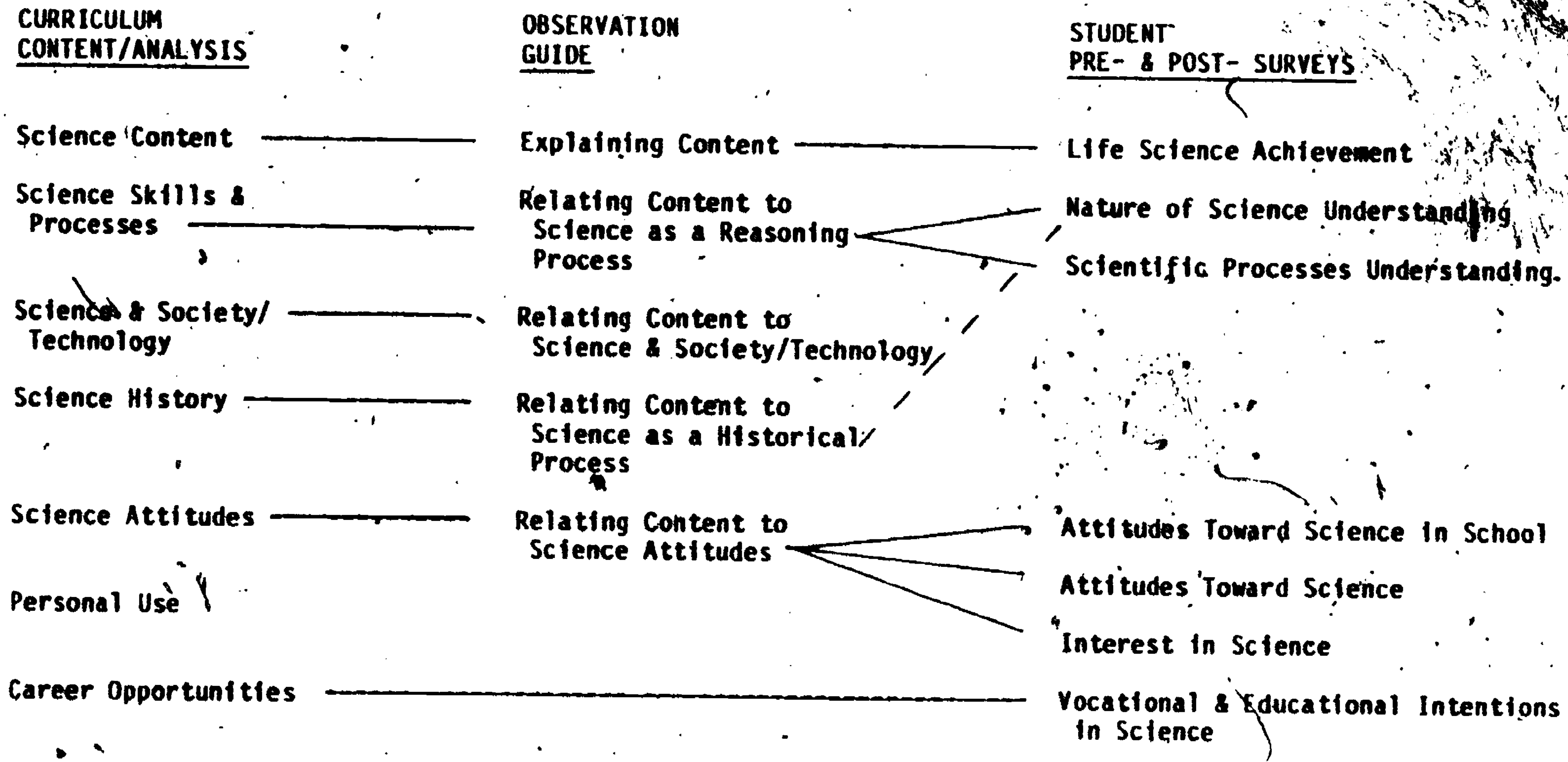

Figure 1.1

Components of Scientific Literacy Represented Across Three Different Measures in Study

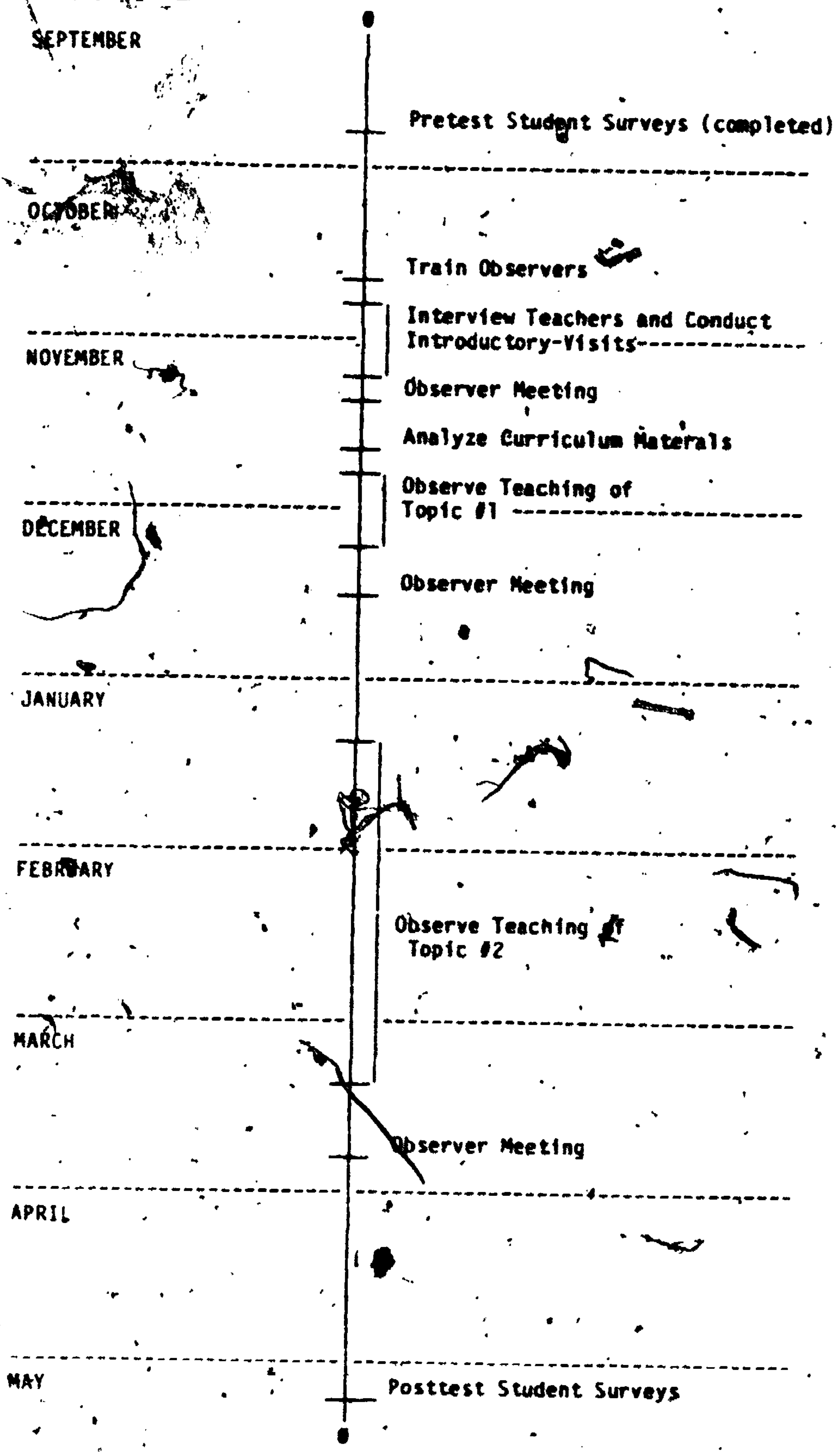

Figure 1.2

Timeline for Intermediate Sci[illegible]e Study will vary depending on the individual syllabus of each teacher. At least one observer meeting will be arranged during or after each set of topic visits. The purpose of these meetings will be not only to clarify any problems, but also to try to develop some emergent themes to enrich the analysis and results of the study. The final activity of the study involves posttesting students.

A variety of instruments will be employed in this study, one or more associated with each activity. Table 1.1 lists the instruments for each activity. With the exception of the student pretest, observers will be responsible for data collection with these instruments.

Organization of the Manual

This manual is divided into sections. The first section contains several articles to read. We ask all observers to read these articles so that a common set of concepts and terminology can be shared among us. The remaining sections of the manual correspond to the instruments for the study. In order of appearance, the sections are the Science Teacher Interview, Curriculum Content Analysis Packet, Class Narrative Record, Science Class Ratings Form, Teacher Topic Self-Report Form, and Student Topic Involvement and Interest Form and Target Student Interview. A final section has been added which presents the general procedures for the study.

Table 1.1

Instruments Used with Each Data Collection Activity in the Intermediate Science Study

ACTIVITY	INSTRUMENT
Pretest and Posttest Student Surveys	Science Class Survey
Interview Teachers	Science Teacher Interview
Conduct Introductory Visits	No Instruments - Take Notes on Any Problems
Analyze Curriculum Materials	Curriculum Content Analysis Packet
Observe Teaching of Topic #1 and #2	Class Narrative Record Science Class Ratings Form Teacher Topic Self-Report Form Student Topic Involvement and Interest Form Target Student Interview

SECTION TWO: READINGS

In this section, there are copies of three articles that we would like you to read. The articles are:

Achieving Wider Scientific Literacy, by A. B. Arons

The Programme, the Plans and the Activities of the Classroom: The Demands of Activity-Based Science, by Edward Smith & Neil Sendelbach.

Academic Work, by Walter Doyle

The purpose of the first reading is to present you with one view of the meaning of scientific literacy. The purpose of the second article is to present a good example of an analysis of science instruction that builds on narrative records. The purpose of the third article is to present you with the background for the concept of academic tasks.

It should be noted that the Intermediate Science Study does not adopt the exact framework expressed in any of the readings. Instead, the articles present concepts or methods that have helped shape our study, which has a unique combination of foci.

SECTION THREE: SCIENCE TEACHER INTERVIEW

Overview

Observers will be responsible for conducting interviews with their assigned teachers as a first activity. The purpose of these interviews is to gather information on the teacher's background, curriculum, and classroom organization. You also will be asked to discuss the scheduling of the topic visits during the interview. These pages provide general guidelines on the practice of interviewing and a copy of the interview.

All interviews will be tape-recorded, and the recordings will be transcribed. It is also important that you provide adequate written notes for each interview as a good summary for yourself, and as a backup for the tape.

The Purpose of the Teacher Interview

Semi-structured interviews with teachers have been included as part of the data-collection effort to provide a "window" into the teachers' perceptions and understandings of their science class.

The methodology of semi-structured interviewing combines: (1) an overall plan of the topics to be covered; and (2) a set of sample questions and probes. Interviewers must be completely familiar with the topic areas covered in the interview, and the kinds of information that are being sought with regard to each topic. These topics remain the same in each interview.

With the essential topics that must be covered by the interview in mind, and the sample interview questions in hand, the interviewer may adapt the interview questions (and probes) to fit the particular interviewing situation. Such adaptation should only occur when the sample questions are inappropriate, given the preceding comments of the teacher, or when they fail to elicit the information desired within each topic area. The general rule, however, is to use the sample questions and probes before departing to your own inventions.

The teacher interview will take place at the end of the school day, or in the teacher's free period. It may require more than one period. If so, schedule another interview appointment at the end of the first interview.

Interviewing Techniques and Tips

- Test your tape-recorder before conducting the interview. Make sure the batteries are fresh and that it is working properly. If the tape-recorder has an adapter, plug it in during the interview.

- Initiate and conclude each interview pleasantly using common introductory and closing statements. (Sample statements appear in the interview schedule.)

- Cover the topics of the interview completely and in the order specified. Make sure you get thorough, detailed answers.

- Respond to the flux of the interview situation itself. The strength of an interview -- as opposed to a questionnaire -- is that it can be sensitive to the phrasing, hesitations, or excitement of the teacher. Be aware of these, and attempt to engage the teacher, much as you would engage a friend in conversation.

- Continue probing the teacher until you have a clear and complete understanding of what s/he is thinking. There is no infallible rule which specifies when the interviewer has probed enough. Keep asking probe questions until you feel you can state the teacher's response to the interview question in a clear and concise way which makes sense. Stop probing if the teacher becomes irritated.

- General probe questions which are useful in many situations include the following: "Can you tell me more about that?" "That's interesting. Could you say some more about that?" Avoid asking "Why?" This often puts people on the defensive.

- Ask the teacher to specify and define words and phrases with which you are unfamiliar, or which are unclear. A general clarification question can be phrased as follows. "I'm unclear about one thing. What do you mean by...?"

- Phrase your own questions and probes so that they do not suggest a single answer. The question, "What do you see as valuable in your science text?" is better than "What is the most important aspect of your science text?"

- Open-ended questions generally are better than questions which require only a one-word, or yes/no answer. Rather than asking, "Does X matter to you?" it would be better to say, "How do you feel about X?" (Not, note, "How does X matter to you?" because phrasing presupposes that X does matter, and a teacher may take this as an indication that the interviewer believes that X should matter, and reply accordingly.)

- Similarly, do not lead the teacher by suggesting an answer to the question as it is being asked. "What students are the most motivated to learn science?" is a good question. "Boys are the most motivated to learn science, don't you think?" is not.

- When you receive more than one answer to a question you have posed, wait until the teacher has elaborated all of the answers and then ask which is most important. This is especially important as we are attempting to understand a teacher's dominant values and orientation.

- Ask questions using words and concepts which are familiar to the teacher.

- Use nonverbal communication (where appropriate!) to indicate that you are interested in what the teacher has to say, and are enjoying the interview. Nods, smiles, and an attentive facial expression encourage participation. Also, expressions of puzzlement can be used as effective probes. Become aware of the messages your expression is giving the teacher!

- Say "uh-huh" or "That's interesting" occasionally throughout the interview. This response from the interviewer indicates interest and generally encourages participation. But remember: A nod or "uh-huh" should indicate understanding, not agreement.

- The interviewer should not express his or her own opinions during the interview. We all have opinions and biases. It is important for the interviewer to recognize and understand his or her biases (opinions, positions, beliefs, etc.) and guard against allowing these biases to intrude on the interview. It does not matter whether the interviewer agrees or disagrees with the teacher. What does matter is that the opinions recorded in the interview belong to the teacher -- not the interviewer.

- Assure the teacher that their privacy will be protected. When interviews are transcribed, they will be identified by number only. No one will know their identity from reading the interview.

- If the teacher objects to being tape-recorded, assure him/her that the purpose of tape recording the interview is only to maintain an accurate record of the conversation. If it is impossible to alleviate the teacher's apprehensions concerning the tape recorder, switch it off, and continue taking notes by hand. Should this occur, immediately following the interview and after leaving the presence of the teacher, dictate your own recollections of the teacher's actual words and phrases into the tape recorder and indicate that the teacher objected to being tape-recorded.

- The teacher has ~~the~~ right to terminate the interview or the recording of the interview at any time. The teacher is not obligated to participate in any way.

The following suggestions should be followed concerning the mechanical operation of the tape recorder and conduct of the interview:

- Place the tape recorder between the teacher and the interviewer, and position it so that it will pick up both voices.
- Record no more than one interview on a cassette. Label clearly each side of the cassette to indicate interviews which continue on more than one side.
- Make sure the tape recorder is picking up the interview. After the introductory remarks and receiving the teacher's permission to record, test and play back the tape to make sure.

The Interview Cover Sheet

A Science Teacher Interview Cover sheet will be provided. This sheet is to be filled out by the interviewer at the beginning of the interview. The identifying information which appears on this sheet will be kept in strict confidence and will be separated from the data sets on which analyses are to be performed.

Labeling the Cassette-Tape

At the completion of the interview, the interviewer should fill in an adhesive label and affix it to the appropriate side of the cassette-tape used. The following information is required: date, observer number, and identification code of teacher (circle teacher).

COVER SHEET: SCIENCE TEACHER INTERVIEW

Teacher's ID: ______________________________

School: ____________________________________

Interviewer ID: ____________________________

Date: ______________________________________

SCIENCE TEACHER INTERVIEW SCHEDULE

Introductory Remarks

Hello (Mrs. Jones). I want to thank you for agreeing to talk with me today. As you know, I'm (your name) from Far West Laboratory, and we are conducting a study of science at the intermediate level. I am looking forward to observing your classroom during the school year, and I want to learn about your background and curriculum, how you organize instruction, and your perceptions as a teacher, so I can better understand your classroom.

I would like to tape-record this interview so I can remember our discussion. Is that OK? Let me assure you that what you say to me is entirely confidential. Your name will not appear anywhere on this interview transcript, and your privacy will be completely protected.

Before we begin the interview, do you have any questions?

Teacher Background

I'd like to begin by learning about your background as a teacher.

1. Where did you receive your undergraduate training? Did you receive graduate training as well? (Where was that? Did you receive a graduate degree? When?)

2. In training to be a teacher, did you have an area of specialization? (What was this area? Do you have a credential in this area? Any other credentials? In what areas?)

3. Have you participated in in-service science activities? (What were the most memorable ones? Why was that? Did they make a direct contribution to your science teaching? In what ways? Any other ways?)

4. Have you participated in in-service activities which did not focus on science? (What were the most memorable ones? Why was that? Did they make a direct contribution to your science teaching? In what ways? Any other ways?)

5. How many years have you taught 7th grade (course name)? (How many years have you taught at this school [no matter what subject]?)

6. What other classes besides 7th grade life science are you teaching this year? (If applicable: Is teaching 7th grade life science different from teaching your other classes? In what ways? Any other ways?)

7. Anything else you would like to tell me about your background that I haven't asked?

Curriculum Topics

8. As you may remember, we are planning to do class observations when you are teaching particular topics. We would be interested in coming to visit when you are teaching any two of the following four topics:

Topic Dates

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Can you tell me which of these topics you cover, and the approximate dates when you plan to teach them? (Write the dates above.)

Expectations for Students

Now I am going to ask you some questions about your students.

9. When the 7th graders come to your class, what, in general, do they know about life science? How would you characterize their general attitude and motivation toward science? What percent of your students are like that? What are the other students like? Do you see any differences between boys and girls? Are there any other things about your students that seem to make a difference in how they react in class?

10. What would you like your students to know when they leave your class? What attitudes and motivation would you like an "average" student to have? What percent of your students achieve this goal?

11. Some teachers have told us that different activities and lessons work better with girls than boys. Has this been your experience? Do you think there are any differences in the way life science should be taught to boys and girls? (If yes: What are these? Do you do this?)

12. Now, considering all of your students, are there certain things a student might say or do in class that you try to encourage? (e.g., discussions about certain topics, materials brought into class from home, questionning other students or the teacher. [The trick here is to respond to a teacher's "What do you mean?" question in a general fashion: "Oh, certain discussions, things students might do at home -- anything you really want to encourage students to do."])

13. How about the other side of the coin. Are there certain things that students might do or say in class that you try to discourage? (Be aware of management/discipline issues as well as curriculum content and methods.)

Curriculum Materials

14. You have already indicated that you use ________________ as your major textbook. How is it that you came to be using this text?

15. From your point of view, does this text have any particular strengths?

16. How about from the students' point of view? Do they perceive any particular strengths (e.g., do they enjoy reading it, like the activities, say they can understand it, like the layout)?

17. Now let's turn the questions around. From your point of view, are there any weaknesses to this text? Any content information the text writers left out which you [illegible] should be there? Any information about the processes of science which was left out? Are there "hands-on" activities that work well with students that weren't used? Any information in the teachers' edition about specific teaching techniques or materials that was missing? Anything else?

18. Do students perceive any particular weaknesses in the text (e.g., they can't understand it, are bored, don't like the activities, say there aren't enough pictures)?

19. Do you do find a need to supplement what's in the text? (If yes: How? How did you begin doing this? Anything else?)

20. Are there any other major materials that you use in class? (Any other published materials? Any other materials you make up?)

21. A number of teachers have told us that departmental science budgets have decreased. Is this true for you? (If yes: Has this affected your teaching? Has it had an impact on the materials you use? How have you coped with this problem?)

Organization and Planning of Instruction

Now I'm going to ask you some questions about the way you organize the class we will be observing.

22. Could you describe what you do with this class in a typical week? (If no typical week: Are there several typical weeks or patterns?) What percent of the time do you think you follow this plan (or patterns?) Are there regularly scheduled lab days? lecture days? workbook days? How did you come to develop this plan (or patterns)?

23. This sounds like a lot to coordinate -- especially in a number of different classes. How do you keep it all straight? (Intent is to evoke spontaneous description of teacher planning. Possible probes: Do you have to write things down? What sorts of things? Do you keep a planbook or are you able to keep it all in your head?)

24. As an example, let's take the class you taught today. What did you do? How did you decide to do it that way? When did you make those decisions. Was the teachers' edition helpful in preparing the lesson? In what way? (Probes should elicit the types of decisions made at different points in time, as well as the assumptions held and materials used by the teacher in planning today's lesson.)

25. Some teachers have told us they make general plans at the beginning of the year and then make more specific plans as the year progresses. Others work on a day-to-day basis adjusting as needed. How would you characterize your planning? (What sorts of things do you determine at the beginning of the year? When do you make other decisions [e.g., monthly, weekly, daily, by unit, by chapter])?

26. I'd like to learn more about your lab activities. How are your lab groups formed (voluntarily, by teacher)? Do boys and girls work together? How does that work? How often do you have labs? So, approximately how many lab days do you have each semester?

Concluding Statement

Thank you very much, (Mrs. Jones), for talking with me. I've been asking a lot of questions. What would you like to ask me? (After all questions are answered) Thank you again for telling me about your science class.

UTAH SCIENCE TEACHER INTERVIEW SCHEDULE

Introductory Remarks

Hello (Mrs. Jones). I want to thank you for agreeing to talk with me today. As you know, I'm (your name) from the University of Utah. We're working with the Far West Laboratory in San Francisco to conduct a study of science at the intermediate level. I am looking forward to observing your classroom during the school year, and I want to learn about your background and curriculum, how you organize instruction, and your perceptions as a teacher, so I can better understand your classroom.

I would like to tape-record this interview so I can remember our discussion. Is that OK? Let me assure you that what you say to me is entirely confidential. Your name will not appear anywhere on this interview transcript, and your privacy will be completely protected.

Before we begin the interview, do you have any questions?

Teacher Background

I'd like to begin by learning about your background as a teacher.

1. Where did you receive your undergraduate training? Did you receive graduate training as well? (Where was that? Did you receive a graduate degree? When?)

2. In training to be a teacher, did you have an area of specialization? (What was this area? Do you have a credential in this area? Are you still teaching in this area? Are you teaching or have you taught in any other area? Do you have credentials in these areas?)

3. Have you participated in in-service or other professional development activities concerned with science? (What were the most memorable ones? Why was that? Did they make a direct contribution to your science teaching? In what ways? Any other ways?)

4. Have you participated in in-service or professional development activities which did not focus on science? (What were the most memorable ones? Why was that? Did they make a direct contribution to your science teaching? In what ways? Any other ways?)

5. How many years have you taught 7th grade (course name)? (How many years have you taught at this school [no matter what subject]? How many years has it been since you began teaching? What subjects have you taught? How many years did you teach each one?)

6. What other classes besides 7th grade life science are you teaching this year? (If applicable: Is teaching 7th grade life science different from teaching your other classes? In what ways? Any other ways?)

7. Anything else you would like to tell me about your background or current activities outside of school? (e.g., other jobs, professional activities, community activities, school activities, family involvement)

Curriculum Topics

8. As you may remember, we are planning to do class observations when you are teaching particular topics. Can you tell us what topics you plan to cover before Christmas? (If any of the topics below are mentioned by the teacher, probe to find out exactly when they will be covered. If topics below are not mentioned by the teacher, find out if and when they will be covered. Write down any of teacher's spontaneous reactions or characterizations of the topics, e.g., "I really like to teach..." or "I don't think that goes over well...")

Topic Dates

1. Land Ecosystems-Communities: ____________________

____

2. Seed Plants: ____________________

____

3. Genes-Heredity: ____________________

____

4. Bacteria, Protozoa (Protists) & Viruses: ____________________

____

5. Bones, Muscles, & the Nervous System in the Human Body: ____________________

____

Expectations for Students

Now I am going to ask you some questions about your students.

9. When the 7th graders start your class, what, in general, do they know about life science? How would you characterize their general attitude and motivation toward science? What percent of your students are like that? What are the other students like? Do you see any differences between boys and girls? Such as? Are there any other things about your students that seem to make a difference in how they react in class?

10. What would you like your students to know when they leave your class? What attitudes and motivation would you like an "average" student to have? What percent of your students achieve this goal?

11. Now, considering all of your students, are there certain things a student might say or do in class that you try to encourage? (e.g., discussions about certain topics, materials brought into class from home, questionning other students or the teacher. [The trick here is to respond to a teacher's "What do you mean?" question in a general fashion: "Oh, certain discussions, things students might do at home -- anything you really want to encourage students to do."])

12. How about the other side of the coin. Are there certain things that students might do or say in class that you try to discourage? (Be aware of management/discipline issues as well as curriculum content and methods.)

Curriculum Materials

13. You have already indicated that you use ______________ as your major textbook. How is it that you came to be using this text?

14. From *your* point of view, does this text have any particular strengths?

15. How about from the *students'* point of view? Do they perceive any particular strengths (e.g., do they enjoy reading it, like the activities, say they can understand it, like the layout)?

16. Now let's turn the questions around. From your point of view, are there any weaknesses to this text? (Any content information the text writers left out which you think should be there? Any information about the processes of science which was left out? Activities that work well which were left out? Any information in the teachers' edition about specific teaching techniques or materials that was missing? Anything else?)

17. Do students perceive any particular weaknesses in the text (e.g., they can't understand it, are bored, don't like the activities, say there aren't enough pictures)?

18. Do you do find a need to supplement what's in the text? (If yes: How? How did you begin doing this? Anything else?)

19. Are there any other major materials that you use in class? (Any other published materials? Any other materials you make up?)

20. A number of teachers have told us that departmental science budgets have decreased. Is this true for you? (If yes: Has this affected your teaching? Has it had an impact on the materials you use? How have you coped with this problem?)

Organization and Planning of Instruction

Now I'm going to ask you some questions about the way you organize the class we will be observing.

21. Could you describe what you do with this class in a typical week? (If no typical week: Are there several typical weeks or patterns?) What percent of the time do you think you follow this plan (or patterns?) Are there regularly scheduled lab days? lecture days? workbook days? How did you come to develop this plan (or patterns)?

22. This sounds like a lot to coordinate -- especially in a number of different classes. How do you keep it all straight? (Intent is to evoke spontaneous description of teacher planning. Possible probes: Do you have to write things down? What sorts of things? Do you keep a planbook or are you able to keep it all in your head?)

23. As an example, let's take the class you taught today. What did you do? How did you decide to do it that way? When did you make those decisions. Was the teachers' edition helpful in preparing the lesson? In what way? (Probes should elicit the types of decisions made at different points in time, as well as the assumptions held and materials used by the teacher in planning today's lesson.)

24. Some teachers have told us they make general plans at the beginning of the year and then make more specific plans as the year progresses. Others work on a day-to-day basis adjusting as needed. How would you characterize your planning? (What sorts of things do you determine at the beginning of the year? When do you make other decisions [e.g., monthly, weekly, daily, by unit, by chapter])?

25. I'd like to learn more about your lab activities. How are your lab groups formed (voluntarily, by teacher)? Do boys and girls work together? How does that work? How often do you have labs? That makes for approximately how many lab days each semester?

Concluding Statement

Thank you very much, (Mrs. Jones), for talking with me. I've been asking a lot of questions. What would you like to ask me? (After all questions are answered) Thank you again for telling me about your science class.

updated 11/04 version

SECTION FOUR: CURRICULUM CONTENT ANALYSIS PACKET

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This section presents the instruments that will be used to analyze the curriculum materials. The packet contains different systems of analyses for different kinds of materials. In other words, some analyses are used for the text materials, and others are used for teacher-made worksheets and tests. The number of times you will use any one system will depend on the kinds of materials a teacher relies on most. You will be asked to analyze the teacher's text materials prior to the topic observations. Other kinds of materials will be analyzed as you acquire them.

Directions and definitions for use of the analysis packet are a part of the packet itself. Thus, this section consists of a copy of the packet. Eight systems of analysis are represented:

1. General Orientation of the Text: Content vs. Activity Centered
2. Science Orientations and Linkages in the Text
3. Concept Density in the Text
4. Graphics in the Text
5. Chapter Review Questions in the Text
6. Laboratory Activity Level
7. Orientations and Levels of Worksheets
8. Orientations and Levels of Tests and Quizzes

It should be emphasized that one major reason for doing the curriculum analysis is to increase your awareness of the nature of the materials that students are exposed to. As you gain a more complete picture of the materials, you should think about any things a good teacher would have to do to supplement the materials. Any things you identify should, in turn, help guide your observations (see Section Five).

1. General Orientation of the Text: Content vs. Activity Centered

A brief examination of the goals and rationale of a text as specified in the teacher's edition and the student's edition gives a fair impression of the flavor and spirit of a science series. With such information, a science series can be placed on a continuum. At one end of the continuum, the emphasis is on student mastery of a body of scientific facts and concepts with scant attention to teaching science by using the processes of investigation. A program such as this is content-centered. At this end of the continuum, the teacher's edition will lack suggestions for optional investigative activities and field projects, and descriptions of laboratory activities will not be part of the text.

By contrast, the other end of the continuum is signalled when the text stresses the importance of enquiry activities, suggesting particular activities in the teacher's and student's editions and tying them to the rest of the text. These activities should have the potential to involve students in real investigations of materials and the reasons for these activities should be made very clear and convincingly. Also, there will be explicit linkages between the activities and the rest of the text (e.g, student's text will reference an activity).

In judging the quality of the connection between the activities and text, it is helpful to make the following distinction: if the activities are (a) thematically inappropriate or (b) simply thematically appropriate with no explicit verbal linkage, the connection is poor; if the activities are thematically appropriate and there are explicit verbal linkages between the text and activities (either the text referencing the activity or the activity referencing the text), the connection is good. In general, good linkages occur rarely.

Directions: Skim the entire textbook to determine the presence of any suggested enquiry activities and, if present, the average number per chapter. If the teacher's edition of the text is available, then go back and read the goals and rationale stated; note whether there are optional activities suggested in this edition. If activities are present in the student's regular text, randomly select one from each of eight chapters and judge the extent to which the activity is tied to content and rationale in the text. Please mark an "x" on the continuum that best indicates the general orientation of the text.

TCHR ID:

RATER ID:

DATE:

1. General Orientation of the Text

Title of Text:

Authors:

Publisher: Year:

Circle One: major text supplemental text

content-centered

- no activities in student's or teacher's editions.
- some activities given (on average, less than 2 per chapter), with poor connection to text.
- many activities given (on average, 2 or more per chapter), with poor connection to text.
- some activities given (on average, less than 2 per chapter), with good connection to text.
- many activities given (on average, 2 or more per chapter), with good connection to text.

activity-centered

Comments:

2. Science Orientation and Linkages in the Text

The goals of science curriculum programs can be viewed in terms of seven categories of scientific literacy. These categories can be briefly defined as follows:

1. Science content - prose material intended to teach the student definitions, facts, and concepts. Examples: "Most mutations are harmful and often result in the death of the mutant;" "The amoeba is a [illegible]oan that moves by a flowing motion."

2. Science skills/processes - addresses the procedures and logic for acquiring scientific knowledge. This includes discussions of observation, measurement, theory development, and hypothesis testing. Examples: "But science can correct itself - with new evidence and better thinking. New theories replace those the evidence does not support;" "Scientists patiently observe many, many objects and events."

3. Science and society - addresses the social impact, both positive and negative, of scientific knowledge and scientific technologies, i.e., how this knowledge affects individuals and communities in terms of their health, lifestyle, work, and environment. Examples: "If the smog content is high, the results may be eye irritation and actual physical harm to the people;" "Hundreds of people a year are killed or injured by pesticide poisoning;" "Officials like Dr. Kesley help to protect the public from drugs that produce dangerous side effects."

4. History of science - addresses the development of scientific theory and knowledge over time, including biographical accounts of the work of individual scientists. Examples: "As early as 1900, the chemical make-up of DNA was known;" "Early in the 17th century, Jean-Baptiste van Helmont planned a simple, but important, experiment."

5. Personal use - presents ideas and information that are relevant to a student's personal development, typically suggesting how the student can think and act responsibly. In short, the text is providing explicit prescriptive statements for the students. Examples: "Rest and proper diet are our best protection against infection of the respiratory system;" "It is important for you to be aware that alchohol can become addicting."

6. Science-related attitudes - encourages the student to view science with enthusiasm and curiosity. This category also is broadened to include extended portions of text (i.e. more than one rhetorical question) that clearly are attempts to engage the reader. Examples: "You may at some time have noticed a curious thing. Let's suppose that you are eating a meal..."

7. Career opportunities - presents information about one or more science-related careers. This often takes the form of a special inset in the text. Examples: "There are several programs in

nursing;" "If you like the outdoors, you might enjoy a career in forestry or wildlife management."

These categories are representative of the definition of scientific literacy which guides this study. While the introduction in teacher's editions often suggest that these categories are central, actual examination of the text prose sometimes indicates otherwise. Thus, this analysis will be based on the text prose that students read.

Two aspects of the seven science categories are considered in this analysis. First, there is a focus on the number of times each category is addressed within a certain block of text. Second, there is a focus on if and how examples from one category are linked to examples from other categories within the same unit of text. The analysis system allows you to code text in a way that indicates both its orientations and linkages. As a general rule, unless the prose obviously strikes you as an attempt to relate science, it should be coded as science content with no linkage.

Directions: For a given class, identify the chapters or subsections in the text that cover the two topics that will be observed. Use one set of coding sheets to do each topic. Fill out the top of the coding sheet to identify the text, topic, and relevant pages.

For every page in the text where the topic is covered, select the second and fifth full paragraphs that are each at least four sentences long. (You count paragraphs of any length but only use paragraphs of at least four sentences.) If there is no fifth paragraph, then you are finished with that page. Do not count or use paragraphs that are split across two pages. Also, do not include paragraphs that are parts of activity inserts or summary/review sections. An example of selected paragraphs from text appears on the next page.

Next, mark the text to isolate coding units within each selected paragraph. For our purposes, the unit of coding is defined as the presentation of one idea. Thus, the unit may consist of just one sentence or it may consist of two or more sentences. You will need to use your careful judgment to segment the paragraphs into units.

Example: Take the following paragraph:

> "Suppose you tied a rope around a young tree at a 1-meter level. If you visit the tree in ten years, will the rope be at the same level? You might be surprised to find that it is. |Growth in a plant occurs only at the tips of the stems and roots. The newest stems and leaves are always at the top of a tree. The older branches remain near the bottom of a tree. The rope will stay where you tied it at the level of the older branches.|"

In this example, there are two distinct units. The first unit is an attempt to engage student interest, while linking to science content. The second unit is a presentation of science content with don't count; split paragraph

seeds store much of their food supply as starch. But some plants store part of their food as proteins or as fats. For instance, the seeds of the bean plant have a high protein content. Other seeds, for example, nuts, have a high fat content. You may know, for instance, that the cotton seed has a great store of oil. The corn that we eat, a seed, is also high in fat content.

Just as chlorophyll was necessary for the process of photosynthesis, other special substances are necessary to synthesize fats, proteins, and vitamins. These specific substances, you will recall, are the enzymes (Chapter 8). Enzymes not only function in the synthesis of carbohydrates, fats, proteins, and vitamins, they also function in breaking them down. In the dark reaction of photosynthesis, enzymes are necessary for putting the CH_2O molecules together into glucose with six carbon atoms, $C_6H_{12}O_6$.

#1

A-46

#2, too short

Plants and animals have many enzyme systems in common, but only green plants are able to use the radiant energy of light by means of photosynthesis. Animals must get their energy by eating plants or other animals that have eaten plants.

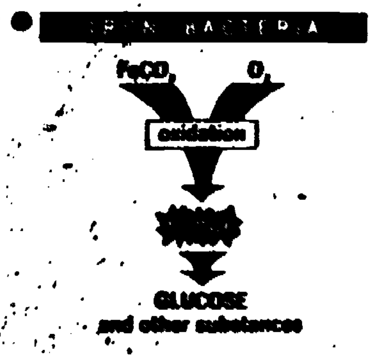
also too short

There are exceptions, however, to the general rule that all living organisms except green plants must depend directly or indirectly upon green plants for their food. There is a group of plants able to make food without light. The energy they use for making food substances comes from sources other than light and the process of photosynthesis.

#2 you code

In the discussions of photosynthesis and all other kinds of synthesis, you should not lose sight of the main point. It is the energy that is important. The products made are important only in terms of their ability to store and release the energy that is needed to carry on the activities of living

313



Energy, of course, must be obtained in order to synthesize substances such as glucose, protein, fat, or vitamins. And green plants are able to capture this energy from light. If green plants got this energy from some other source, it would be just as useful. In fact, as we stated before, there are such plants. These plants are called chemosynthetic (kĕm′ō-sin-thet′ik) plants. *Photosynthetic* plants get their energy from light. *Chemosynthetic* plants get their energy from chemicals. (It is better to say *substances* or *chemical energy* than it is to say *chemicals*.) In the correct terms, photosynthetic plants use radiant energy, while chemosynthetic plants use chemical energy.

Chemosynthetic Plants

One group of these chemosynthetic plants uses iron rather than light as its source of basic energy for manufacturing food substances. These are the so-called iron bacteria. The iron bacteria live in water that contains large amounts of dissolved iron compounds, such as iron carbonate ($FeCO_3$). The bacteria absorb the iron compounds and combine them with oxygen (oxidation). ● In short, they oxidize iron carbonate. This oxidation

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food chain

passed along in this manner, we have what is called a *food chain*.

The following is an example of a food chain. Green plants make food. Grasshoppers feed on grass. Toads eat grasshoppers, and garter snakes often eat toads. Hawks eat garter snakes. See Fig. 13-1. The hawk is at the top of this food chain. There is more grass than there are grasshoppers, more grasshoppers than toads, more toads than snakes, and more snakes than hawks.

#1

Fig. 13-1
A food chain. What does the sun have to do with this? What do you think becomes of the hawk when it dies?

This is true because each member of the chain uses up some of the food, so there is less and less as it moves along in the chain. If any plant or animal in the food chain dies, it will decay. Waste material from the living animals will also decay. So all of the food that is made by the producers is finally used up. It is used partly by the green plants and partly by the animals and decomposers in the food chain. Can you think of a food chain with people in it?

Cycles. Study Fig. 13-2. It shows the food relationships we have just been talking about. How does it also illustrate the cycles we studied in Chapter 12? Carbon dioxide from the air

no full

#2314

no linkage made to any other area of scientific literacy. A small vertical line separating "is" from "Growth" on the 4th line of this paragraph indicates the division into coding units.

Once coding units are established, coding begins. Use the chart on the coding sheet to indicate the orientation(s) and linkages within each coding unit by placing hatchmarks in the appropriate box(es). For the first coding unit in this example, you would place a mark in the box that is the cross between Science Content and Science-Related Attitudes. For the second unit, you would place a mark in the Science Content/No Link box. The last sentence of the paragraph is not coded separately, because it is redundant with the first unit. The coding corresponding to this example is marked on the sample coding sheet.

Here is another example:

> "We cannot know what was responsible for the cure; and because we cannot know, we cannot say which cause was responsible for the effect, the "cure." |But suppose we know that the magic drug was prepared from the bark of the cinchona tree. The bark of the cinchona tree contains the drug quinine, which acts to depress many fevers, especially those of malaria. Therefore we might conclude that the drug was responsible for the recovery. |To confirm this hypothesis we would have to have been there and insisted that the drug be given without the magic dance or the magic words.|"

In this example, there are three coding units. These are indicated by the small vertical marks on lines 3 and 9. The first unit is an example of Science Skills/Process with no linkage (except to a hypothetical example, which is not coded). The second unit represents a linkage between Science Skills/Process and Science Content. The third unit is another example of Science Skills/Process with no linkage. These codings also are marked on the sample coding sheet.

The following page provides additional examples:

Additional Examples of Science Orientations Codings

"Alcohol produced by yeast plants may be used either as industrial alcohol or as beverage alcohol. Alcohol is one of the most important chemicals used in industry. Large amounts of it can be produced when yeast is used to ferment molasses.| However, much industrial alcohol today is made synthetically without yeast.| Beverage alcohol is made by allowing yeasts to ferment fruit juices to produce wine, or grain products to produce beer. The more concentrated drinks, like whiskey, are produced from fermented grain mixtures by a process called distillation. This process is used to concentrate the alcohol.|"

Unit 1: Science Content/No Link
Unit 2: Science Content/No Link
Unit 3: Science Content/No Link (Note: This example does not include Science and Society/Technology because there are no explicit references to implications for society or technology.)

"Linnaeus wanted to work out a system of scientific names that would be in the same language throughout the world. He did not expect people to use these names in daily conversation. They were to be used by scientists to identify the types of living things that they worked with. He used Latin, because in those days all educated people knew Latin.|"

Unit 1: History of Science/No Link.

"Forest management. Fire protection is the most important part of forest management, but it is not the only part. There are several other things that need to be done also. Where small trees grow too close together, none can grow well. Some of these trees may be cut out to give the rest of the forest a better chance to grow. This practice is called thinning.| Sometimes crooked trees, diseased trees, and trees of less desirable species are removed, leaving only the more valuable trees to grow and produce lumber. This is improvement cutting. Thinning and improvement cutting can be combined in a single operation.|"

Unit 1: Science Content/No Link.
Unit 2: Science Content/No Link.

"The potato blight in Ireland in the 1840's completely destroyed the valuable potato crop. Many Irish people starved to death, and many others fled to America. The potato blight is still a problem, but we now know how to protect the plants by spraying them."

Do not code. This paragraph has fewer than 4 sentences.

SAMPLE

Title of Text: ____________________

Authors: ____________________

Publisher: ____________________ Year: __________

CIRCLE ONE: major text supplemental text CIRCLE ONE: topic #1 topic #2

Page numbers where topic covered: ______________

	No Link	1.	2.	3.	4.	5.	6.	7.
1. Science Content	|		|				|	
2. Science Skills/ Process	||							
3. Science and Society/ Technology								
4. History of Science								
5. Personal Use								
6. Science-Related Attitudes								
7. Career Opportunities								

Comments:

2. Science Orientations and Linkages in the Text

Title of Text: ____________________

Authors: ____________________

Publisher: ____________________ Year: ________

TCHR ID: ________

RATER ID: ________

DATE: ________

CIRCLE ONE: major text supplemental text CIRCLE ONE: topic #1 topic #2

Page numbers where topic covered: ________

	No Link	1.	2.	3.	4.	5.	6.	7.
1. Science Content								
2. Science Skills/ Process								
3. Science and Society/ Technology								
4. History of Science								
5. Personal Use								
6. Science-Related Attitudes								
7. Career Opportunities								

(continued)

Comments:

3. Concept Density in the Text

Concept Density refers to the quantity of terminology that a student is expected to comprehend in the text. Publishers typically highlight new terms as they are introduced in the text and these words also appear in a separate glossary. However, these highlighted words do not nearly represent all of the terms students need to know in order to fully comprehend the text. There are many scientific terms in texts that are not highlighted.

In this analysis, you are asked to keep track of all the scientific terms presented in a particular block of text. For convenience, you will work with the same paragraphs you used in the previous analysis (Orientations and Linkages).

Directions: Fill out one concept list sheet for each of the two topic sections in the text. For every page in the text where the topic is covered, select the second and fifth paragraphs that are at least four sentences long. If there is no fifth paragraph, then continue on to the next page. Do not include paragraphs that are part of activity inserts or summary/review sections. On the coding sheet number the selected paragraphs consecutively and indicate the text page number. For each paragraph, indicate the number of lines in the paragraph. Then list all of the scientific terms presented in the paragraph. Common names of plants, animals and body parts should be included as scientific terms; also, geographic terms should be included. Within any one paragraph, do not list a term more than once. However, if a term shows up in at least two different paragraphs that you are analyzing, you would list it for each respective paragraph.

Example: Consider the following paragraph:

> "Most taxonomists would agree on placing the green, golden, red, and brown algae in the subkingdom Thallophyta. Others would include the fungi, bacteria, and blue-green algae in a single subphylum. Other taxonomists would place the bacteria and blue-green algae in a separate subphylum, thus separating the bacteria from the fungi."

Here, you would first indicate that the paragraph is 7 lines long. Then, you would list the following words:

taxonomists
algae
subkingdom
Thallophyta
fungi
bacteria
subphylum

Consider another paragraph:

> "When a fern spore lands in a suitable environment, it develops into a microscopic plant. On the underside of this plant, special cells form sperm and eggs. As in moss reproduction, sperm must swim in water to reach the egg. When the egg is fertilized, it develops into the familiar fern plant."

This paragraph is 6 lines long, and the following words should be listed:

fern
spore
environment
microscopic
cells
sperm
eggs
moss
reproduction
fertilized

TCHR ID: ____________

RATER ID: ____________

DATE: ____________

3. Concept Density in the Text

TITLE OF TEXT: ____________________________

AUTHORS: ____________________________

PUBLISHER: ____________________________ YEAR: ____________

CIRCLE ONE: major text supplemental text CIRCLE ONE: topic #1 topic #2

Page numbers where topic covered: ____________________________

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

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Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ 3 No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Paragraph # ____ Terms:

Page # ____

Lines = ____ No. of terms = ____

Summary: Total number of paragraphs analyzed = ______

Total number of lines analyzed = ______

Total number of terms = ______

Comments:

4. Graphics in the Text

Textbooks vary not only in the number of graphics used but also in the extent to which the graphics truly link with the text and aid comprehension. At the least desirable extreme, a graphic is used only to make the text attractive, with no reference made to it in the text. At the most desirable extreme, a graphic is discussed in the text, captioned, and serves a clear purpose in facilitating comprehension.

Directions: In this analysis, we again ask you to look at the two parts in the text that correspond to the two observation topics and to complete a coding sheet for each part. Here, you are to consider all graphics that appear in the text part. Each coding sheet first requires you to place each graphic into one of seven categories and thus tally the number of graphics used. In addition, for each graphic, you are asked to indicate the quality of the text referral and its caption status. In categorizing and rating each graphic, place a hatch mark in the appropriate row and under the appropriate columns.

In judging the quality of the text referral and caption status, use the following guidelines:

Quality of Graphic Text Referral

1. A rating of 1 is given if there is no obvious link between the graphic and the text content. This would mean not only that there is no reference to the graphic in the text but also that there is no obvious purpose to the graphic other than to "prettify" the page. Graphics that come at the very beginning of chapters sometimes fall into this category (e.g., a picture of colorful snail shells on the first page of a chapter on mollusks). The key here is that there is no mention in the adjacent text of the specific thing the graphic illustrates.

2. A rating of 2 is given if the graphic is thematically appropriate but there is no specific reference to the graphic in the text. Thus, for example, a figure of the human skeleton would be rated a "2" if it appeared in a block of text disucssion about the human skeleton but there was no reference to the figure in the text.

3. A rating of 3 is given if the graphic is thematically appropriate and the graphic is referenced, but not discussed in the text. Here, the key distinction, relative to rating 2, is that the graphic is referenced or identified in the text. Examples of a reference are (a) placing the same key (e.g., number) by the figure and at a certain point in the text; (b) "See Fig. 39.4"; and (c) "Fig. 27-1 shows the outside view of a clam."

4. A rating of 4 is given if the graphic is thematically appropriate, referenced in the text, and discussed in the text. This highest rating is given only if the text in some way directly discusses the graphic referring to more than simply its identity. An example would be: "Another type of nerve cell is shown in Fig. 41-2. It is a sensory nerve cell. It has the same parts as a motor nerve cell, but the arrangement is a little different. Notice that the dendrites of the sensory nerve cell are not attached to the cell body..." This example qualifies as a "4" because the text describes the graphic in detail and leads you to examine aspects of the graphic in a comparative fashion.

Caption Status

1. A graphic receives a "1" if there is no caption accompanying the graphic, or simply a Figure or Table number with no label.

2. A graphic receives a "2" if there is a caption that simply labels the graphic, with no elaboration. Examples would be: (a) "The cell structure of Hydra"; (b) "The internal structures of the frog"; and (c) "Various types of leaves. Top left, red maple; Top right, strawberry; Bottom left, palm; Bottom right, Japanese maple."

3. A graphic receives a "3" if there is a caption that goes beyond labeling and either describes something about the graphic or asks a question abbut the graphic. Examples would be: (a) "The jawbone of a shark. Notice the several rows of teeth;" (b) "Can you tell to which carbohydrate each of these belongs?"; (c) "The digestive systems has several parts. What is the function of each organ?"

TCHR ID: ____________

RATER ID: ____________

DATE: ____________

4. Graphics in the Text

TITLE OF TEXT: ____________

AUTHORS: ____________

PUBLISHER: ____________ YEAR: ____________

CIRCLE ONE: major text supplemental text CIRCLE ONE: topic #1 topic #2

Page numbers where topic covered: ____________

Type of Graphic	Total Number	Quality of Graphic Text Referral				Caption Status		
		1	2	3	4	1	2	3
1. Graphic is one picture that presents visual example								
2. Graphic is two or more pictures that show a comparison								
3. Graphic shows spatial structural relationship; parts labeled								
4. Graphic shows quantitative relationship								
5. Graphic illustrates set-up or procedures for an experiment								
6. Graphic illustrates process or cycle								
7. Graphic classifies or summarizes tests or data								
8. Other (please explain): ____________ ____________ ____________								

(continued)

Comments:

5. Chapter Review Questions in the Text

Textbook chapters typically end with a set of review or summary questions/exercises. The purpose of this analysis is to judge the demands of these questions/exercises. Two aspects of the questions/exercises will be considered. First, the analysis examines the mode of response required. Here, the continuum ranges from items for which the student simply marks 't' for true and 'f' for false to questions that ask the student to write a coherent well-structured expository essay. Second, the analysis examines the connection between the questions/exercises and the preceding text prose. There is a range for this aspect also, with questions that ask for answers that can be pulled directly from the text at one end and questions requiring original analysis at the other end.

Directions: For this analysis, you are to focus on all the chapters that contain the portions of the text associated with each of the two topics (i.e., the chapters containing the parts you've examined for the previous three analyses). In some instances there may be more than one chapter involved for each topic. Read each chapter even if this entails reading parts that are not directly on the topic. It is important to read thoroughly because part of the analysis entails assessing the link between the questions and the text. Next, turn to the review questions/exercises at the end of each chapter. (Do not include suggested investigative activities). Read each question and categorize it according to the mode of response required. Then examine the same question in terms of its relationship to the text, going back to the text to see what relevant information is provided. The categories under mode of response and relationship to text are as follows.

Mode of Response: There are four main categories for this dimension: (1) Verbal Restricted, (2) Verbal Extended, (3) Numerical Calculations, and (4) Figural. Category 1, verbal restricted, is further subdivided into five subcategories: (i) Matching, (ii) True/False, (iii) Fill-in/Label, (iv) Multiple-Choice, and (v) Short Answer. These are all self-explanatory, save the last, which is defined to mean questions that can be answered well by writing one simple sentence. Category 2, verbal extended, is broken into two subcategories: (i) paragraph and (ii) essay/report. Paragraph is defined to mean a question where a good answer would require a set of at least two sentences, all addressing a common idea. Essay/report refers to a question where a good answer would entail two or more paragraphs, each addressing a slightly different idea. Here, it is likely that the question will specify that an essay or report is necessary. The third main category is Numerical Calculations. This refers to questions where the main task is to perform a mathematical operation, even if the answer is expressed verbally. The fourth main category is Figural. This includes all problems where the main task is to make a drawing or graph data. In deciding what a "good" answer to any question consists of, you will have to use your own judgment. If a teacher's edition is available to you, it may be very helpful to see what model answers they give.

The mode of response categorization may raise the issue of what the unit of the question/exercise is. Take the following example:

"6. How does the nervous system in man function in
   a. recognition of the environment?
   b. interpretation of the environment?
   c. response to the environment?"

The text treats this as one item but there are three questions given, each requiring a separate, if related, answer. Thus, you would code this as three separate questions. Another example to consider is one problem where the student is asked to match 10 scientific terms with their definitions. Here, you would treat this as 10 separate questions.

Relationship to Text: For this dimension, you are asked to decide which of the following three categories best characterizes each question or exercise: (1) Textually Explicit, (2) Textually Implicit, or (3) Scriptally Implicit. (This taxonomy was developed by Pearson & Johnson, 1978). Textually explicit questions have answers that are right there on a page of text. Other reading educators might refer to such questions as "literal comprehension" questions. Textually implicit questions have answers that are derived from the text but in an indirect sense. There is some degree of inference necessary for the reader to generate the answers. The point to stress is that the relationship between the question and the answer is to some degree an implicit one. Finally, "scriptally" implicit questions ask the reader to use his or her own script (prior knowledge and general reasoning) to come up with an answer. These are called, in terms of other reading frameworks, critical/evaluative items. Again, it is important to emphasize that it is necessary to study the text in order to make these categorizations.

TCHR ID: ____________

RATER ID: ____________

DATE: ____________

5. Chapter Review Questions in the Text

TITLE OF TEXT: ____________

AUTHORS: ____________

PUBLISHER: ____________ YEAR: ____________

CIRCLE ONE: major text supplemental text CIRCLE ONE: topic #1 topic #2

CHAPTER(S): ____________

MODE OF RESPONSE REQUIRED BY QUESTIONS/EXERCISES	TOTAL NUMBER	QUESTIONS/EXERCISES RELATIONSHIP TO TEXT*		
		Textually explicit	Textually implicit	Scriptally implicit
1. Verbal Restricted A. Matching				
B. True/False				
C. Fill-in/Label				
D. Multiple Choice				
E. Short Answer (can be answered in one simple sentence)				
2. Verbal Extended A. Paragraph (requires at least two sentences)				
B. Essay/Report (requires at least two paragraphs)				
3. Numerical Calculations				
4. Figures (drawing or graphing)				
5. Other (please explain:) ____				

*Place actual problem numbers in these three boxes

(continued)

Comments:

6. Laboratory Activity Dimensions

Most life science classes include one or more laboratory activities as part of the learning experience for each topic. This analysis asks you to provide basic descriptive information about each laboratory activity that is assigned during your observations of each topic. Further, you will be asked to categorize each laboratory exercise in terms of three dimensions: 1) Type of Activity; 2) Level of Discovery; 3) Topic Appropriateness. Each of these dimensions is explained below:

Type of Activity

Lab activities can be considered as falling into one of three categories:

a) Methodological - The main purpose of a methodological lab activity is to learn or improve upon a scientific technique or procedure. Examples would be preparing a wet mount microscopic slide or finding a way to measure how mucn water a rat drinks in a 24-hour period.

b) Observational/Exploratory - This kind of laboratory activity is characterized by following an exploratory approach to discovering relationships or events. These activities would rarely involve systematically manipulating one or more independent variables. The observation of these relationships or events may or may not be intended to lead to further systematic investigation. Examples of such activities would be observing the growth of a seedling's root hairs or dissecting a frog to examine its anatomical structures.

c) Fact Gathering/Hypothesis Testing - This kind of laboratory activity entails addressing specific questions or hypotheses by gathering data. Unlike exploratory activities, data are collected under a greater variety of conditions. There are two forms of such activities: in one students arrive at answers by careful observation often to verify previous information; the other is truly experimental in the sense that hypotheses are tested (e.g., performing an experiment to test how varying light intensity influences the rate of photosynthesis). This category also encompasses the special case of boundary-setting experiments, a special kind of fact-gathering experiment. These entail studying the range of application of some idea or the breadth of conditions under which a hypothesized relationship is present (e.g., determining the highest pitch and the lowest pitch sound that a dog will respond to).

Level of Discovery

For this dimension, developed by Herron (1971), it is necessary to view each laboratory activity as consisting of three parts: a) a problem or related set of problem(s); b) a method for addressing the problem(s); and c) answer(s) to the problem(s). Given these three parts, the level of discovery will vary depending on how many of the parts are already specified for the student and how many the student must develop for him/herself. Four different levels can be specified as follows:

Level of Discovery	Problems	Methods	Answers
0	Given	Given	Given
1	Given	Given	Open
2	Given	Open	Open
3	Open	Open	Open

In deciding which aspects of the lab activity are "given" or "open," you should focus largely on the formal resources available for the task. For example, if the lab materials did not give the answers to the students, you would consider answers as "open." This would hold true even if the teacher gave part of the answer to the class during the lab period. In this case, you should note the teacher's behavior under "comments." Here, it is important to separate the formal structure of the curriculum (the focus of this packet) from teacher implementation of the structure. This will allow us to later determine if and how the teacher changes the formal curriculum.

Topic Appropriateness

This dimension addresses the extent to which the laboratory activity is appropriate and purposeful given the rest of the topic activities you have observed (e.g., the particular context of your classroom). While appropriateness is often linked to timing (i.e., when it makes most sense to present an activity) it also involves a judgment about how appropriately assigned the content and procedures of the lab are given what students have been exposed to up to that point in time. There are three categories of appropriateness:

a) Mostly or Completely Inappropriate - You would use this if the lab activity assigned was mostly inappropriate in terms of timing, content, or procedures. Examples would be doing a lab on plant cell structure when the topic was photosynthesis, or simply copying the diagram of a frog skeleton when the topic is frog anatomy. Another example would be an activity where the procedures for the lab (e.g., using a bunson burner) are so involved that the real intent of the lab (e.g., doing a sugar test) gets relatively less attention.

b) Partly Appropriate - This category is used in instances where the lab activity appears neither clearly inappropriate or clearly appropriate. In this case, there will be something important about the timing, content, or procedures that could be improved without seriously negating the usefulness of the activity.

c) Mostly or Completely Appropriate - This is used if the lab activity seems appropriate in most or all respects with regard to timing, content, and procedures. In short, this would entail an activity that was very appropriate for the topic, was introduced at a reasonable point in the topic coverage, and involved procedures that students were already familiar with or were easily acquired.

Directions: Fill out one set of coding sheets for each lab activity that is assigned during the two topic observation periods. Whatever the source of the lab, make a copy of the assignment and staple it to the coding sheets. (If the lab assignment is only written up on the board, copy down what is on the board on a separate sheet of paper and then attach this.) Then complete the coding sheets, referring to the definitions of the dimensions already presented.

In some instances, there may be difficulty in determining what the unit of the lab activity is. For instance, the teacher may hand out a lab assignment, several pages long, that involves three separate experiments that will take a total of one week to complete. In this instance, you would treat each activity that requires one set of procedures -- i.e. each experiment -- as a separate lab and fill out three separate coding sheets.

TCHR ID: ____________

RATER ID: ____________

DATE: ____________

6. Laboratory Activity Dimensions

Laboratory Activity # ________ Circle One: Topic #1 Topic #2

Source of Laboratory Activity (circle one): Textbook Companion Lab book

Other Commercial Source Teacher Made Other (explain: ____________)

Attached copy of laboratory activity _____ Yes _____ No (explain ____________)

General Description of Laboratory Activity:

Type of Activity (check one):

_____ Methodological

_____ Observational/Exploratory

_____ Fact Gathering/Hypothesis Testing

Level of Discovery (check one):

_____ 0 - Problems, methods, and answers given

_____ 1 - Problems and methods given; answers opens

_____ 2 - Problems given; methods and answers open

_____ 3 - Problems, methods, and answers open

(continued)

Topic Appropriateness (check one):

_____ Mostly or completely inappropriate

_____ Partly inappropriate

_____ Mostly or completely appropriate

Comments:

7. Orientations and Levels of Worksheets

This analysis examines all worksheets assigned during the two topic observation periods. Often, these worksheets comprise the bulk of work products that students complete for a class; thus, they deserve careful attention as indicators of the learning demands placed on students. In this analysis, you are asked to consider three aspects of worksheet problems: 1) Mode of Response Required; 2) Problem Level; and 3) Science Orientation. The concepts behind these aspects have already been introduced. A brief summary of these aspects appears below:

Mode of Response Required

This refers to the same set of categories used in coding the chapter review questions (pp. 23-26). As you may recall, the modes of response are broken into four main categories -- verbal restricted, verbal extended, numerical calculations, and figural -- with further subdivisions under the first two categories. Read page 23 for a more thorough review.

Problem Level

This aspect attempts to capture the cognitive requirements of each problem. Here, your knowledge of the class context is vital, for it is problematic to judge cognitive requirements without a sense of available resources and the history of students' previous exposure to the topic. For purposes of this analysis, we will use three broad categories of "textually explicit," "textually implicit," and "scriptally implicit" that, again, were used in the coding of chapter review questions (see p. 24). In the case of worksheets, however, the "text" is no longer the only reference point; instead, you need to consider all the given sources of academic information for students (e.g., teacher lectures, filmstrips, teacher handouts). Thus, Problem Level 1, or "textually explicit," refers to problems that call for answers that can be pulled directly from information the student has been given. Problem Level 2, "textually implicit," refers to problems where the answers are implicit in the given information, and thus can be derived by way of inference. Problem Level 3, "scriptally implicit," refers to problems where the student would have to go beyond the given information (e.g., using prior knowledge, general reasoning or other available resources) to obtain a good answer. If a problem entails operations at more than one of these levels, the higher problem level takes precedence and should be coded.

Science Orientation

For this third apsect, we are interested in the scientific literacy areas of explaining and relating that each problem refers to. Here, it is possible that a problem will refer to just one area of scientific literacy or that it will refer to a linkage between two different areas of scientific literacy. As defined in the second analysis in this packet (see pp. 4-5), there is one area of explaining: explaining science content. Next, there are six areas of science relating: science skills/processes, science and society, history of science, personal use, science-related attitudes, and career opportunities. Problems that demand science content with no linkage are most common. Thus, there is a separate column allocated for this on the coding sheet. For any problem falling into this category, you place a hatchmark under this column. All other areas and linkages between areas can be indicated under the "Other" column using the following numbering system:

1 - Science content
2 - Science skills/processes
3 - Science and society
4 - History of science
5 - Personal use
6 - Science-related attitudes
7 - Career opportunities

For example, if one problem refers to science and society, then you would place "3" under the "Other" column. If another question entails a link between science content and science skills/processes, then you would indicate a "1 - 2" under the "Other" column.

Directions: Fill out one set of coding sheets for each separate worksheet that you collect. Fill out the basic descriptive information on the top of the coding form. Then take each problem on the worksheet and decide its mode of response required. Follow the appropriate row across and place a hatchmark in the "Total Number" column. Then continue across the row and indicate the corresponding problem level and science orientation for that problem.

Deciding the correct problem unit may sometimes be difficult. Here, you are to follow the same guidelines given in the fifth analysis for chapter review questions (see p. 24). Here, each question or statement requiring a separate answer is treated as an individual problem, even if there are several questions listed under one worksheet item.

(NOTE: If a so-called "worksheet" calls for predominantly laboratory activities, then you should use the Laboratory Activity Dimensions analysis rather than this one.)

TCHR ID: ____________

RATER ID: ____________

DATE: ____________

7. Orientations and Levels of Worksheets

Worksheet # __________ Circle One: Topic #1 Topic #2

Source (circle one): Commercial Source (specify: ______________) Teacher Made

Other (explain: ______________________)

Attached copy of worksheet _____ Yes _____ No (explain ______________)

Type of Assignment (check all that apply): _____ in-class _____ homework

_____ new material _____ review

MODE OF RESPONSE REQUIRED BY WORKSHEET PROBLEMS	TOTAL NUMBER	PROBLEM LEVEL			SCIENCE ORIENTATION	
		1	2	3	Science Content/ No Link	Other (Please specify - see ke
1. Verbal Restrict						
A. Matching						
B. True/False						
C. Fill-in/Label						
D. Multiple Choice						
E. Short Answer (can be answered in one simple sentence)						
2. Verbal Extended						
A. Paragraph (requires at least two sentences)						
B. Essay/Report (requires at least two paragraphs)						
3. Numerical Calculations						
4. Figures (drawing or graphing)						
5. Other (please explain:) ______						

(continued)

Comments:

Key:

1 - Science content
2 - Science skills/processes
3 - Science and society
4 - History of science
5 - Personal use
6 - Science-related attitudes
7 - Career opportunities

8. Orientations and Levels of Tests and Quizzes

This analysis examines all tests and quizzes assigned during the two topic observation periods on the selected topics. These measures are important indicators of the learning demands placed on students. In this analysis, like the previous analysis, you are asked to consider three aspects of tests and quizzes: 1) Mode of Response Required; 2) Problem Level; and 3) Science Orientation. The concepts behind these aspects have already been introduced. A brief summary of these aspects appears below:

Mode of Response Required

This refers to the same set of categories used in coding the chapter review questions (pp. 23-26). As you may recall, the modes of response are broken into four main categories -- verbal restricted, verbal extended, numerical calculations, and figural -- with further subdivisions under the first two categories. Read page 23 for a more thorough review.

Problem Level

This aspect attempts to capture the cognitive requirements of each problem. Here, your knowledge of the class context is vital, for it is problematic to judge cognitive requirements without a sense of available resources and the history of students' previous exposure to the topic. For purposes of this analysis, we will use three broad categories of "textually explicit," "textually implicit," and "scriptally implicit" that, again, were used in the coding of chapter review questions (see p. 24). In the case of tests and quizzes, however, the "text" is no longer the only reference point; instead, you need to consider all the given sources of academic information for students (e.g., teacher lectures, filmstrips, teacher handouts). Thus, Problem Level 1, or "textually explicit," refers to problems that call for answers that can be pulled directly from information the student has been given. Problem Level 2, "textually implicit," refers to problems where the answers are implicit in the given information, and thus can be derived by way of inference. Problem Level 3, "scriptally implicit," refers to problems where the student would have to go beyond the given information (e.g., using prior knowledge, general reasoning or other available resources) to obtain a good answer. If a problem entails operations at more than one of these levels, the higher problem level takes precedence and should be coded.

Science Orientation

For this third apsect, we are interested in the scientific literacy areas of explaining and relating that each problem refers to. Here, it is possible that a problem will refer to just one area of scientific literacy or that it will refer to a linkage between two different areas of scientific literacy. As defined in the second analysis in this packet (see pp. 4-5), there is one area of explaining: explaining science content. Next, there are six areas of science relating: science skills/processes, science and society, history of science, personal use, science-related attitudes, and career opportunities. Problems that demand science content with no linkage are most common. Thus, there is a separate column allocated for this on the coding sheet. For any problem falling into this category, you place a hatchmark under this column. All other areas and linkages between areas can be indicated under the "Other" column using the following numbering system:

1 - Science content
2 - Science skills/processes
3 - Science and society
4 - History of science
5 - Personal use
6 - Science-related attitudes
7 - Career opportunities

For example, if one problem refers to science and society, then you would place "3" under the "Other" column. If another question entails a link between science content and science skills/processes, then you would indicate a "1 - 2" under the "Other" column.

Directions: Fill out one set of coding sheets for each separate test or quiz that you collect. Fill out the basic descriptive information on the top of the coding form. Then take each problem on the test or quiz and decide its mode of response required. Follow the appropriate row across and place a hatchmark in the "Total Number" column. Then continue across the row and indicate the corresponding problem level and science orientation for that problem.

Deciding the correct problem unit may sometimes be difficult. Here, you are to follow the same guidelines given in the fifth analysis for chapter review questions (see p. 24). Here, each question or statement requiring a separate answer is treated as an individual problem, even if there are several questions listed under one test or quiz item.

(NOTE: If a so-called "test" or "quiz" calls for predominantly laboratory activities, then you should use the Laboratory Activity Dimensions analysis rather than this one.)

TCHR ID: ____________

RATER ID: ____________

DATE: ____________

8. Orientations and Levels of Tests and Quizzes

Test or Quiz # ________ Circle One: Topic #1 Topic #2

Source (circle one): Commercial Source (specify: ____________) Teacher Made

Other (explain: ____________)

Attached copy of test/quiz ____ Yes ____ No (explain ____________)

Type of Assignment (check all that apply): ____ in-class ____ homework

____ new material ____ review

MODE OF RESPONSE REQUIRED BY TEST/QUIZ PROBLEMS	TOTAL NUMBER	PROBLEM LEVEL			SCIENCE ORIENTATION	
		1	2	3	Science Content/ No Link	Other (Please specify - see k
1. Verbal Restrict						
A. Matching						
B. True/False						
C. Fill-in/Label						
D. Multiple Choice						
E. Short Answer (can be answered in one simple sentence)						
2. Verbal Extended						
A. Paragraph (requires at least two sentences)						
B. Essay/Report (requires at least two paragraphs)						
3. Numerical Calculations						
4. Figures (drawing or graphing)						
5. Other (please explain:) ____						

(continued)

Comments:

Key:

1 - Science content
2 - Science skills/processes
3 - Science and society
4 - History of science
5 - Personal use
6 - Science-related attitudes
7 - Career opportunities

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SECTION FIVE: NARRATIVE RECORD

John Mergendoller and Alexis Mitman

Introduction

This section of the manual introduces the methodology of naturalistic observation and its utilization in the Intermediate Science Study. We cannot emphasize enough the importance of conducting observations according to the guidelines set out in this manual.

The Use of Naturalistic Observation in the Intermediate Science Study

Naturalistic observation is not a technique, but a collection of observation strategies applicable to different conceptual and empirical ends. These strategies can be used in both exploratory and confirmatory studies, but the nature of the strategy changes according to the goals of the study.

If the goal is to discover or illuminate uncharted territory, creativity is the key: one seeks to make the familiar strange, and see old realities in new ways. This allows the observer to identify and label aspects of a situation which have been heretofore overlooked or are poorly understood. Lundgren's (1972) discovery of "steering groups" is one example of exploratory research where the idiosyncratic attentions of the observer produced an important theoretical advance in the understanding of classrooms. In such research, novel and provocative description which captures events identified and selected by the observer take precedence over the consistent attention to the predetermined characteristics of a situation.

If the goals is to test hypotheses, consistency is the key. Bossert (1979), for example, used observational narratives in combination with other data to test hypotheses regarding the formation of friendship groups in classrooms characterized by different instructional formats. Obviously, when comparisons are made among classrooms, teachers or students, it is necessary that narrative descriptions are comparable in their attention to particular details. Without such comparability, it is impossible to aggregate individual events or classrooms into exemplary types or patterns, and examine relationships between classes of phenomena. With hypothesis testing as the goal, the priorities described above are reversed: the consistent documentation of predefined characteristics takes precedence over the creation of a new conceptual vocabulary.

The Intermediate Science Study sits in the middle of this exploratory/confirmatory continuum. On the one hand, it seeks to discover the techniques of individuals who teach their students to be scientifically literate, and create an innovative vocabulary capable of describing these techniques. In so doing, we hope to portray and contrast the classroom behaviors of both more effective and less effective teachers. On the other hand, the study will attempt to test several existing hypotheses regarding the development of scientific literacy. Consequently, some of the conceptual boundaries of the study are fixed, and data must be collected in a consistent fashion by all of the observers.

Data collectors are thus charged with a dual task: to describe creatively the features of unknown territory while providing complete information which can be used to test already developed hypotheses about this territory. The accomplishment of this task is not easy, and requires active concentration and application of the guidelines described below.

Consistency in Observation with Multiple Observers

The Intermediate Science Study will involve eight observers. Two potential problems immediately arise: (1) What if different observers focus on different aspects of the classroom? and (2) What if different observers focus on the same aspect of the classroom, but interpret it in different ways? These problems -- termed "observer bias" -- must be recognized and resolved to the best of our abilities.

If observers attend to different aspects of the classroom, then we receive a skewed notion of what really occurred. We might call this a "personal observation strategy," where observers select whatever is of most interest to them for examination. Some might focus on student behavior and leave us befuddled about the teacher's instruction. Others might give us thorough descriptions of teaching, but leave us wondering where all the students went. Still others might emphasize ways in which laboratory exercises were used in the pursuit of scientific literacy, but provide minimal information about how the teacher explained scientific concepts to the class. To ensure uniformity, it is crucial that all observers understand the observational priorities with regard to both the structure and content of behavior. These observational priorities are described later in this section, and provide a framework for consistent observation.

Even though all observers focus on the same classroom phenomena, their interpretation (and hence, depiction) of these events may vary. This would leave us with a study of observers rather than science instruction, and would be equally detrimental to the goals of this research. The resolution of this problem, like the personal observation strategy problem discussed above, requires the careful use of judgment.

Observers inevitably interpret what they see; being human, there is no way to completely preclude this tendency. Nor would we want to. Narrative descriptions which omitted all observers' judgments regarding tones of voice, facial expressions, nonverbal gestures, or classroom climate would not only make dull reading, they would neglect aspects of the classroom that only a flesh and blood observer can see.

The key here is to focus on the thorough documentation of behavior, and then use this as evidence for a separate interpretation.

Consider these two examples:

> Students were bored. The teacher was doing a lousy job, just as I've seen her do many times before. Those poor kids.

> The teacher continued to talk about the four chambers of the heart, stressing the reasons why scientists had changed the terminology from auricle to atrium. She spoke -- or rather read -- in a monotonic voice, hands holding her lecture notes, eyes always on the notes rather than the class. Sammy looked over at Bill and mimicked the teacher; both stifled laughs. Looking around the room, I would estimate that 1/2 the class was either looking out the window or had their heads down on the desk. The other 1/2 seemed to be playing tic-tac-toe or other paper and pencil games with their lab partners. Sue, always studious, was working math problems. (I was amazed by the lack of disruptive behavior by the students. The teacher was doing a poor job; students seemed uniformly bored.)

These examples hardly bear elaboration. The first presents unsupported judgments. We have to take the observer on his or her word. The second is equally judgmental, but is convincing as a result of the behavioral detail the observer presents. Moreover, in the second excerpt the observer has placed the behavioral details first, and then presented conclusions, observations, and interpretations. These subjective remarks are placed within parentheses to separate them from the behavioral record.

The organization of behavioral details followed by interpretations incased in parentheses is more than a stylistic convention. It is a constant reminder to separate reports of behavior from the interpretation of that behavior, and to give priority to nonevaluative portrayal. The use of parentheses signals the observer and the reader that interpretation is occurring. Both writer and reader are thus alerted that the worth of this interpretation rests on the strength of the supporting evidence just depicted.

The points made about the separation of behavioral detail from the interpretation of this detail suggest another central aspect of naturalistic observation: active concentration (rather than passive, sponge-like involvement) is required. Observers must constantly think about what they are doing; they must not be lulled by the familiarity of the classroom, or seduced by an interesting lecture. Because we know classrooms so well, it is difficult to avoid taking things for granted and neglecting to record details which strike one as obvious (e.g., everyone would know that). It is just this familiarity which makes it very difficult to be an active observer.

For an observer to produce rich, usable accounts of classroom life, however, s/he must remain an active and slightly distant observer of a scene, conscious of what s/he is doing, aware of choices being made and the reasons for making them. This pertains to both the content of the information being captured as well as the meaning(s) the observer attributes to this information. Active concentration is necessary if the observer is to guard against the dual pitfalls of random observation and unsupported generalization.

The Structure of Classroom Behavior: Interactions, Episodes, Segments, and Activities

When looking at science lessons, it is important to be aware of the structure of behavior as well as the content around which it occurs. Later, we will discuss the observational priorities to guide observers' selection of the "content" to be recorded. Here, we are concerned with depicting a conceptual "structure" of interaction assumed to underlie all classroom behavior, regardless of the content of the lesson, the activities in which students are engaged, or the number or status of the actors.

We assume that classroom behavior may be conceptualized according to a number of structural units. These units define both the spontaneous, informal interactions found in all human behavior, as well as the more formal, curriculum-driven activities which characterize life in science classrooms.

At its most basic level, classroom behavior consists of a recognizable series of interactions between individuals and the environment. These interactions may involve teachers and students, students and students, students and materials, or teachers and materials. The important point here is that every interaction has two sides, and observers must describe the contribution of both sides if we are to understand what is occurring.

Consider a teacher lecture about cell structure. Although the teacher is doing all of the talking, s/he is talking to students. Given the interactional stance taken here, students' responses to this lecture are an integral part of this lecture. An observer must not ony capture the way the teacher explained cell structure, s/he would note the reactions (both verbal and nonverbal) of the students. In watching the classroom, the observer would shift attention from the teacher to students, describing one, then describing the other.

In a discussion, the same general rule also holds. Observers should assume that a discussion is built around the interactions of individual talkers as they take conversational turns. We need to know who says what to whom, and how the person addressed responds. This conversational chain may have more than two links. For example, if Jane answers the teacher's question about cell division in protozoa and is spontaneously corrected by another student, who is then corrected by the teacher, we need to know the contribution of each participant to the discussion.

In a lab group, information regarding the structure of interaction is also crucial. When one student says that frogs are yucky, how and in what order do the other students respond? Who laughs? Who remains silent? Who begins the next topic of discussion? Who starts to dissect the frog?

Student-teacher, student-materials, teacher-materials and student-student interactions are the basic conceptual links in an interactional chain which extends from the beginning of class to the final bell. If we label the contributions of individual actors to these interactions using letters, a simplified schematic diagram of a classroom discussion might look like this:

A => B; B => A; A => B; B => C; C => A

The obligation of the observer is to focus on these individual contributions to classroom behavior and record them as fully and accurately as possible.

A spontaneous cluster of interactions, focusing on the same content, that seems to hang together and make sense as a whole constitutes an episode. Such clusters represent whirlpools in the flow of classroom interactions. Examples include a series of teacher questions on a single topic answered by different students, inappropriate student behavior and the teacher's response (or lack of response), veiled fits of giggling in lab groups or a single student's continuing attempts to get help from an unresponsive teacher. Whatever the content of an episode, it represents a spontaneous and coherent series of interactions only loosely associated with the formal demands of the curriculum. Although you are not required to make specific reference to episodes in your narratives, they provide a useful way to make sense of what is happening, and provide another frame to help you organize your observations.

To this point we have been discussing structural units assumed to underlie all classroom behavior regardless of content. Thinking in terms of interactions and episodes will help you to capture the spontaneity of classroom behavior. Although classroom behavior is characterized in large part by spontaneous interaction, it is also driven by the requirements of the formal curriculum. The final two units focus on the structure of the lesson established by the teacher or the materials that define a context for the occurrence of interactions and episodes. These two units are the activity and the activity segment.

Class periods generally consist of several activities during which students engage in qualitatively different behavior. Roll call is often followed by passing in homework, which is followed by a short introductory teacher lecture, followed by seatwork or labwork, followed by dismissal. In our terminology, all of these are activities. Some of these activities may be subdivided into activity segments. Labwork, for example, may consist of gathering materials, setting up the experiment, recording data, carrying out calculations, comparing these calculations with friends', and writing up the results. Other classroom actitivies like seatwork or silent reading do not require qualitatively different behaviors, and thus there are no activity segments.

Observers must record the time each activity or activity segment begins and ends, the general nature of student and teacher behavior, any materials usage, the grouping arrangement, (e.g., whole group, multiple groups, individualized) chosen or allowed by the teacher and should multiple groups be used, the way membership in these groups was established (chosen by teacher, self-chosen by students, random assignment by teacher). This information is essential because it allows us to summarize the social features of science activities and understand and explore the social (in addition to the cognitive and attitudinal) outcomes of science instruction.

Framework for Narrative Record

The framework is organized into two parts (see Table 5.1). Part One refers to some specific ways of teaching science. Part Two refers to the general task features of the class. Looking for the behaviors described under Part One takes precedence over the features described under Part Two. However, since some of the Part One behaviors may occur with low frequency, you should rarely encounter difficulties in thoroughly capturing what is asked for under Parts One and Two.

It is important to emphasize that you are not being asked to organize your narrative according to the framework; rather, the framework is here to help you understand and internalize the kinds of things that are important to capture. The narrative itself should reflect the natural flow of events during class. Sometimes, for example, one statement by the teacher may contain several elements of interest from the outline below; in this case, it is sufficient to record accurately what the statement was.

Part One: Specific Ways of Teaching Science

It is helpful to think of the teaching of science as taking one of two forms: explaining or relating. As defined below, explaining and relating can occur as fairly discrete behaviors or simultaneously as part of one behavior (e.g., part of one teacher statement).

You should have a notion of the "ideal" ways in which a teacher could explain or relate a topic from what you have read about scientific literacy. Of course, it is unlikely that most teachers will meet this ideal. It is even possible that you will encounter many bad examples of trying to explain and relate a topic. Thus, you should anticipate the possible range in quality of explaining and relating and capture in your narratives any attempts by the teacher to explain or relate--whether well done or poorly done.

A. Explaining Orientation. Explaining refers to teacher presentations of the topic content. There are several ways in which a teacher can attempt to communicate content--e.g., by short statements, by longer discourse, by questioning students, by reading out-loud, by writing things on the board, and even by a demonstration. What is important is that regardless of the instructional method used, the teacher is trying to communicate facts and concepts that are fundamental to the understanding of the topic.

It is important to distinguish explaining topic content from explaining procedures. Teachers explain procedures when they tell students the things they must do to get ready to process information (e.g., pass out papers, open up books, check out the contents of their dissecting kits, etc.). While you should summarize the nature of these procedural explanations in your narrative, it is not necessary

Table 5.1

Framework for Narrative Record

PART I. SPECIFIC WAYS OF TEACHING SCIENCE

A. Explaining Content - the topic knowledge the teacher presents and the way in which it is presented

B. Relating Content - when a teacher takes scientific facts and concepts and relates them to any of the following:

1. science as a social historical process -- the historical development of ideas and the contributions of individuals

2. science as a reasoning process -- includes science as a way of thinking, examining "how we know," hypothesis formation, observation, measurement, inductive-deductive reasoning, the notion that ideas evolve and change.

3. science and society-technology -- problems that society faces in the past, present, and future, and applications of science to everyday living.

4. positive attitudes towards science -- students' and other people's feelings about the value of science.

PART II. TASK GENERAL

A. Teacher's Directions for Assignments

B. Resources Made Available to Students

C. Statements about Grading Policies and Accountability for Work

D. Cognitive Orientation of Assignments

E. Students' Engagement in Work

to record them in detail. In contrast, we ask that you capture content explanations in as much detail as possible. Although you will probably be forced to use a combination of verbatim, paraphrase, and summary notes (the exact mixture will depend on how quickly events occur), the ideal is to maximize verbatim accounts while minimizing summarization.

Below are several examples of narratives that capture explaining content:

Example 1:

Teacher: DON'T FORGET THE EARTHWORM--HE'S NOT A VERY DEVELOPED CRITTER. HE'S NOT EXACTLY WHAT YOU WOULD CALL ONE OF YOUR HIGHER ORGANISMS ON THE LADDER OF LIFE. WHO SITS AT THE TOP OF THAT, BY THE WAY? YOU'VE HEARD. YOU'RE LOOKING AT US. WE, AND THE OTHER ANIMALS LIKE US, ARE THE MOST COMPLEX. O.K. WHAT'S THE SIMPLEST FORM OF ANIMAL LIFE? IF YOU START AT THE TOP WITH US AND FORMS LIKE US AND MOVE DOWN THROUGH THE DIFFERENT LEVELS, WHAT WOULD YOU FIND AT THE BOTTOM? THE ONE-CELLED ANIMALS, EH? BUT WHETHER YOU HAVE ONE CELL, OR WHETHER YOU HAVE MILLIONS OF CELLS, YOU STILL NEED FOOD. YOU STILL NEED TO GET RID OF WASTE MATERIALS. YOU STILL NEED TO SOMEHOW DIGEST THAT FOOD...

Example 2:

Student: I'M TRYING TO FIND THE FUNCTION OF THE TRACHEA, OR WHATEVER IT'S CALLED.

Teacher: THE TRACHEA?

Student: YEAH.

Teacher: NOW, WHERE IS IT, TO START OFF WITH?

Student: WINDPIPE?

Teacher: WINDPIPE, RIGHT.

Student: IT'S THE SAME THING

Teacher: YUP, THE SAME THING...REMEMBER, IT'S THE WINDPIPE AND IT GOES FROM THE BACK OF THE THROAT TO WHERE IT BREAKS OUT INTO THE TWO BRONCHIAL TUBES...REMEMBER YESTERDAY YOU WERE LOOKING AT TRACHEA TUBES FROM THE GRASSHOPPER?

Student: OH YEAH.

Teacher: THEY CONNECTED THE SPHERICALS TO THE INNER SACS. IT'S JUST THE PIPING. YOU GET THE AIR COMING FROM THE OUTSIDE TO THE ORGAN OF BREATHING...

Example 3:

He wrote the notes on the overhead projector as the students copied them into their books. The notes contained the scientific knowledge the students were to know, as illustrated by the first sentence--

> "The basic unicelluar organism contains all the same cell structures that the basic specialized animal or plant cell contains (nucleus, mitochondria, golgi bodies, endoplasmic reticulum, etc.)."

B. Relating Orientation. Relating refers to using the content of a topic to demonstrate one of the following goals of scientific literacy:

1) Science as a social historical process

2) Science as a reasoning process

3) Science and society-technology

4) Positive attidues toward science

Definitions and examples of each of these relating areas follow.

B1. Relating to Science as a Social Historical Process. This takes place when a teacher attempts to communicate the historical context of some scientific knowledge or process. This context can be portrayed in specific or general terms. In specific terms, the teacher would refer to particular individuals in history and their contributions--e.g., Mendel's work in genetics, Salk's development of the polio vaccine, Fleming's discovery of penicillin, Watson and Crick's determination of the structure of DNA, etc. In general terms, the teacher would refer to scientists or other people, without mentioning specific individuals.

In order to judge the quality of the teacher's relating of content to historical process, you should focus on whether there is a convincing point being made. Simply listing a bunch of historical names, dates, and events does not mean a high quality "relating." Instead, higher quality "relating" takes place when the teacher uses the historical context to demonstrate points such as: people's conceptions of phenomena have changed over time, some discoveries were made by accident, ruling out alternative hypotheses is a laborious process, some theories have challenged the social order of the times, etc.

Below are two narrative examples of relating content to science as a social historical process:

Example 1:

Teacher: YOU WERE SUPPOSED TO READ CHAPTER 8 FOR TODAY. O.K. I'VE GOT SOME QUESTIONS. WHO WAS THE FIRST PERSON THEY TALK ABOUT WHO DID AN EXPERIMENT WITH A PLANT? GEORGE?

George: DON'T KNOW.

Sally(calls out): VAN HELMONT.

Teacher: O.K. WHAT DID VAN HELMONT DO FOR HIS EXPERIMENT?

Sally: PLANTED A TREE IN A TUB.

Teacher: YES--AND WHAT ELSE DID HE DO WITH THIS TREE? HE WATERED IT, RIGHT? AND WHAT HAPPENED TO THIS TREE? MARK?

Mark: IT GREW BIG.

Teacher: ALRIGHT. SO THE TREE GREW BIG. THE BOOK SAYS THE TREE GREW FROM 5 POUNDS TO 200 POUNDS. SO, WHAT DOES THIS MEAN? WHAT WAS VAN HELMONT TRYING TO FIND OUT?

Sally: HOW TREES GROW...HOW THEY GET LARGE.

Teacher: O.K. HOW TREES GROW. WELL, WHAT IDEAS DO YOU THINK VAN HELMONT HAD ABOUT THAT? WHAT COULD BE THE EXPLANATIONS FOR WHY A TREE GETS LARGE? WHAT DO YOU THINK MOST PEOPLE BACK THEN BELIEVED WAS THE REASON THAT TREES GREW?...

Example 2:

Teacher: I WANT TO REVIEW SOME OF THE THINGS YOU SHOULD KNOW FOR THE TEST TOMORROW. THE TEST IS GOING TO BE ON DISEASES AND WHAT CAUSES THEM. I EXPECT YOU TO BE ABLE TO TELL ME WHAT A BACTERIA IS AND WHAT A VIRUS IS. ALSO, WE TALKED SOME ABOUT THE HISTORY OF DISEASE THEORY--HOW BACK IN THE OLD DAYS, PEOPLE USED TO THINK DISEASES WERE CAUSED BY EVIL SPIRITS AND BAD AIR. YOU SHOULD BE ABLE TO EXPLAIN WHY PEOPLE THOUGHT THIS. ALSO, YOU SHOULD KNOW SOME OF THE IMPORTANT SCIENTISTS WHO DID WORK THAT CHANGED PEOPLE'S IDEAS ABOUT WHAT CAUSED DISEASES...

B2. Relating to Science as a Reasoning Process. A teacher is relating science content to the scientific reasoning process when he/she attempts to communicate how scientific knowledge is acquired. This would include talking about observing natural events, formulating and testing hypotheses and theories, deductive and inductive reasoning, concepts of randomness and probability, and the tools and methods of measurement

A teacher's "relating" of the scientific reasoning process can be done very poorly or very well. A poor job would entail presenting misguided notions of what scientific process is or listing "steps" in a process without giving the underlying rationale. A good job would entail some illustration of the general point that scientific knowledge is not accumulated in an accidental or arbitrary fashion, but instead is accumulated through a set of agreed upon standards that have a logical foundation.

Below are examples of relating to science as a reasoning process:

Example 1:

Student (to teacher): PLEASE COME HERE. NOTHING HAPPENED WITH OUR EGG WHITE.

Teacher: REPORT WHAT YOU FOUND. BUT IT DOES SEEM A LITTLE STRANGE. COMPARE IT WITH YOU NEIGHBOR'S. IN YOUR CONCLUSIONS SPECULATE A LITTLE BIT. REPORT WHAT YOU FOUND, BUT SAY IT IS DIFFERENT FROM YOUR NEIGHBOR'S AND THAT IT IS A LITTLE STRANGE BECAUSE EGG WHITE IS PROTEIN. YOU CAN INDICATE THAT MAYBE YOUR METHOD GOT FOULED UP.

Example 2:

Teacher: WE KNOW THAT ALL BACTERIA ARE NOT HARMFUL, BUT IT ISN'T ENOUGH JUST TO SAY THAT. YOU'VE GOT TO CONVINCE ME THAT YOU KNOW WHAT YOU ARE TALKING ABOUT. WHEN I ASKED YOU THE QUESTION, SOME OF YOU SAID, "NO-OH." I KNOW FROM HOW UNCERTAIN YOU SOUNDED THAT YOU DON'T KNOW WHAT YOU ARE TALKING ABOUT.

NOW SOME BACTERIA ARE HARMFUL. CAN YOU TELL ME ABOUT SOME OF THOSE?

Students: (make several suggestions, including scarlet fever)

Teacher: I DON'T JUST NEED THE ANSWER. I NEED THE SOURCE OF YOUR INFORMATION. YOU KNEW THE ANSWER BUT YOU DIDN'T KNOW THE PAGE NUMBER. THIS IS WHAT WE REFER TO AS BEING SCIENTIFIC. YOU MUST KNOW THE SOURCE OF THE INFORMATION.

Example 3:

Teacher: WHAT IS THE TECHNICAL METHOD? I'M ASKING YOU RIGHT NOW.

Student: THERE'S AN OUTLINE TO FOLLOW, AND YOU RECORD THE OBSERVATIONS AND REPORT TO SOMEONE ELSE.

Teacher: THE RESEARCH METHOD?

Student: DEFINE THE PROBLEM

Student: COLLECT INFORMATION.

Student: MAKE AN HYPOTHESIS

Student: THEN EXPERIMENT.

Student: RECORD YOUR FINDINGS.

Teacher: BUT, BEFORE YOU RECORD...

Student: ORGANIZE YOUR OBSERVATIONS.

Teacher: IN TABLES AND GRAPHS...

Student: DRAW CONCLUSIONS.

Teacher: FINALLY...

Student: PREPARE A REPORT.

Teacher: WHEN PEOPLE REPEAT THE EXPERIMENT, THEN THE HYPOTHESIS MAY BECOME A THEORY...OK, THE PURPOSE OF A CONTROL IN AN EXPERIMENT--LOTS OF TIMES WE LEAVE THIS OUT BECAUSE WE FOLLOW THE TECHNICAL METHOD.

Student: SO AN EXPERIMENT HAS ONLY ONE VARIABLE.

Teacher: YES, CONTROL EVERYTHING BUT LEAVE OUT ONE FACTOR. FOR EXAMPLE, IN PHOTOSYNTHESIS, GIVE TWO PLANTS ALL THE SAME CONDITIONS, BUT LEAVE ONE IN THE LIGHT AND THE OTHER IN A CLOSET...

B3. Relating Science and Society/Technology. This area of relating refers to a teacher communicating how specific areas of scientific knowledge have implications for society or for technology. Often, there is a direct link between a technological product (e.g., a new drug, a new fertilizer) and its societal consequences (longer life spans, more productive farming).

The teacher who does a good job of relating in this area will go beyond a cursory mention of some connection and really encourage students to consider how specific scientific knowledge has either affected people in the past or will affect them in the future. Furthermore, it often will be most ideal for a teacher to present at least two points of view (e.g., the advantages and disadvantages of pesticides). In short, a teacher who does a good job of relating in this area will model parts of a decision-making process that students can apply in their own lives as they consider their use of science-based technologies.

Three examples of relating science to society/technology follow:

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Example 1:

Teacher: O.K. YESTERDAY WE TALKED ABOUT THE DIFFERENCE BETWEEN NATURAL SELECTION AND ARTIFICIAL SELECTION. REMEMBER THAT ARTIFICIAL SELECTION IS WHAT PEOPLE USE IN AGRICULTURE--TO BREED BETTER ANIMALS AND PLANTS. CAN SOMEBODY GIVE ME SOME EXAMPLES OF THINGS THAT ARE THE RESULT OF ARTIFICIAL SELECTION--THINGS THAT WE DEAL WITH EVERY DAY?

Student: COWS--PEOPLE BREED COWS.

Teacher: YES, AND WHAT ARE THEY TRYING TO IMPROVE IN THE COWS?

Student: UM....THE MILK OR MEAT.

Teacher: HOW ABOUT ANOTHER EXAMPLE? (pause) HOW ABOUT SOME OF THE PLANTS WE EAT?

Student: I KNOW. GRAPES--GRAPES THAT DON'T HAVE SEEDS.

Teacher: GOOD EXAMPLE. SO, IN GENERAL, WHAT WOULD YOU SAY ARE SOME OF THE ADVANTAGES OF ARTIFICIAL SELECTION FOR ALL OF US? WHY ARE WE BETTER OFF WITH IT THAN WITHOUT IT?

Student: BECAUSE THINGS GROW BIGGER, SO THERE'S MORE OF IT.

Teacher: YES. THAT'S ONE ADVANTAGE--GETTING GREATER YIELDS OF FOOD. ANYTHING ELSE? (pause) WELL, YOU SHOULD ALSO THINK ABOUT THE HEALTH OF THINGS. FOR INSTANCE, ANIMALS ARE BRED TO BE STRONGER, AND PLANTS ARE BRED SO THAT THEY RESIST DISEASE AND LAST LONGER. NOW, CAN ANYONE THINK OF SOME DISADVANTAGES OF ARTIFICIAL SELECTION?

Student: YEA--IT'S A LOT OF WORK.

Teacher: ALRIGHT. THAT'S ONE THING--IT IS EXPENSIVE BOTH IN TERMS OF MONEY AND TIME. ANY OTHER IDEAS?...

Example 2:

The teacher spent the first 10 minutes of the period discussing the chapter section on "Drugs and Your Body." The teacher first mentioned drugs used to fight disease, specifically antibiotics. The teacher did not define antibiotics, but just gave penicillin as an example of "a drug that fights infection." One student then raised her hand and asked if aspirin was an antibiotic. The teacher replied that it wasn't, but that it was a drug used to relieve pain. The teacher then picked up on the topic of aspirin and said it was a drug that there was some debate about--that it was a common drug that has given relief to millions of people over the years, but that now it is known that aspirin may cause some problems too. The teacher asked students if they ever took aspirin and for what reasons..

Example 3:

Teacher: IN THE FILM YESTERDAY, THE LAST THING THEY TALKED ABOUT WAS SPACE STATIONS OF THE FUTURE. THEY WOULD BE PLACES WHERE PEOPLE COULD LIVE FOR LONG PERIODS OF TIME. SO, WHAT WOULD THESE STATIONS HAVE TO BE LIKE FOR THAT TO WORK?

Student: THEY'D HAVE TO BE LIKE HERE ON EARTH.

Teacher: O.K. LIKE EARTH. BUT WHAT IS IT ABOUT EARTH THAT THEY WOULD HAVE TO IMITATE? THINK ABOUT ALL THE THINGS WE LEARNED ABOUT EARTH'S ECOSYSTEM.

Student: THERE WOULD HAVE TO BE THE SAME AIR, AND SOIL, AND PLANTS...

Teacher: ALRIGHT. THEY WOULD NEED TO HAVE THE SAME ATMOSPHERE, AND THERE WOULD NEED TO BE SOIL AND PLANTS IN ORDER TO GROW FOOD. IF THERE WERE PLANTS, WHAT KIND OF CYCLE WOULD HAPPEN?

Student: THE WATER CYCLE...

Teacher: WELL, THAT WASN'T WHAT I WAS THINKING OF, BUT THE WATER CYCLE IS ALSO IMPORTANT...

B4. Positive Attidues Toward Science. This area of relating refers to a teacher's attempt to deal with the individual or collective affective reactions people have towards science as a discipline and specific science knowledge, concepts, and applications. This probably will take place most commonly in the context of a class discussion.

The teacher who does a good job of relating in this area will try to foster well-founded positive attitudes and curiosity toward science. The teacher may also model his or her own positive attitude toward science as a discipline.

Following are two examples of relating to science attitudes:

Example 1:

The teacher is going over the worksheet on human reproduction with her students. She gets to the next to the last question, which asks for the distinction between identical and fraternal twins. A student responds with the right answer. Then another student calls out, "What about 'test-tube' babies?" The teacher asks that student to explain what a "test-tube" baby is; the student gives a jumbled answer suggesting the misconception that the baby "grows up" in a test tube. The teacher provides the correct definition. She then asks the class how they feel about the idea of a "test tube" baby. Several students raise their hands. One student says it seems unnatural and scary. Another student says it might turn out to be bad because scientists could take control. A third student says it might be a good thing because there are lots of people who can't have babies and this might be the only way...

Example 2:

Teacher: ALRIGHT. WE'VE JUST ABOUT TIED UP OUR UNIT ON PLANTS. NOW, IN THE BOOK, THERE ARE SEVERAL EXAMPLES OF CAREERS THAT INVOLVE WORKING WITH PLANTS. LET'S SEE -- ON PAGE 241 WE SEE PEOPLE WHO ARE FLORISTS, AND ON PAGE 261 THERE ARE PEOPLE WHO LUMBER, AND ON PAGE 281 THEY TALK ABOUT PEOPLE WHO HYBRIDIZE PLANTS. ARE THERE ANY OF THESE JOBS YOU MIGHT LIKE TO DO?

Student: I'D THINK WORKING WITH LUMBER WOULD BE NEAT.

Teacher: OK. WHAT ABOUT IT WOULD BE NEAT?

Student: WELL -- GETTING TO BE OUTDOORS AND GETTING A LOT OF EXERCISE.

Teacher: O.K. WHAT DO THE REST OF YOU FEEL?

Student: I'D LIKE TO BE A FLORIST...

Part Two: Task General

As indicated in Table 5.1, the next set of observational priorities have to do with capturing the features of classroom academic tasks. These features are not specific to science; however, since you will be observing science classes, all of the academic tasks you see ostensibly will be related to science.

Our notion of academic tasks is taken from Doyle (1983). Doyle defines tasks as something for which there is an observable work product. This clearly includes anything where students must mark answers, draw, or write; also, in science, we broaden this to include laboratory experiences and exercises where there may or may not be an immediate, tangible work product that results.

It is important to clarify where teacher recitation and question-and-answer sessions fit in with the concept of academic tasks. On the one hand, these activities may not seem especially relevant to academic tasks since an immediate work product is rarely required. On the other hand, recitation and question-and-answer can be viewed as an opportunity to practice content, and thus, as a resource for doing tasks. Further, it often is difficult to determine ahead of time how a teacher will use these activities; it is always possible that these activities may be leading up to a work product. Here, we want you to adopt the latter view: that teacher recitation and question-and-answer sessions are important for the complete understanding of academic tasks and, thus, need to be captured as resources for tasks. Of course, under Part One of the framework, we already have asked you to pay particular attention to recitation and question-and-answer activities as vehicles for explaining and relating science content. Here, we suggest that these activities also have significance from the standpoint of resources for academic tasks.

The five general task features that we ask you to focus on are defined below. By capturing these features, you will be giving us a well-rounded portrait of what the tasks observed in your classroom(s) were like.

A. Teacher's Directions for Assignments. Here, you are asked to capture the formal statements a teacher makes about what the task is and how to do the task. The teacher may communicate this orally, by written information (e.g., on the board or on a worksheet), or by both. You should copy down the form of any communication, or in the case of directions that are handed out on worksheets, collect a copy of the worksheet. If the directions appear in a published workbook or text, copying down the assigned page numbers is sufficient.

It is important to realize that directions for one task often evolve as the result of interactions with students and also may change over time. For example, students often ask questions or make comments during class discussion or seatwork that result in the teacher making more explicit the directions for the task. A teacher also may give more directions in response to viewing students' work. Some of the changes and additions to directions can occur over a relatively long time frame. For example, a teacher might first indicate that a final unit report is due in five days. Upon seeing initial efforts of students, the teacher might change the directions on the second day by saying a draft of the report is due in four days, with the final being due in eight days. The date for the final might even be further postponed after the teacher reads the drafts. In a case like this, it is critical to capture exactly both the nature and timing of the changes. "In essence you want to be able to describe the requirements for a task as these were announced to students during the course of working on a task. A useful frame of mind is to imagine that you are a student in the class and ask yourself whether you know what to do and how to get it done" (Doyle, Sanford, & Emmer, 1982).

B. Resources Made Available to Students. This aspect of academic tasks refers to capturing any and all resources students have available to help them complete a task. A number of things can serve as resources, including: (a) textbooks or other curricular materials; (b) posters or chalkboard messages; (c) notes taken previously; (d) tasks completed previously; (e) models of finished products; (e) the work or comments of other students; (f) the presentation of "correct" answers, if students can still change their answers before they hand the product in; and (g) verbal hints, clues, or prompts given by the teacher spontaneously or in response to helping individuals and seeing students' work.

It is important to note that resources may not be equally available to all students. For example, the teacher may give helpful hints to some students, and other students may not be able to hear these hints. Also, it is likely that the available resources will not be equally used by all students--e.g., with some students prefering to get help from their neighbors while others are content to rely on a text. In sum, it is important for you to capture what is actually available, who it is available for, and if it is used.

C. Statements about Grading Policies and Accoutability for Work. For this aspect of tasks, we ask you to capture the teacher's formal and informal statements about what is most important about the task (i.e., what he/she is "looking for"), how the task will be graded, how much weight the grade for this task will have in determining the term grade, and whether extra credit is available in doing the task.

D. Cognitive Orientation of Assignments. This aspect refers to the kind of general cognitive operations necessary for carrying out a task. While other researchers have developed category systems for levels of cognitive demandingness (e.g., Bloom's taxonomy of educational objectives), it seems most appropriate to use a category system that is closer to the language of cognitive operations. Doyle's (1983) four categories are appropriate for this purpose. These categories are defined as follows:

"1. memory tasks in which students are expected to recognize or reproduce information previously encountered (e.g., memorize a list of spelling words or lines from a poem);

2. procedural or routine tasks in which students are expected to apply a standardized and predictable formula or algorithm to generate answers (e.g., solve a set of subtraction problems) [in short, students will be carrying out a procedure that has become automatic through repeated practice];

3. comprehension or understanding tasks in which students are expected to (a) recognize transformed or paraphrased versions of information previously encountered, (b) apply procedures to new problems or decide from among several procedures those which are applicable to a particular problem (e.g., solve "word problems" in mathematics), or (c) draw inferences from previously encountered information or procedures (e.g., make predictions about a chemical reaction or devise an alternative formula for squaring a number);

4. opinion tasks in which students are expected to state a preference for something (e.g., select a favorite short story)" (Doyle, 1983, pp. 162-163). In addition, it is important that the task require students to state a rationale for their preference.

For every task observed, then, you are asked to judge which one of these categories best describes the operations students will have to use to complete the task. Of course, it is likely that some tasks will entail more than one of these categories of operations. If so, all appropriate categories should be indicated.

E. Students' Engagement in Work. Here, we are asking you to focus on what students actually do during the class time that they are supposed to be carrying out a task. Because you will not be able to look over every students' shoulder, we ask that you make a rough estimate. It is helpful to think of engagement in terms of three broad categories: (1) students appear to be engaged in the assigned task; (2) students appear not to be engaged because they are doing nonacademic procedural activities or waiting for the teacher; and (3) students appear not to be engaged because they elect not to be (i.e., are "goofing off"). In your description of each activity during class, estimate approximately what percentage of students fall under each category in terms of their predominate behavior. Thus, the percentages for the three engagement categories should add up to 100%.

HOW TO CREATE THE NARRATIVE

So far, you have read about the art of naturalistic observation and the framework you should use to focus your observations. Now, we will turn to a brief discussion of how to actually create the narrative record.

In this study, it is important to intrude as little as possible when you visit a classroom. For this reason, you will not be using any audio or visual equipment, but instead will be expected to create the narrative in two steps:

STEP 1) Take handwritten notes during class

STEP 2) Immediately after class, read your notes and then audio-record a complete narrative of what took place.

As indicated earlier, your notes should be a combination of verbatim, paraphrase, and summary. The section below on shorthand provides hints on how you can record the notes as efficiently as possible.

When you turn to recording your narrative, review not only your notes; but also the narrative record framework. In short, be certain you address all the variables of interest, even if it is to say that you never saw certain things occur.

After you record your narrative, you will be responsible for giving the tape to a designated typist within 24 hours. The typist, in turn, will try to have ready a transcription of your tape within the next 24 hours. You should pick up this transcript as soon as it is ready and <u>read it immediately</u>. Mark on it any corrections that are necessary, complete the summary information form described below, and jot down your own notes on any patterns or themes you see.

The Use of Shorthand

Observers' ability to capture classroom behavior is greatly increased through the use of shorthand abbreviations. It is thus imperative to develop your own system of notation. Typical abbreviations might include:

Cl = students

T = teacher

|__| = blackboard

———> = looks at

━━━> = goes to

↑ = gets up

↓ = stoops down

! = disciplines

◡ = responds positively

∧ = responds negatively

w = whispers

⊙ = talks

" = direct quotation

Typical lines of notes might then appear:

T ⇒ ▭, T ⊙ cell structure, draws ▭ protozoa cells, Cl interested, Mike w Sue, T! Mike, T ⊙ "Protozoan cell division is no different than it is for us. In fact..."

Summarizing Narrations

Observers are responsible for recognizing and recording the nature and duration of the activity segments and activities which make up a lesson. After the observation period, observers will be asked to summarize some of the information from the narratives on the Narrative Record Summary Sheets. These summary sheets are divided into three parts. The first part is used to describe all of the activity segments you observed; the second part is used to record the nature of the tasks worked on during the observation; the third part summarizes the tasks handed in to the teacher during the observation. Each of these parts is to be completed independently. The categories of information requested on the Summary Sheets require elaboration to ensure consistency among the observers. We discuss each part of the sheets in turn.

Part 1: Activity Segment. Lessons are made up of one or more activity segments. Number segments sequentially within each observation. The name given to individual segments should be telegraphic and express a generic classroom activity (e.g., "Roll" "Concept Review," "Lab Procedure Review," "Lab Experiment," "Lecture," "Lecture-Recitation," "Seatwork," "Silent Reading," "Demonstration," etc.) The one-sentence description should indicate the academic content of the activity segment. (No further description is necessary if the activity segment was concerned solely with a procedural activity.) Typical descriptions might include: "The teacher lectured about mitosis." "Students completed the starch/sugar tests begun yesterday." "The demonstration of photosynthetic leaves was projected on the OH projector."

Be specific in recording the time information. Calculate to the nearest minute.

Then indicate any materials used by the teacher or students. If no materials were used, write none. Otherwise, describe both the form and the content of the teacher and student materials (e.g., chalkboard, 100 ml graduated cylinder, small vials of iodine and table sugar, 3 test tubes, cans of rice and oat flakes, medicine dropper, test tube rack).

Include the following information under grouping arrangements: (1) Number of groups, and (2) number of students in each group. A typical laboratory lesson might have 15 two-person groups; a typical recitation lesson is conducted in a single 30 person group. (Do not worry should there be minor exceptions to the overall grouping pattern. We are concerned with the usual grouping arrangements, not the idiosyncrasies of one or two students.)

Groups may be unisex or they may include a mix of boys and girls. At the same time, they may be homogeneous with respect to academic ability, or they may be heterogeneous and include members of differing abilities. Please record whether group membership is homogeneous or heterogeneous with regard to both gender and academic ability.

Students come to be in groups in a variety of ways. Please indicate the method by which group members are selected by recording whether: (1) students choose who they work with, (2) groups are formed on the basis of seating arrangements (which are ultimately established/accepted by the teacher), or (3) the teacher forms special groups for the activity segment.

Finally, please summarize the role of the teacher during the activity segment. Record whether the teacher was a "manager" during roll call, or "monitored student work" during a laboratory or seatwork assignment, or "ignored the class" during silent reading.

Part 2: Today's Tasks. This part asks you to list the tasks that students worked on during the class period. The definition of task is given on page 18 of this section. Briefly, a task is an activity for which there is an observable work product or an activity which is a laboratory experience or exercise. For each task, then, you are to briefly name the task (e.g., lab on focusing a microscope), the approximate length of time devoted to the task (e.g., 25 minutes), and the status of the task (e.g., whether it was handed in or will be continued tomorrow).

Part 3: Completed Task Summary. A Part 3 sheet is to be filled out every time a task is completed. Here, you provide basic descriptive information about the task -- its identity, the date handed in, the dates it was worked on, and the total time allocated to the task (if the task was worked on for two or more days, then estimate the total time added across days). Next, this sheet asks for you to summarize the task dimensions of Doyle (1983): teacher's directions, resources available to students, grading policies and accountability, cognitive orientation of task, and student engagement. You should reread pages 18-21 of this section to strengthen your understanding of these dimensions.

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ARRATIVE RECORD SUMMARY SHEET - Part 1: Activity Segment

TEACHER ID: ________ OBSERVER ID: ________ DATE: ________

Activity Segment # ____: (name and one-sentence description)

____

Time begun: ________ Time ended: ________ Elapsed Time: ________

Teacher materials: ________ Student materials: ________

GROUPING:

Whole Class ☐ Sub-groups ☐

Other: ________

Sub-group Membership:

	Heterogeneous	Homogeneous
gender:	☐	☐
ability:	☐	☐

Other: ________

Selection: ☐ by seating ☐ by teacher
☐ by students

Other: ________

COGNITIVE ORIENTATION:
(check all that apply)

Memory	
Procedure/Routine	
Comprehension	
Opinion	
Not applicable	

STUDENT ENGAGEMENT:

Engaged	%
Procedural/waiting	%
Nonengaged	%

TEACHER ROLE: ______________________________

Activity Segment # ____: (name and one-sentence description)

____

Time begun: ________ Time ended: ________ Elapsed Time: ________

Teacher materials: ________ Student materials: ________

GROUPING:

Whole Class ☐ Sub-groups ☐

Other: ________

Sub-group Membership:

	Heterogeneous	Homogeneous
gender:	☐	☐
ability:	☐	☐

Other: ________

Selection: ☐ by seating ☐ by teacher
☐ by students

Other: ________

COGNITIVE ORIENTATION:
(check all that apply)

Memory	
Procedure/Routine	
Comprehension	
Opinion	
Not applicable	

STUDENT ENGAGEMENT:

Engaged	%
Procedural/waiting	%
Nonengaged	%

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TEACHER ID: ____________

OBSERVER ID: ____________

DATE: ____________

NARRATIVE RECORD SUMMARY SHEET
Part 2: Today's Tasks

Today's Tasks: (one phrase description w/applicable dates & times -- e.g., vocabulary test from Chapter 4, handed in, 10 minutes):

1. ____

2. ____

3. ____

4. ____

5. ____

6. ____

7. ____

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TEACHER ID: ____________

OBSERVER ID: ____________

DATE: ____________

NARRATIVE RECORD SUMMARY SHEET
Part 3: Completed Task Summary

Summary of Any Completed Task (fill out only if task was finished today):

Task description: ____________________

Date handed in: ____________________

Dates task worked on: ____________________

Total time allocated to task across days: ____________________

Teacher's directions to whole class: (brief summary)

Resources available to students:

Grading policies and accountability:

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Cognitive orientation (check all that apply):

_____ Memory Task

_____ Comprehension or Understanding Task

_____ Procedural or Routine Task

_____ Opinion Task

Student engagement on task across days:

% students engaged _____

% students procedural or waiting _____

% students nonengaged _____

TOTAL 100%

NARRATIVE TIPS

1. Give the time at least once every 5 minutes. Always give the time at the beginning and the end of each activity segment.

2. Stay attuned to activity segments; focus on the beginning and endof segments and the transitions between segments.

3. Your interpretations are useful, and help us to make sense of what happened in the class. Remember, however, to:

   (a) Describe behavior before interpreting it;

   (b) Encase your interpretations in parentheses. Make sure the evidence on which the interpretation is based is included.

   (c) Present your interpretations both as you go along, and at the end of your dictation

4. Describe behaviors within the context in which they occur. This may be a lab group, a question asked by the teacher, or the interruption of class activities by an announcement over the squawk box.

5. Explicitly dictate quotation marks when you are recording a direct quote. Don't be afraid to paraphrase, but indicate same.

6. Label each tape you dictate. Don't reuse tapes. You can, if you want, use one side for one observation, and the reverse side for another.

7. If the teacher's behavior is repetitive (as in monitoring during laboratory activities), focus in on student-student interactions.

8. As a general rule, you should TAKE NOTES CONTINUOUSLY during the observation. There is always something to record.

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updated version

SECTION SIX: SCIENCE CLASS DESCRIPTION (SCD)

Alexis Mitman, Rose Giaconia and John Mergendoller

Overview

The Science Class Description (SCD) allows the observer to record summary judgments about several aspects of the period's activities, teacher's behavior, and students' behavior by using a number of higher-inference concepts. Higher-inference refers to the fact that the observer is called upon to make judgments (inferences) about different qualities of teachers and students based upon the total information he/she has collected while observing for a single period. This procedure contrasts with a lower-inference procedure that employs an observation instrument to count instances of discrete behavior (e.g., the exact number of times the teacher provided negative feedback to students' responses to questions.) Some of the items on the SCD ask you to indicate the number of minutes and percent of time spent on various science activities. Lower-inference procedures would involve recording the precise amount of time spent on each activity with a stopwatch. Instead, you will use higher-inference procedures that involve making subjective estimates of the proportions of time the teacher seemed to spend on each activity.

As you are observing the class for the Narrative Record, you should keep in mind that you will be asked to make judgments about each class period and record these inferences on the SCD. It is not the purpose of the SCD to capture discrete behaviors of teachers or students.

The Science Class Description should be completed immediately after the period of observation in a class, so that many of the impressions gathered during your observations still will be fresh in your mind.

The SCD consists of three main parts. Part I asks you to record general descriptive information about the time use in class. Part II of the SCD requires you to make more detailed judgments about the Explaining and Relating aspects of the teacher's science presentation. The Framework for the Narrative Record (see pp. 7 to 20 of Section Five of this manual) describes in detail what is meant by Explaining and the four different types of Relating, and provides several examples of Explaining and Relating. You should thoroughly familiarize yourself with these concepts, because careful and valid ratings of the Explaining and Relating aspects of science teaching are central to both the SCD and the Intermediate Science Study. When you rate the Explaining and Relating emphases, keep in mind that your standard for comparison is the science "ideal," i.e., the best possible way you could imagine a teacher having used each science emphasis. Part III of the SCD asks for judgments about several specific aspects and phases of the class period, from the teacher's preparedness to students' behavior during the period to how the teacher ends the period.

For Part III, you will be focusing on more generic instructional and magagerial aspects that are applicable to any class, regardless of subject matter taught. Here, in contrast to Part II, your standard of comparison should be based on your perceptions of what the teacher set out to accomplish, taking into account any obvious constraints.

The SCD is a useful and valid instrument only if all observers have similar understandings of the higher-inference concepts in the instrument. The meaning of each concept for each item in the Science Class Description is discussed briefly. Further consensus about these concepts will be developed during practice observation sessions.

Item Concepts

Part I. General Description of Class Time Use

1. Estimate the percent of time devoted to the following. Here the observer is asked to estimate the percent of class time devoted to nine modes of instruction: (1) seatwork; (2) recitation; (3) group discussion: (4) demonstration; (5) laboratory exercises; (6) surrogate instruction; (7) nonacademic instruction; (8) procedures; and (9) other: transitions, interruptions, waste time. Categories 1 through 6 refer to modes that convey academic content only.

   - O Seatwork refers to students working alone on science worksheets, reading silently the text or other science materials, etc. It is characterized by a minimum of interaction between teacher and students or among students.

   - O Recitation is characterized by a short presentation of science content by the teacher that often includes a question-and-answer session in which the teacher initiates most of the questions and students do most of the responding. This mode also is used for correcting homework. The essential characteristic that defines recitation is that the bulk of interaction is between teacher and students and there is little, if any, student-to-student interaction.

   - O Group Discussion involves an open-ended discussion by members of the class of a central science topic or theme. The group discussion differs from the recitation in that there is more student-to-student interaction and more student-initiated questions.

   - O Demonstration refers to the manipulation of science materials or equipment by the teacher for one of two purposes: 1) to illustrate to students how they should similarly manipulate equipment when performing an upcoming lab exercise and 2) to illustrate a scientific concept, e.g., performing a lab exercise which students will not themselves perform.

- 0 Laboratory Exercises refer to the performance by students of exercises either: 1) explicitly labelled as science lab exercises (e.g., working exercises described in a lab book) or 2) implicitly designed as science lab exercises (i.e. involving any of the scientific processes of observation, measurement, data recording, etc.). Lab exercises performed by the teacher only are classified as Demonstrations.

- 0 Surrogate Instruction refers to instruction via a teacher surrogate such as a film, videotape, or guest lecturer. This mode is characterized by the teacher taking either a passive role (e.g., running the film projector) or no role at all while students are still being exposed to academic content.

- 0 Nonacademic Instruction refers to formal instruction, led or directed by the teacher, that does not meet the narrow definition of academic (i.e., the acquisition and practice of skills that facilitate better performance on scientific literacy tests). Time spent in teacher-led digressions, humorous or not, is recorded here if it appears purposeful and part of the lesson.

- 0 Procedures refers to behaviors that support an academic task but do not directly facilitate the actual learning of academic content as it is narrowly defined. This mode includes behaviors such as passing out papers, sharpening pencils, and gathering laboratory supplies. This mode also includes behaviors such as the teacher's directions about the format of students' responses, explanation of the materials to be used for a task, and stipulation of the timeline for completion of the task.

- 0 Transitions, interruptions and waste-time refers to time spent in management not related to a specific academic task (e.g., taking roll) and in switching from one activity to the next. This category also includes activities that are neither managed nor coordinated by the teacher and that distract from instruction. In short, this category contains all the things that are not covered by the previous eight categories.

In filling the table out, first determine the formal total length of the period, as defined by the beginning and ending bells (i.e., do not count time when students are in class before and after the period). Then estimate the percentage time by first writing down the number of minutes devoted to each of the nine categories. Please estimate to the nearest whole minute. These minutes should sum to the total length of the period. The percentage time for each category is then calculated by dividing the minutes for each category by the total minutes for the period.

2. Teacher's academic task orientation (percent of available class time). This concept asks the observer to assess the percentage of class time that the teacher devotes to academic subject matter. Academic is narrowly defined as the acquisition and practice of skills that facilitate better performance on scientific literacy tests. To make this rough calculation the observer should consider the greatest amount of time the teacher could possibly devote to academic instruction if he/she wanted to once necessary management activities are completed, and then what percentage of this time is actually spent on academics.

3. Number of same students attending to teacher or class activities most of the time. This concept refers to the number of students in the class that show appropriate student attention to all class activities most of the time. "Most of the time" refers to the reasonable amount of attention time that could be expected from students. The accuracy of student's responses is not a consideration, only whether they are attending to class activities.

Part II. Explaining and Relating.

Items 4 to 7 require the observer to make judgments about various dimensions of five science lesson emphases: (1) Explaining Content; (2) Relating to Science as a Social Historical Process; (3) Relating to Science as a Reasoning Process; (4) Relating to Science and Society/Technology; and (5) Positive Attitudes Towards Science. Here, you are to focus on these emphases whenever they occur during a recitation or demonstration by the teacher.

Pages 7 to 20 in Sec. Five of this manual include detailed descriptions and examples of these lesson emphases. Listed below are briefer descriptions for review purposes. You are strongly encouraged to read pages 7 to 20 to clarify any questions.

A. Explaining. Explaining refers to teacher presentations of the topic content. There are several ways in which a teacher can attempt to communicate content--e.g., by short statements, by longer discourse, by questioning students, by reading out-loud, by writing things on the board, and even by a demonstration. What is important is that the teacher is trying to communicate facts and concepts that are fundamental to the understanding of the topic (by whatever method).

B. Relating to Science as a Social Historical Process. This takes place when a teacher attempts to communicate the historical context of some scientific knowledge or process. This context can be portrayed in specific or general terms. In specific terms, the teacher would refer to particular individuals in history and their contributions--e.g., Mendel's work in genetics, Salk's development of the polio vaccine, Flemings' discovery of penicillin, Watson and Crick's determination of the structure of DNA, etc. In general terms, the teacher would refer to scientists or other people, without mentioning specific individuals.

C. Relating to Science as a Reasoning Process. A teacher is relating the scientific reasoning process when he/ she attempts to communicate how scientific knowledge is acquired. This would include talking about observing natural events, formulating and testing hypotheses and theories, deductive and inductive reasoning, concepts of randomness and probability, and the tools and methods of measurement.

D. Relating to Science and Society/Technology. This area of relating refers to a teacher communicating how specific areas of scientific knowledge have implications for society or for technology. Often, there is a direct link between a technological product and its societal consequences.

E. Positive Attitudes Towards Science. This area of relating refers to a teacher's attempt to deal with the individual or collective affective reactions people have towards science as a discipline and specific science knowledge, concepts, and applications. This probably will take place most commonly in the context of a class discussion. The teacher who does a good job of relating in this area will try to foster well-founded positive attitudes and curiosity toward science.

4. Estimate the percent of teacher academic presentation (recitation and demonstration) time and content linkage in the following science emphases. Here the observer is asked to estimate the percent of class time devoted to each of the five science emphases described above. The observer also is asked to indicated whether four of the science emphases are linked to science content. The observer can estimate the percentage time by first writing down the number of minutes devoted to each of the five emphases. If an emphasis was addressed for less than one minute, then estimate in quarters of a minute, writing .25, .50, or .75 under the minutes column. If an emphasis is given one minute or more of time, then round to the nearest minute. These minutes should sum to the total amount of recitation and demonstration time you estimated in item I. The percentage time for each science emphasis is then calculated by dividing the minutes for each emphasis by the total minutes for all five science emphases. If no time is spent on one or more of the emphases, record "0" minutes and "0%" for those emphases. Emphases that receive 0% here should be checked as not applicable in items 5, 6, and 7. For the content linkage aspect, you are to consider how the teacher presents any of the last four science emphases (i.e., science as a social historical process, science as a reasoning process, science and society/technology and positive attitudes toward science). If the teacher discussed any of these aspects by itself, i.e., without specific examples, or with reference to non-topic examples, then you would place a check mark under the "No

Linkage" column. If the teacher discussed one of the aspects and included examples from the topic content, then you would place a check mark under the "Linkage to Content" column.

5. Overall effectiveness and appropriateness of teacher's use and execution of each science emphasis during recitation and demonstration. Here the observer is asked to indicate both how successfully each of the five science emphases was executed and its appropriateness according to an ideal standard. For example, the emphasis, "Relating to Science Attitudes" would be rated low on this concept if the teacher presented his/her attitudes toward an issue as the only acceptable attitude and presented misinformation or slanted information to support this attitude. If some of the five science emphases are not observed, the NA (not applicable) box is marked.

6. Number of students paying attention to each science emphasis during recitation and demonstration. This concept refers to the number of students in the class that show appropriate student attention to each of the five science emphases. If some of the five science emphases are not observed, the NA (not applicable) box is marked.

7. Degree to which each science emphasis during recitation and demonstration expanded on content in curricular materials. This concept refers to the extent to which the teacher provided content beyond that provided by the curricular materials, for each of the five science emphases. A low rating means the teacher merely read from the text or worksheet, reiterated only text or worksheet material, and provided no new information beyond that found in the text or worksheet. A high rating means the teacher used text or worksheet material as only the starting point; he/she provided additional content and original examples. If some of the five science emphases are not observed, the NA (not applicable) box is marked.

Part III. Qualities of the Class Period.

8. Overall effectiveness of activities during entire period. This concept refers to the extent to which the lesson could be classified as "successful" in terms of all of the following:

   1) meeting the intentions of the teacher;

   2) relating well to the broader topic;

   3) meshing well with other lessons on the same topic; and

   4) maintaining student interest and attention.

   The observer is asked to make a judgment about the overall quality of the period's activities, based on all the information gathered during the observation.

9. Teacher's preparation for instruction (materials and activities preparation). This concept calls for a judgment about the level of a teacher's preparation. Here, preparation refers to things a teacher does before class (and, to a lesser extent, in class) in order to instruct students during class. A teacher can be very well prepared by having all materials ready ahead of time, by having [illegible] plan or notes written down that he/she can easily refer to once the class begins. The well-prepared teacher also presents accurate material. In short, this teacher would never appear to be making up an activity on the spot or present material that is incorrect.

10. Teacher provides overview of the content and objectives of period activities before beginning the activities. This concept refers to the extent to which the teacher introduced the period's activities by telling students both what content would be covered and what students were to learn or know about the content objectives. This overview or introduction can take many forms such as a verbal description (e.g., "Today, we will be studying X, Y, and Z"), a written outline on the board, a printed handout, or some combination of these approaches. A low rating means the teacher began the period immediately without providing any introduction or overview. A medium score indicates that the teacher described either (1) what content would be covered or (2) what students were to learn or know about this content, but not both. A high rating means the teacher provided a good overview of both the content and objectives.

11. Teacher explains how today's activities relate to previous lessons and the topic. This concept refers to the extent to which the teacher explicitly points out to students the ways in which the activities relate to previous lessons and the topic. Verbal descriptions and written outlines are among the ways a teacher might provide these links. A low rating means the teacher treats each activity as independent and provides no clues about how the activity relates to previous lessons or the topic. A high rating means that the teacher makes frequent references to how the current activity builds on or relates to previous lessons; he/she also indicates how today's activities fit into the larger context of the topic.

12. Teacher provides students with rationale for today's work. This concept refers to the teacher's ability to preface or follow up assignments with a rationale. The teacher who receives a high score on this concept explicitly tells students why they are doing a task and where the task fits into the more global curriculum and realm of practical application. In short, this teacher clearly lets his/her students know that a task is important and something worthwhile to do.

13. Clarity of teacher's directions, expectations for what students are to do. This concept asks the observer to rate the clarity with which the teacher communicates his/her directions and

expectations to students about what the students are to do and how they are to do it. The teacher who is very clear presents students with concise, articulate directions before they are to begin work. This communication can be both verbal and nonverbal (e.g., information on the chalkboard or worksheet). In order to be effective, the teacher also must know when and how to obtain the students' attention so that students will absorb this important organizing information.

14. Topic content presented to students in organized and sensible manner. For this concept, the observer must make a judgment about how well the teacher presented the topic content in an organized way. Aspects of an organized presentation include:

    (1) content is presented in a logical sequence.
    (2) most content relates to a central theme; content is not scattered bits of unrelated facts.
    (3) the direction in which the activity is headed is apparent; structure is built into activity.
    (4) presentation is internally consistent; little contradiction among various parts of the activity.

    If there is no topic presentation, the NA box is checked.

15. Teacher gives verbal markers in content presentation (includes knowledge, skills and principles). Not all the information and content conveyed during a content presentation is equally important; some of this information may be incidental. This concept refers to the extent to which the teacher indicates to students which content presented is most important. Verbal markers of importance (e.g., "This is an important definition to remember") or writing the important points on the chalkboard are ways the teacher may identify salient content. If there is no content presentation during the period, the NA box is checked.

16. Teacher suggests specific ways students are to learn today's content. This concept refers to how well the teacher provides students with guidelines or hints about how best to learn the content addressed during the period. These suggestions should be specific (e.g., outlining or diagraming material, describing mnemonic devices, suggesting study groups, indicating resources, readings, and other study aids, etc.), not vague comments like "I want you to think hard about this" or "Pay attention so you'll learn this." In short, these suggestions would mean that the teacher is addressing metaknowledge, i.e., the mental process of learning. Thus a high rating indicates that the teacher clearly explains several types of learning strategies. A low rating means the teacher merely presents the content and provides no clues about how to master the content. If there is no content presentation, the NA box is checked. If a teacher does a good job of presenting one learning strategy but also does a poor job of presenting one or more other learning strategies, the good presentation takes precedence (i.e., a "4" rating is given).

17. Smoothness of teacher's academic presentation. This concept refers to the extent to which the teacher can cover the intended instructional material at a good pace, without unnecessary interruptions and repeats. A teacher can facilitate smooth instruction both by having a good presentation planned, where information will be communicated logically and clearly, and by being in control of the class so that students do not disrupt this plan. If there is no content presentation, the NA box is checked.

18. Type of questions asked by teacher during recitation and demonstration. This concept summarizes the predominant cognitive orientation of the teacher's questions during recitation and demonstration. (See p. 19 in Sec. 5 of this manual for a description of Doyle's four categories of cognitive orientation of assignments). Briefly, a low rating indicates that the teacher asked mostly fact or memory questions; a high rating means the teacher asked mostly comprehension or opinion questions, i.e., questions that required the student to apply principles as well as facts. If teacher's questions are not observed, the NA (not applicable) box is marked.

19. Relevance to topic and organization of teacher's questions. Here the observer is asked to judge the overall relevance of the teacher's questions and how well the questions form an organized whole. A low rating indicates that the questions were not related to the topic, and tended to be scattered, unrelated questions with no logical pattern. A high rating means that the questions were highly relevant to the topic, facilitated mastery of the content, and seemed interrelated, i.e. questions built upon each other and were organized around a central theme. If teacher's questions were not observed, the NA (not applicable) box is marked.

20. Teacher allows students enough time to answer questions. This concept summarizes how well the teacher paced the question-and-answer session to allow students enough time to answer. Here, wait time is measured as the time from when the teacher finishes asking the question (regardless of whether a respondent is designated afterward) to the time when the teacher cuts off the student's opportunity to respond. A low rating indicates that the recitation was very fast-paced (less than one-half second allowed); the teacher called on another student before one student had time to begin his/her answer to the question or interrupted or cut off a student before the student had completely finished an answer--i.e., the general atmosphere was one in which the students were encouraged to answer first and were not given enough time to think. A high rating means that the teacher gave students plenty of time (3 seconds or more) to begin their response to a question, did not rush a student during the course of his/her answer or call on another student prematurely, and allowed each student plenty of time to elaborate on his/her response. If teacher's questions are not observed, the NA (not applicable) box is marked.

21. Teacher's feedback to academic student responses. This concept asks the observer to estimate the extent to which the oral feedback from the teacher is positive or negative. Positive feedback consists of the teacher praising and encouraging students in their responses to academic questions. Negative feedback consists of criticizing students about their responses. If no feedback is observed, the NA box is checked.

22. Teacher efficiency in classroom management. For this concept, the observer must make a judgment about the extent to which the teacher manages the classroom efficiently. Here management refers to all aspects of the class except instruction itself. Procedures necessary for instruction fall under the management heading. The teacher who is a highly efficient manager will have a system for "housekeeping" in place so that students spend little time waiting for the teacher to tell them how to carry out simple nonacademic- and academic-procedural tasks (e.g., passing out supplies, getting drinks of water, collecting homework papers). This system also should give students clear roles and duties, thus minimizing potential conflict among students.

23. Teacher effectiveness in handling discipline problems. This concept taps the teacher's ability to handle any potential discipline problems. The teacher who is very effective usually prevents discipline problems from occurring in the first place. This can be done by various means, including frequent monitoring of students and the establishment of a "no nonsense" standard in the class. If a disciplinary problem does occur, the very effective teacher is able to stop it quickly by interacting with the approprfate student(s) and by taking measures to prevent it from happening again.

24. Teacher monitors students during seatwork and labwork. This concept asks the observer to judge the amount of time the teacher spends monitoring students during seatwork and labwork. Monitoring refers to teacher observation of students and movement around the classroom. This monitoring is both to observe student task performance and behavior. The teacher who monitors students all the time keeps herself/himself alert to all that is going on in the classroom. If no seatwork or labwork takes place, the NA (not applicable) box is marked.

25. Teacher accessibility to individual students during seatwork and labwork. This concept requires the observer to distinguish between teachers who are not accessible to students (and who, thus, actively discourage help-seeking behavior) from teachers who make an active effort to help students who have requests. This item requires a judgment about the teacher on the basis of behavior not intentions. A low rating indicates the teacher secludes and distances him/herself from students and provides no help to individuals with requests. A high rating indicates the teacher is accessible by promptly answering the requests of nearly all individual students. If students make no requests for help, or seatwork or labwork do not occur, then the NA (not applicable) box is marked.

26. Teacher provides unsolicited feedback to individual students during seatwork and labwork. This concept requires a judgment about the extent of unsolicited feedback (including positive and negative feedback) the teacher gives during seatwork and labwork. A low rating is given if the teacher provides no unsolicited feedback to students. A high rating is given if the teacher gives nearly every student at least one instance of unsolicited feedback. If seatwork or labwork do not occur, the NA (not applicable) box is marked.

27. Teacher fairness in academic and behavioral treatment and evaluation. This concept asks the observer for a global rating of teacher fairness or the extent to which the teacher discriminates among students in unnecessary ways. The teacher who is very fair will not exhibit likes or dislikes for particular students and instead will make explicit efforts to assure that everyone has the same opportunities and receives comparable rewards and punishments for comparable behavior.

28. Teacher's attitude about learning and individual potential. This concept calls for a rating of the attitude about learning that the teacher communicates to students. A teacher communicates a very positive attitude to students by indicating that the work of all students has worth and that all students are capable of achieving well and producing good products. This teacher also communicates the idea that learning is an instrinsically rewarding thing. Teacher comments like "I know you can do it" or "I can tell you are thinking very hard" would indicate a positive attitude.

29. Teacher paces period. This concept requires a judgment about how well the teacher allocates and manages the limited time during the class period. An unevenly-paced period in which the teacher has to speed up at the end or has excess time left over should receive a low rating. A high rating indicates that the period is evenly-paced; the teacher covers all the intended activities within the time limits.

30. Teacher summarizes important points and concepts at the end of the period. This concept describes how the teacher ends the period. A low rating means that the period ends abruptly; the teacher does not provide any summary of the important points from the period's activities. A high rating means that at the end of the period the teacher recaps the important points and reminds students which material they should know. He/she may do this by verbally describing highlights of the period, outlining important content on the chalkboard (or referring to previous outlines on the chalkboard), or providing a handout. Ideally, the teacher's summary is linked to his/her original overview of the content and objectives of the lesson (item #10).

31. Teacher's knowledge of topic subject matter. This concept requires the observer to make a judgment about the extent and

accuracy of a teacher's knowledge of the subject matter taught during the topic interval. A low rating means the teacher was unable to answer students' basic questions about the presented material, provided inaccurate information, or "bluffed" when answering questions. A high score means the teacher seemed to have thoroughly mastered the content of the topic, addressed questions well, and provided accurate information about the topic. If a teacher responds, "I don't know," to a student's question, consider whether the question bears directly on the topic (and, hence, the teacher should know the answer) or whether the question is tangential (and, hence, there is no reason to expect the teacher to be able to answer it.)

32. Teacher rapport with most students. This concept asks the observer to estimate the quality of rapport between the teacher and his/her students. The quality of rapport can be judged not only by the things the teacher says to students but also by the way the students react to the teacher. A low rapport would be indicated by negative remarks or an absence of contact on the part of the teacher and by derogatory remarks about the teacher by students (usually made to other students). A high rapport would be indicated by positive nonverbal behaviors on the part of the teacher and students (e.g., smiles, touching) and by some personal exchanges initiated by both parties. A flashy, humorous teacher personality is not a necessary requirement for high rapport.

03/12/84
updated version

TEACHER ID: ____________

OBSERVER ID: ____________

DATE: ____________

Science Class Description (SCD)

Names of students absent today: ______________________________

____

Part I. General Description of Class Time Use

1. Estimate the percent of actual (not allocated) time devoted to the following:

	Mode	Allocated Minutes	Actual Minutes	Actual % of Time
Academic	Seatwork			
	Recitation			
	Group Discussion			
	Demonstration			
	Laboratory Exercises			
	Surrogate Instruction			
	Nonacademic Instruction			
	Procedures			
	Other: Transitions, Interruptions, Waste Time			
	TOTAL (time between bells)			100%

2. Teacher's academic task orientation (percent of available class time):

1	2	3	4	5
Very low	Low	Moderate	High	Very High
(0-20%)	(21-40%)	(41-60%)	(61-80%)	(81-100%)

3. Number of same students attending to teacher or class activities most of the time:

1	2	3	4	5
More than 12 students inattentive	All but 7-12 students	All but 4-6 students	All but 1-3 students	All of the students

Part II. Explaining and Relating
The standard of comparison for Part II is the ideal science teacher (not existing science teachers).

4. Estimate the percent of teacher academic presentation time (recitation and demonstration) devoted to the following science emphases:

Science Emphasis	Minutes	% of Time	Linkage to Content	No Linkage
Explaining Content	_____	_____		
Relating to Science as a Social Historical Process	_____	_____	_____	_____
Relating to Science as a Reasoning Process	_____	_____	_____	_____
Relating Science and Society/ Technology	_____	_____	_____	_____
Positive Attitudes Towards Science	_____	_____	_____	_____
TOTAL RECITATION AND DEMONSTRATION TIME	_____	100%		

5. Overall effectiveness and appropriateness of teacher's use and execution of each science emphasis during recitation and demonstration:

Science Emphasis	Quality					
	Highly ineffective; far from ideal science teaching		Moderately effective		Highly effective; near ideal science teaching	NA
Explaining Content	1	2	3	4	5	☐
Relating to Science as a Social Historical Process	1	2	3	4	5	☐
Relating to Science as a Reasoning Process	1	2	3	4	5	☐
Relating Science and Society/Technology	1	2	3	4	5	☐
Positive Attitudes Towards Science	1	2	3	4	5	☐

6. Number of students paying attention to each science emphasis during recitation and demonstration:

Science Emphasis	Student Attention					
	Very few students paying attention		About half		All or most students paying attention	NA
Explaining Content	1	2	3	4	5	☐
Relating to Science as a Social Historical Process	1	2	3	4	5	☐
Relating to Science as a Reasoning Process	1	2	3	4	5	☐
Relating Science and Society/Technology	1	2	3	4	5	☐
Positve Attitudes Towards Science	1	2	3	4	5	☐

7. Degree to which each science emphasis during recitation and demonstration expanded on content in curriculum materials:

Science Emphasis	Degree Lesson merely reiterated curriculum content and examples				Lesson provided new content; original examples used	NA
Explaining Content.	1	2	3	4	5	☐
Relating to Science as a Social Historical Process	1	2	3	4	5	☐
Relating to Science as a Reasoning Process	1	2	3	4	5	☐
Relating Science and Society/Technology	1	2	3	4	5	☐
Positive Attitudes Towards Science	1	2	3	4	5	☐

Part III. Qualities of the Lesson
The standard of comparison for Part III is the normal distribution of existing teachers.

8. Overall effectiveness of activities during entire period:

1	2	3	4	5
Very ineffective; none of teacher's intentions were realized		Moderately effective; some of teacher's intentions were realized		Very effective all of teacher's intentions were realized

9. Teacher's preparation for instruction (materials and activities preparation):

1	2	3	4	5
Very poorly prepared		Average		Very well prepared

10. Teacher provides overview of the content and objectives of period's activities before beginning the activities:

1	2	3	4	5
No overview provided; begins activities immediately		Somewhat outlines		Clearly outlines content and objectives of the activities

11. Teacher explains how today's activities relate to previous lessons and the topic:

1	2	3	4	5
No link to previous lessons		Vague link to previous lessons		Explicit link to previous lessons

12. Teacher provides students with rationale for today's work:

1	2	3	4	5
Teacher never provides rationale		Teacher provides mostly mundane rationale		Teacher provides higher purpose rationale

13. Clarity of teacher's directions, expectations for what students are to do:

1	2	3	4	5
Ambiguous, students don't know what's expected		Moderate clarity		Very clear, students know what's expected

14. Topic content presented to students in organized and logical manner:

1	2	3	4	5	☐
Presentation is scattered and disorganized				Presentation is logical and well structured	NA

15. Teacher gives verbal markers in content presentation (includes knowledge, skills and principles):

1	2	3	4	5	☐
No clear identification of most important points				Several important points emphasized and reinforced	NA

16. Teacher suggests specific ways students are to learn today's content:

1	2	3	4	5	☐
No specification of learning strategies	Poor specification of a single learning strategy	Poor specification of several learning strategies	Good specification of a single learning strategy	Good specification of several learning strategies	NA

17. <u>Smoothness</u> of teacher's academic presentation:

1	2	3	4	5	☐
Very rough, uneven pace, many interruptions and unnecessary repeats				Very smooth, good even pace, very few interruptions and unnecessary repeats	NA

18. Type of questions asked by teacher during recitation and demonstration:

1	2	3	4	5	☐
Mostly memory or fact questions		Mix of fact and comprehension questions		Mostly questions that require comprehension or opinion	NA

19. Relevance to topic and organization of teacher's questions:

1	2	3	4	5	☐
Scattered, unrelated questions that have little to do with topic		Some questions relate well to topic		Questions build upon each other; most relate well to topic	NA

20. Teacher allows students enough time to answer questions:

1	2	3	4	5	☐
Fast-paced; teacher a[illegible] less tha[illegible] second		Moderate pace; teacher allows 1 second		Slower-paced; teacher allows 3 seconds or more	NA

21. Teacher's feedback to academic student responses:

1	2	3	4	5	☐
None or mostly negative		Both negative and positive feedback		Mostly positive feedback	NA

22. Teacher's efficiency in classroom management:

1	2	3	4	5
Not efficient, many interruptions and delays, no system that works		Moderate efficiency		Highly efficient, few interruptions and delays, a system that tells students what to do

23. Teach[illegible]effectiveness in handling discipline problems:

1	2	3	4	5
Often does not see inappropriate or disruptive behavior		Catches wrong target or stops misbehavior after is spreads		Stops misbehavior early; initiates contacts before students get off-task

24. Teacher monitors students during seatwork and labwork:

1	2	3	4	5	☐
None of the time		About half of the time		All the time	NA

25. Teacher's accessibility to individual students during seatwork and labwork:

1	2	3	4	5	☐
Avoids nearly all students who have requests	Helps only the most persistent students who have requests	Helps some students who have requests	Helps most students who have requests	Helps nearly all students who have requests	NA

26. Teacher provides <u>unsolicited feedback</u> to individual students during seatwork and labwork:

1	2	3	4	5	☐
Teacher provides no unsolicited feedback		Teacher provides unsolicited feedback to about half the students		Teacher provides unsolicited feedback to nearly all students	NA

27. Teacher fairness in academic and behavioral treatment and evaluation:

1	2	3	4	5
Often not fair		Moderately fair		Always fair

28. Teacher's attitude about learning and individual potential:

1	2	3	4	5
Communicates very negative, pessimistic attitude to most students		Neutral		Communicates very positive, optimistic attitude to most students

29. Teacher paces period:

1	2	3	4	5
Poorly; runs out of time or has too much time left; unevenly paced period				Well; accomplishes most of what s/he sets out to do; evenly paced period

30. Teacher summarizes important points and concepts at the end of the period:

1	2	3	4	5
Not at all; period ends with no summary		Summarizes somewhat		Summarizes well; highlights important concepts at end of period

Fill out the next two items only on the LAST day of a topic observation:

31. Teacher's knowledge of topic subject matter:

1	2	3	4	5
Teacher demonstrates no knowledge		Teacher confuses some points or fails to recognize errors		Teacher demonstrates thorough mastery

32. Teacher rapport with most students:

1	2	3	4	5
Teacher disliked, not respected by most students				Teacher well-liked, respected by most students

SECTION SEVEN: TEACHER TOPIC QUESTIONNAIRE

Alexis Mitman, John Mergendoller, and Andrea Lash

We would like to gather teacher's perceptions about teaching a selected topic prior to beginning the observations of the topic. We have designed a brief questionnaire for this purpose. The questions in the questionnaire are intentionally open-ended, thus allowing the teachers to present their ideas in their own styles.

Directions. Determine the date you will begin observing a teacher's presentation of a topic. Fill in the questionnaire with the topic description and the return date, which is the first day of your observations. One week prior to this date, give the teacher the Topic Questionnaire, paraphrasing its purpose. Remind the teacher that it is fine to answer each question briefly, and that we do not expect him or her to devote a ~~lot~~ of time to the questionnaire. Then, when you come to class on the first day of the observation, pick up the completed questionnaire from the teacher. Write down the teacher's ID number and your observer number in the upper right hand corner as soon as you receive the completed form.

Topic Questionnaire

Topic description: ____________________

Directions: The purpose of this questionnaire is to get your impressions about teaching the above topic to the class we are observing before actual instruction begins. This information will help us understand the topic and your approach to the topic. Because your time is valuable, we encourage you to answer each item briefly; a couple sentences should be adequate in most cases.

Please return this to your observer by ______________.

---

1. Have you taught this topic before? ______ Yes ______ No

If No, how is it that you come to be teaching this topic this year?

If Yes, approximately how many times have you taught the topic (taking into account number of years and number of classes)?

If Yes, are you doing anything different in teaching the topic to this class that you have not done in the past? What?

2. Are there any particular reasons why this topic is being covered at this particular time of year? If so, what are they?

3. What are the major materials you will be using in teaching this topic (e.g., textbook, films, worksheets you made, etc.

4. Do you plan to use any laboratory or demonstration activities for this topic?

_____ Yes _____ No

If yes, how did you get the ideas for them?

5. What are the most important things that students can learn when they study this topic?

6. Is there anything this topic demonstrates particularly well that most other topics do not? If so, what?

7. Is there anything you would like to be able to do with this topic that you already know will not be feasible?

_____ Yes

_____ No

If Yes, what is it, and why is it not feasible?

8. What--if anything--is especially enjoyable about teaching this topic?

9. What--if anything--is difficult in teaching this topic?

10. What--if anything--do your students especially enjoy about this topic?

11. What--if anything--do students find difficult about this topic?

12. Will you be formally assessing how students have learned the topic material?

______ Yes ______ No

If yes, how will you do the assessment?

If you will be grading their work, what standards will you use?

Thank you for you time. We greatly appreciate your contribution.

12/7/83
Updated

SECTION EIGHT: STUDENT CLASS SURVEY

John R. Mergendoller, Alexis L. Mitman, and Kenneth D. Peterson

Overview

This survey is intended to capture student's perceptions of their science class. It is to be administered to all students in the classes you are observing. The observer must choose the day of administration according to the following guidelines.

1. Do not administer the survey on a day when laboratory, demonstration, or hands-on activities consume the entire period.

2. Do administer the survey on a day when the preponderance of instruction takes place in a lecture, recitation, or discussion format.

3. Do try to administer the survey on a day which is typical or representative of the teacher's instructional approach.

Arrange beforehand with the teacher when the student class survey can be administered. Pass out the survey yourself, and read the directions at the top of the page to the class. Collect the surveys yourself and write the teacher number on the top of the stack of surveys.

Should students ask you about the meaning of individual questions, simply tell them to "try to understand the questions as best you can." Do not provide clarification.

Name: ______________________ Date: ______________________

STUDENT CLASS SURVEY

We are trying to understand how students learn about science, and we need your help in answering the following questions. Please be honest. Your teacher will not see your answers, and we will not tell anyone what you said. This is NOT a test, and there are no right or wrong answers. Please answer carefully. All of the questions refer to this period.

1. What idea do you think the teacher wanted you to remember today?

2. During science today, how much of the period were you paying attention?

____	____	____	____	____
100% of the time	75% of the time	50% of the time	25% of the time	None of the time

3. How much of the period were you thinking about the lesson?

____	____	____	____	____
100% of the time	75% of the time	50% of the time	25% of the time	None of the time

4. I was confused today.

[ ] Not at all. [ ] Once [ ] More than once

5. Did the teacher connect today's lesson to things you studied before today?

☐ No

☐ Yes (If yes, what things were they?)

6. How hard was the work you did today?

______	______	______	______	______
Very Hard	Somewhat Hard	Average	Easy	Very Easy

7. How interesting was the work you did today?

______	______	______	______	______
Very Interesting	Somewhat Interesting	Average	Uninteresting	Very Uninteresting

8. Did you learn from other students today?

☐ No ☐ Yes

9. Did you ask any questions today?

☐ No ☐ Yes

10. Was the class quiet enough for you to learn today?

☐ No ☐ Yes

11. What will you do in science class when it meets next?

12. Is learning science different than learning English? Please explain.

Thank you for your help.

03/14/83
Updated

SECTION NINE: REVISED TARGET STUDENT INTERVIEW

John R. Mergendoller and Alexis L. Mitman

NOTE: The format of this interview has been changed based on our February discussions. You will need to carefully study this new format and the changes in the questions and probes before conducting the second topic interview.

Overview

Observers will be responsible for conducting semi-structured interviews with six target students in each classroom at the conclusion of each topic observation period. These interviews will be focused on work conducted during the last 5 class meetings. They have three goals:

- 0 to understand student's perceptions of and reactions to the lessons they have encountered during the past week;
- 0 to determine whether students have understood the teacher's lessons during the past week; and
- 0 to identify other lessons or activities during the semester which were memorable to students and captured their attention and curiosity.

To facilitate the topic coverage, the interview schedule is organized in three sections mirroring these goals.

Methodology

The interview is constructed using both open-ended and forced-choice questions. It is essential that observers follow the interview schedule as closely as possible. Although we expect that some questions will have to be modified from interview to interview in order to fit the current situation and the responses of the interviewee, the general rule is to stick with the questions as stated.

At the end of the interview, observers will complete two rating scales summarizing their perceptions of the interviewee's knowledge of science.

All interviews are to be conducted with one student at a time and will be tape recorded. The tape should be transcribed as soon as possible, and the interviewer is responsible for checking the accuracy of the transcript before it is mailed to the Far West Lab. Do not reuse interview tapes. They should be kept and shipped to the Lab.

Scheduling

The interviews should take approximately 30 minutes per student. They should be scheduled to occur at the conclusion of the last week of observation for each topic. If possible, interview all six students on two consecutive days. If this is not possible, interview the students over a three-day period. It is especially important that the interviews do not drag out. [illegible]nt memories are short; the greater the time between the wee[illegible]ssons and the interview, the more difficult it will be for stu[illegible] to recall their perceptions of the activities.

All interviews are conducted one-on-one with individual students. Group interviews are not appropriate and will produce worthless data.

Pre-Interview Activities

Before conducting the interview, prepare a lesson summary chart using the template supplied. First, write the names of the last seven days of the week in the cells at the top of the chart. Draw X's in the cells representing Saturday and Sunday. (In the example chart, it is assumed that the interview is conducted on the Monday following the observation week.) Then write a brief description of every activity segment which had an academic purpose. (Note that we have not included activity segments such as roll or announcements in the example chart.) Make the descriptions as simple and explicit as possible.

The chart has two purposes: 1) to stimulate the recall of the interviewee; and 2) to provide a structure to elicit students' perceptions of their classes. Remember that THIS INTERVIEW HAS BEEN CHANGED based on our February discussions. Please rehearse your questions and probes carefully before interviewing students.

Throughout this example, probe questions have been formulated in response to five general areas of interest:

1) NATURE OF ACTIVITY: Operationally, what did the student do?

2) LEARNING GOAL: What does the student think s/he was to "remember," "get out of," or "learn" from the activity?

3) ACCOUNTABILITY: How does the student think her/his participation will be assessed and graded?

4) LEARNING STRATEGY: What methods helps the student to learn or to get a good grade?

5) CONNECTION: Does the student see a connection between the week's activities and the content of the lesson.

Lesson Summary Chart (Example)

MON	TUE	WED	THUR	FRI	SAT	SUN
Discussion of Niche Workbook Exercises on Niche	Movie: Tidepools	Nature Walk and Plant Collecting	Draw Maps of Nature Walks and Plants	Discussion of Maps Chapter Test		

Land Ecosystems (Interview Conducted on Monday)

These capitalized words will appear on the interview schedule to signal you to probe the student about each of these areas.

Rehearse your questions using this example as a guide.

BEGIN WITH AN INTRODUCTORY STATEMENT TO ORIENT STUDENT:

"I'm going to ask you some questions about the things you did in class last week, and I'd like you to think hard and remember what Mrs. Jone's life science class was like last week." (Be sure to use the actual name of the class.)

PLACE LESSON SUMMARY CHART DIRECTLY IN FRONT OF INTERVIEWEE. ASK THE STUDENT TO DESCRIBE WHAT HE/SHE DID DURING EACH OF THE ACTIVITIES.

"Now (Student's name), on Monday, Mrs. Jones discussed with the class the word, "niche". What did she say? Can you tell me more? What were you doing during this time? What was the most important thing to remember from that discussion? This discussion continued for about half of the class, and then students did workbook exercises about the concept of niche. What were those about? How did you do them? Will these be graded? How? Do you know a way to get a good grade?

IF THE STUDENT DOES NOT REMEMBER THE ACTIVITIES, PROVIDE FACTUAL DETAIL TO JOG HER/HIS MEMORY. DON'T PROCEED TO THE NEXT DAY UNTIL THE STUDENT APPEARS TO REMEMBER WHAT HAPPENED.

"On Tuesday, there was a movie about Tidepools. What was in the movie? Tell me more. What was the most important thing to learn from the movie? Did the movie have anything to do with the concept of niche?

"On Wednesday, Mrs. Jones took the class outside on a nature walk around the football field. It was cold and windy. What did you see? Did that have any connection to niche? Do you think Mrs. Jones wanted you to learn anything in particular?

"Thursday, the class drew maps. What was on the maps? What did you do to make them? Did they have any connection to niche? Why did Mrs. Jones have you draw the maps? Will the maps be graded? How?

"On Friday, the class did two things. First, there was a discussion of different students' maps. Then, Mrs. Jones gave a test on Chapter 7, "Plants and Their Neighbors." What was the test about? Will it be graded? Do you know how to get a good grade on the test? How?

IF THE STUDENT DOES NOT REMEMBER VERY MUCH, BUILD FROM WHAT <u>IS</u> REMEMBERED, AND PROVIDE FACTUAL DETAILS OF EACH DAY'S ACTIVITIES.

Once you have finished rehársing your discussion of the Lesson Summary Chart, it is necessary to prepare the "explaining" and "relating" questions (e.g., 11 & 12) which appear in the second part of the interview. The purpose of these questions is to assess each student's understanding of one science concept explained by the teacher and one concept which the teacher related to (1) science as a social historical process; (2) science as a reasoning process; (3) science, society/technology; or (4) positive science attitudes. If no relating behavior was observed, skip this question.

The basic format for these questions is to ask the student to teach you the information covered by the teacher in order to provide verbatim, tape-recorded evidence of the student's understanding.

Before conducting the interview, select the explaining and relating concepts you will ask the student about. Choose these concepts to reflect the best teacher explanations you observed, whether they focused on the same or different lesson topics.

Interview Procedures

It is essential that the interviewer review all of the questions to be asked in each part of the interview before talking with the student. Keep an overview of the entire interview in mind, so that you will be able to pace yourself and cover all of the questions.

Introduction

Follow the script you have already rehearsed and review the Lesson Summary Sheet with the student. Do not rush this. It is essential to the completion of a good interview.

Part 1: Student's Perceptions of the Week's Lessons

Questions 1 - 10 focus directly on student's perceptions of the previous week's lessons. They combine both open-ended and structured questions. It is important to probe when asking both of these types of questions; the probing strategy, however, varies with question type.

After asking open-ended questions 1, 3, 7, and 8, probe to elicit as much information as possible about the way students conceptualize their experience in science class and learning science. Try to get inside their heads. Urge them to comment upon what the experience of learning science is like. Eliciting complete answers to question eight (Last week, when did you feel you were learning the most?) is especially important. We want to determine whether students define learning in terms of the grades they receive or with reference to an intrinsically rewarding process of gaining knowledge.

The remainder of questions in Part 1 are explicitly structured. Categories of student response have been predefined. Make sure you ask all parts of the question.

Question 5 (and later Question 15) requires you to determine whether one of the listed characteristics was responsible for the student's interest. The interviewer is charged with formulating questions which make sense given the activity described by the student. If a characteristic is not applicable to the specific case, the observer should mark NA and omit the characteristic from the questioning. Questions 5 and 15 are organized around the following categories: (1) Content, (2) Teacher, (3) Task, and (4) Perceived Accomplishment.

The Content dimension focuses on what the student learns. Four alternatives appear on the interview schedule. Subject Matter refers to the formal content of the lesson, e.g., bacteria, protozoa, seed plants, natural selection and the like. I Learned About Myself refers to personally useful knowledge, e.g., heart rate, effect of drugs, preferred values, etc. There Was No Right Answer refers to instructional formats requiring divergent thinking, e.g., brainstorming, hypothesis generation, etc. The final alternative, Other is available for observers to formulate additional aspects of the content which appear relevant.

The Teacher dimension focuses on the way the teacher presents the curriculum content. It is essential here to discriminate the content itself (e.g., protozoa) from the way the teacher presents the content (e.g., "making it fun to learn about protozoa"). Three alternative codings appear on the interview schedule. Teacher Characteristics includes the humor, the enthusiasm, the clearness with which the teacher speaks as well as other teacher traits. These attributes are long-term and consistent, and make the content being covered more interesting. Demonstration refers to the particular demonstration activity the teacher used to make a fact or concept come alive. Additional aspects of the teacher's instruction which seem appropriate should be formulated by the observer and described in the Other category.

The Task dimension focuses on the actual task students complete. Five self-explanatory categories appear on the interview schedule: (1) Different, Unusual, Novel, Unexpected, (2) Hands-On, Manipulatory Activity, (3) Outdoor Activity/Field Trip, (4) I Worked with My Friends, and (5) Other.

The next dimension, that of Perceived Accomplishment, refers to students' expressions of satisfaction and accomplishment. It Was Easy is used to indicate that the student found the task interesting because it was easy to complete. I Did Well refers to expressions of satisfaction resulting from positive academic attainment. As usual, the Other category is available for invention by the observer.

A final Miscellaneous category appears at the end of the question. Use this category only if you have a hunch about interesting aspects of the lesson missing from the above categories.

Part 2: Student's Understanding of Past Week's Material

The second part of the interview employs questions prepared by the interviewer in advance as described on page 5. These focus directly on topics covered during the observation.

Here, the role of the interviewer is to be a friendly, sympathetic, businesslike questioner. You are to conduct a low-key oral exam with the student in order to assess her/his knowledge. Ask the student to tell you about the appropriate material and probe to determine the limits to understanding.

Part 3: Student's Response to the Semester's Lessons

The final part of the interview employs essentially the same format used in Part 1 to elicit student's perceptions of the science lessons and activities they have encountered during the semester.

The first four questions are structured. As before, the interviewer should probe to determine which predetermined category best represents the student's responses.

The final question, Question 17, is open-ended and provides an opportunity for students to give their unexpurgated reactions to and recommendations for making science classes interesting. Interviewers should spend the remainder of the time allocated to the interview exploring this question with the students. Probe to evoke the kinds of activities, topics, field trips, and movies favored by students. The goal of this question is to elucidate student's visions of what an interesting and productive science class is like.

Rating Scales

Before leaving the school, complete the rating scales which appear as questions 18 and 19. These refer back to questions 11 and 12, and ask for the interviewer's judgment of the student's knowledge.

In completing these ratings, consider the quality of the teacher's explanation as the standard on which you base your ratings. The categories of understanding are as follows:

1 The student appears confused and understands nothing of the teacher's explanation.

2 The student demonstrates some understanding of the explanation given by the teacher. Confusion, however, has not been fully dissipated.

3 The student demonstrates a surface or literal understanding of the teacher's explanation. S/he can "parrot" what was said in class.

4 The student demonstrates an in-depth understanding of the teacher's explanation, and can explain the principles involved, or somehow go beyond the surface explanation.

5 The student's understanding appears to be greater than that of the teacher.

Please provide your own written assessment of the students' attainments in the space reserved for comments. Write as much as you like.

Also, please indicate the quality of the interview in Question 20. An EXCELLENT interview is one where the student is articulate and you feel certain that you understood what was said. A SATISFACTORY interview is one where you did not experience major confusion or uncertainty, and you feel relatively confident that you understood what the student was trying to say. At the end of an UNSATISFACTORY interview, the the interviewer feels confused and questions whether what has been written down on the paper actually corresponds to what the student meant. In all cases, please write a paragraph of comments about the interview under "General Comments."

03/14/84
Updated

COVER SHEET: REVISED TARGET STUDENT INTERVIEW*

Student's ID: ____________________

School: ____________________

Interviewer ID: ____________________

Date: ____________________

*Note: Fill out parts of questions 5, 11, 12, and 15 before conducting the interview.

TARGET STUDENT INTERVIEW SCHEDULE

Introduction

Begin with an introductory statement that orients the student and gives a general idea of what the interview is about.

> "I'm going to ask you some questions about the things you did in class last week, and I'd like you to think hard and remember what Mrs. Jone's life science class was like last week." (Be sure to use the actual name of the class.)

Part 1: Student's Perceptions of the Past Week's Lessons

1. Have students describe previous week's activity and probe the student about each activity and its:

NATURE

LEARNING GOAL

ACCOUNTABILITY

LEARNING STRATEGY USED

and

CONNECTIONS WITH CONTENT AND OTHER ACTIVITIES

2. We've just been talking about the things you did last week.

   Which of these was most interesting? Would you like to do it again? Yes _____ No _____

3. What would you say to a friend who asked you why it was interesting? (PROBE!)

4. Now using the scale on the back of this page, show me exactly how interesting _______________ was. (Circle student's response below)

1 2 3 4 5

5. I'm going to ask you about alot of different things that might make it interesting to make sure we haven't forgotten anything. Was it because? (FILL IN "OTHER" BEFORE ASKING QUESTION)

YES	NO	NA		
			SUBJECT MATTER	(Content)
			I LEARNED ABOUT MYSELF	
			THERE WAS NO RIGHT ANSWER	
			OTHER CONTENT _______________	
			TEACHER CHARACTERISTICS	(Teacher)
			DEMONSTRATION	
			OTHER TEACHER _______________	
			DIFFERENT, UNUSUAL, NOVEL, UNEXPECTED	(Task)
			HANDS-ON, MANIPULATORY ACTIVITY	
			OUTDOOR ACTIVITY/FIELD TRIP	
			I WORKED WITH MY FRIENDS	
			OTHER TASK _______________	
			IT WAS EASY	(Perceived Accomplishment)
			I DID WELL	
			OTHER ACCOMPLISHMENT _______________	
			OTHER _______________	(Miscellaneous)
			OTHER _______________	

6. You've mentioned that ______________, and ______________, and ______________ all helped to make ____________________ interesting. Which was the most important thing? (CIRCLE THE APPROPRIATE ANSWER)

7. Did you feel you were learning something while you were doing this? How did you know this?

8. Now think again about all of the things you did last week (POINT TO THE TEMPLATE). When did you feel you were learning the most? Why was that? (PROBE TO SEE IF STUDENT DEFINES LEARNING ACCORDING TO FORMAL EVALUATIONS VS. VALUING KNOWLEDGE FOR ITS OWN SAKE.)

9. Now using the scale on the back of this page, show me exactly how much you learned. (Circle student's response below)

1 2 3 4 5

10. Would you say the things you did in class last week were the same sorts of things you usually do in a week, or were they different in some way? (PROBE!)

_____ SAME _____ DIFFERENT _____ BOTH

1	2	3	4	5
Very Boring		O.K.		Very Interesting

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(Please circle student's response on opposite side of page)

Part 2:

Student's Understanding of Past Week's Material

11. (EXPLAINING QUESTION) You remember that on (DAY OF THE WEEK), (TEACHER'S NAME) talked about ______________. Could you tell me what she said?

12. (RELATING QUESTION) On (DAY OF THE WEEK), (TEACHER'S NAME) talked about ______________. What exactly was she saying?

Part 3:

Student Response to the Semester's Lessons

13. OK, (student's name), now I am going to ask you some questions about what you have done so far this year in Life Science. Think back about everything you have done in Life Science since we last talked. What DAY did you do the most interesting thing? (PROBE FOR THE ACTIVITY: LECTURE, DISCUSSION, DEMONSTRATION, FILM, SPEAKER, ETC.)

14. What would you say to a friend who asked you why it was interesting? (PROBE!)

1	2	3	4	5
I Learned nothing new		I Learned a few new things		I Learned a lot of new things

(Please circle student's response on opposite side of page)

15. I'm going to ask you about alot of different things that might make it interesting to make sure we haven't forgotten anything.

YES	NO	NA		
____	____	____	SUBJECT MATTER	(Content)
____	____	____	I LEARNED ABOUT MYSELF	
____	____	____	THERE WAS NO RIGHT ANSWER	
____	____	____	OTHER CONTENT ____________	
____	____	____	TEACHER CHARACTERISTICS	(Teacher)
____	____	____	DEMONSTRATION	
____	____	____	OTHER TEACHER ____________	
____	____	____	DIFFERENT, UNUSUAL, NOVEL, UNEXPECTED	(Task)
____	____	____	HANDS-ON, MANIPULATORY ACTIVITY	
____	____	____	OUTDOOR ACTIVITY/FIELD TRIP	
____	____	____	I WORKED WITH MY FRIENDS	
____	____	____	OTHER TASK ____________	
____	____	____	IT WAS EASY	(Perceived Accomplishment)
____	____	____	I DID WELL	
____	____	____	OTHER ACCOMPLISHMENT ____________	
____	____	____	OTHER ____________	(Miscellaneous)
____	____	____	OTHER ____________	

16. You've mentioned that ____________, and ____________, and ____________, all helped make ____________ intersting. Which was the most important thing? (CIRCLE THE APPROPRIATE ANSWER ABOVE)

17. If you were the teacher, and wanted to teach a science class that students thought was interesting what would you do? What else? Why?

Concluding Statement

Thank you ____________________, for talking with me. I've been asking all of the questions; do you have any for me? (ANSWER QUESTIONS. GIVE STUDENT THE $5 HONORARIUM.)

Rating Scales

18. Interviewer's rating of student's understanding of the EXPLAINED CONTENT discussed in Question 11.

1	2	3	4	5
Confused; Understood nothing of teacher's explanation	Some understanding of teacher's explanation	Surface understanding of teacher's explanation	In-depth understanding of teacher's explanation	Articulate understanding grather than the teacher

Comments:

19. Interviewer's rating of student's understanding of the RELATING CONTENT discussed in Question 12.

1	2	3	4	5
Confused; Understood nothing of teacher's explanation	Some understanding of teacher's explanation	Surface understanding of teacher's explanation	In-depth understanding of teacher's explanation	Articulate understanding grather than the teacher

Comments:

20. Overall, this interview was

_____ EXCELLENT _____ SATISFACTORY _____ UNSATISFACTORY

General Comments on Interview:

SECTION NINE: TARGET STUDENT INTERVIEW

John R. Mergendoller and Alexis L. Mitman

Overview

Observers will be responsible for conducting semi-structured interviews with six target students in each classroom at the conclusion of each topic observation period. These interviews will be focused on work conducted during the last 5 class meetings. They have three goals:

- to understand student's perceptions of and reactions to the lessons they have encountered during the past week;
- to determine whether students have understood the teacher's lessons during the past week; and
- to identify other lessons or activities during the semester which were memorable to students and captured their attention and curiosity.

To facilitate the topic coverage, the interview schedule is organized in three sections mirroring these goals.

Methodology

The interview is constructed using both open-ended and forced-choice questions. It is essential that observers follow the interview schedule as closely as possible. Although we expect that some questions will have to be modified from interview to interview in order to fit the current situation and the responses of the interviewee, the general rule is to stick with the questions as stated.

At the end of the interview, observers will complete two rating scales summarizing their perceptions of the interviewee's knowledge of science.

All interviews are to be conducted with one student at a time and will be tape recorded. The tape should be transcribed as soon as possible, and the interviewer is responsible for checking the accuracy of the transcript before it is mailed to the Far West Lab. Do not reuse interview tapes. They should be kept and shipped to the Lab.

Scheduling

The interviews should take approximately 30 minutes per student. They should be scheduled to occur at the conclusion of the last week of observation for each topic. If possible, interview all six students on two consecutive days. If this is not possible, interview the students over a three-day period. It is especially important that the interviews do not drag out. Student memories are short; the greater the time between the week's lessons and the interview, the more difficult it will be for students to recall their perceptions of the activities.

All interviews are conducted one-on-one with individual students. Group interviews are not appropriate and will produce worthless data.

Pre-Interview Activities

Before conducting the interview, prepare a lesson summary chart using the template supplied. First, write the names of the last seven days of the week in the cells at the top of the chart. Draw X's in the cells representing Saturday and Sunday. (In the example chart, it is assumed that the interview is conducted on the Monday following the observation week.) Then write a brief description of every activity segment which had an academic purpose. (Note that we have not included activity segments such as roll or announcements in the example chart.) Make the descriptions as simple and explicit as possible.

The purpose of the chart is to jog the mind of your interviewee, and help stimulate her/his recall of the actual activity segment. To aid this process, you will need to describe each activity to the student at the time you show her/him the chart. Once you have completed the chart, go over it, and rehearse out loud the way you will describe each activity segment.

BEGIN WITH AN INTRODUCTORY STATEMENT TO ORIENT STUDENT:

"I'm going to ask you some questions about the things you did in class last week, and I'd like you to think hard and remember what Mrs. Jone's life science class was like last week." (Be sure to use the actual name of the class.)

PLACE LESSON SUMMARY CHART DIRECTLY IN FRONT OF INTERVIEWEE. GO THROUGH THE ACTIVITIES DAY-BY-DAY.

"Now (Student's name), on Monday, Mrs. Jones discussed with the class what the word, niche, meant and how it was an important concept in ecology. This discussion continued for about half of the class, and then students did workbook exercises about the concept of niche. Do you remember the discussion and doing the exercises?

Lesson Summary Chart (Example)

MON	TUE	WED	THUR	FRI	SAT	SUN
Discussion of Niche Workbook Exercises on Niche	Movie: Tidepools	Nature Walk and Plant Collecting	Draw Maps of Nature Walks and Plants	Discussion of Maps Chapter Test		

Land Ecosystems (Interview Conducted on Monday)

IF THE STUDENT DOES NOT REMEMBER, PROVIDE MORE DETAIL TO JOG HER/HIS MEMORY. DON'T PROCEED TO THE NEXT DAY UNTIL THE STUDENT APPEARS TO REMEMBER WHAT HAPPENED.

> "On Tuesday, there was a movie about Tidepools. It showed sea anenomes and how the tide changed the shape of the land. Do you remember that movie? (If not, provide more detail.)
>
> "On Wednesday, Mrs. Jones took the class outside on a nature walk around the football field. It was cold and windy. Remember? (If not, provide more detail.)
>
> "Thursday, the class drew maps which showed where people had found different flowers and weeds. Mrs. Jones answered a lot of questions that day about dandelions. Remember? (If not, provide more detail.)
>
> "On Friday, the class did two things. First, there was a discussion of different student's maps, and people disagreed about whether there were plants growing on the track. Then, Mrs. Jones gave a test on Chapter 7, "Plants and Their Neighbors." Do you remember the discussion and the test? (If not, provide more detail.)

END THIS INTRODUCTORY SECTION BY CHECKING THE STUDENT'S MEMORY WITH A BRIEF QUESTION ABOUT ONE OF THE DAYS.

> "I'm going to check your memory before we go on. What were some of the animals besides sea anenomes that were shown in the tidepool movie?

IF THE STUDENT'S RESPONSE INDICATES S/HE DOES NOT REMEMBER VERY MUCH, FIND OUT WHAT THE STUDENT DOES REMEMBER AND BUILD FROM THERE, ASKING QUESTIONS, AND PROVIDING FACTUAL DETAILS OF EACH DAY'S ACTIVITIES.

Once you have finished reharsing your discussion of the Lesson Summary Chart, it is necessary to prepare the "explaining" and "relating" questions (e.g., 14 & 15) which appear in the second part of the interview. The purpose of these questions is to assess each student's understanding of one science concept explained by the teacher and one concept which the teacher related to (1) science as a social historical process; (2) science as a reasoning process; (3) science, society/technology; or (4) positive science attitudes. If no relating behavior was observed, skip this question.

The basic format for these questions is to ask the student to teach you the information covered by the teacher in order to provide verbatim, tape-recorded evidence of the student's understanding.

Before conducting the interview, select the explaining and relating concepts you will ask the student about. Choose these concepts to reflect the best teacher explanations you observed, whether they focused on the same or different lesson topics.

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Interview Procedures

It is essential that the interviewer review all of the questions to be asked in each part of the interview before talking with the student. Keep an overview of the entire interview in mind, so that you will be able to pace yourself and cover all of the questions.

Introduction

Follow the script you have already rehearsed and review the Lesson Summary Sheet with the student. Do no rush this. It is essential to the completion of a good interview.

Part 1: Student's Perceptions of the Week's Lessons

Questions 1 - 8 focus directly on student's perceptions of the previous week's lessons. They combine both open-ended and structured questions. It is important to probe when asking both of these types of questions; the probing strategy, however, varies with question type.

After asking open-ended questions 5 and 6, probe to elicit as much information as possible about the way students perceive and conceptualize the act of learning. Try to get inside their heads. Urge them to comment upon what the experience of learning science is like.

The remainder of questions in Part 1 are explicitly structured. Appropriate categories of student response have been predefined. After asking these questions, the function of probing is to clarify into which category the student's response fits. The interviewer should probe until the student's response is unambiguous and can be coded. Consequently, probing can be more direct, and the coding categories can be mentioned. An interviewer might ask, for example, "Was this lesson 'really' good because bacteria are interesting, or because the teacher explained it in an interesting way?"

Question 2 (and later Question 12) requires you to determine what aspect of the student's classroom experience was responsible for his or her interest. The coding of student responses is organized roughly according to the task form heuristic (Blumenfeld, Mergendoller, & Swarthout, forthcoming). This heuristic allows for the organization of classrom experience into the following categories: (1) Content, (2) Teacher, (3) Task, and (4) Perceived Accomplishment.

The Content dimension focuses on what the student learns. Four alternatives appear on the interview schedule. Subject Matter refers to the formal content of the lesson, e.g., bacteria, protozoa, seed plants, natural selection and the like. I Learned About Myself refers to personally useful knwoeldge, e.g., heart rate, effect of drugs, preferred values, etc. There Was No Right Answer refers to instructional formats requiring divergent thinking, e.g., brainstorming, hypothesis generation, etc. The final alternative, Other is used for aspects of the lesson content mentioned by the student but not readily categorizable into the preceding three categories.

The Teacher dimension focuses on the way the teacher presents the curriculum content. It is essential here to discriminate the content itself (e.g., protozoa) from the way the teacher presents the content (e.g., "making it fun to learn about protozoa"). Three alternative codings appear on the interview schedule. Teacher Characteristics includes the humor, the enthusiasm, the clearness with which the teacher speaks as well as other teacher traits. These attributes are long-term and consistent, and make the content being covered more interesting. Demonstration refers to the particular demonstration activity the teacher used to make a fact or concept come alive. Additional aspects of the teacher's instructional performance referred to by students should be noted under Other.

The Task dimension focuses on the actual task students complete. Five self-explanatory categories appear on the interview schedule: (1) Different, Unusual, Novel, Unexpected, (2) Hands-On, Manipulatory Activity, (3) Outdoor Activity/Field Trip, (4) I Worked with My Friends, and (5) Other.

The next dimension, that of Perceived Accomplishment, refers to students' expressions of satisfaction and accomplishment. It Was Easy is used to indicate that the student found the task interesting because it was easy to complete. I Did Well refers to expressions of satisfaction resulting from positive academic attainment. As usual, the Other category is available for additional responses reflecting students' perceptions of accomplishment.

A final Miscellaneous category appears at the end of the question. Use this category only if you are absolutely certain that the student's response will not fit into one of the above categories.

Part 2: Student's Understanding of Past Week's Material

The second part of the interview employs questions prepared by the interviewer in advance. These focus directly on topics covered during the observation.

Here, the role fo the interviewer is to be a friendly, sympathetic, businesslike questioner. You are to conduct a low-key oral exam with the student in order to assess her/his knowledge. Ask the student to tell you about the appropriate material and probe to determine the limits to understanding.

Part 3: Student's Response to the Semester's Lessons

The final part of the interview employs essentially the same format used in Part 1 to elicit student's perceptions of the science lessons and activities they have encountered during the semester.

The first three questions are structured. As before, the interviewer should probe to determine which predetermined category best represents the student's responses.

The final question, Question 14, is open-ended and provides an opportunity for students to give their unexpurgated reactions to and recommendations for making science classes interesting. Interviewers should spend the remainder of the time allocated to the interview exploring this question with the students. Probe to evoke the kinds of activities, topics, field trips, and movies favored by students. The goal of this question is to elucidate student's visions of what an interesting and productive science class is like.

Rating Scales

Before leaving the school, complete the rating scales which appear as questions 15 and 16. These refer back to questions 9 and 10, and ask for the interviewer's judgment of the student's knowledge.

In completing these ratings, consider the quality of the teacher's explanation as the standard on which you base your ratings. The categories of understanding are as follows:

1 The student appears confused and understands nothing of the teacher's explanation.

2 The student demonstrates some understanding of the explanation given by the teacher. Confusion, however, has not been fully dissipated.

3 The student demonstrates a surface or literal understanding of the teacher's explanation. S/he can "parrot" what was said in class.

4 The student demonstrates an in-depth understanding of the teacher's explanation, and can explain the principles involved, or somehow go beyond the surface explanation.

5 The student's understanding appears to be greater than that of the teacher.

Please provide your own written assessment of the students' attainments in the space reserved for comments. Write as much as you like.

Also, please indicate the quality of the interview in Question 18. An EXCELLENT interview is one where the student is articulate and you feel certain that you understood what was said. A SATISFACTORY interview is one where you did not experience major confusion or uncertainty, and you feel relatively confident that you understood what the student was trying to say. At the end of an UNSATISFACTORY interview, the

the interviewer feels confused and qustions whether what has been written down on the paper actually corresponds to what the student meant. In all cases, please write a paragraph of comments about the interview under "General Comments."

References

Blumenfeld, P., Mergendoller, J., & Swarthout, D. (forthcoming). The task form heuristic. Journal of Curriculum Studies.

Pre-Observation Checklist

Have you:

______ Interviewed the teacher?

______ Learned the names and faces of all students in the class?

______ Drawn a detailed map and seating chart of the class?

______ Dictated a detailed class description to accompany the map?

______ Given the parent permission letters and envelopes to the teacher?

______ Completed parts 1 - 5 of the curriculum content analysis packet, thus analyzing the teacher's main textbook?

______ Given the teacher the Topic Questionnaire one week prior to beginning observations (applicable to topics #1 <u>and</u> #2)?

______ Obtained sufficient numbers of copies of the forms you will need during observation (i.e. narrative summary sheets, SCD)?

______ Read and reviewed Sections 4-9 of the Observer Manual?

Topic Observation Period Checklist

First Day of Observation

Have you:

_____ Picked up the Topic Questionnaire on the first day of observation and identified it?

_____ Scheduled interviews with target students?

Each Day of Observation

Have you:

_____ Labeled the tape of the class?

_____ Completed your narratives?

_____ Labeled the tape of your narrative?

_____ Completed the appropriate Narrative Record Sheets?

_____ Filled in the SCD?

_____ Labeled and identified any curriculum materials or copies of assignments you collected?

_____ Read and corrected your transcript from the previous day?

Last Days of Observation

Have you:

_____ Arranged and administered the Student Topic Involvement and Interest Form to entire class?

_____ Conducted interviews with 6 target students?

_____ Labeled tape of each student interview?

_____ Read and corrected transcripts of each student interview?

_____ Arranged and conducted teacher Post Topic Interview?

_____ Labeled tape for teacher Post Topic Interview?

_____ Read and corrected transcript of teacher Post Topic Interview?

_____ Borrowed and photocopied all tests or quizzes on topic that students completed?

_____ Returned borrowed tests or quizzes to teacher?

_____ Handed over all forms, transcripts and tapes to site data manager?

SECTION TEN: TEACHER POST-TOPIC INTERVIEW

Alexis Mitman and John Mergendoller

After completing the observation of each topic, we would like you to schedule a brief interview with the teacher. It is desirable that this interview be scheduled no later than one week following the last day of observation. Also, it is important to plan the interview so that it could be completed during a teacher's prepartory period.

The purpose of this post-topic interview is two-fold. First, it is an opportunity for you to fill in any "blank spots" in your data collection. For example, observers have noted that some teachers' responses to the Teacher Topic Questionnaire were not always complete and that it also was difficult to get information on task dimensions (e.g., the teachers' grading system) during class. This interview, then, will give you the chance to collect these kinds of data. The second purpose of the interview is to collect some of the teacher's general perceptions about the topic instruction.

For the first part of the interview, it is impossible to anticipate the kinds of questions each observer may need to ask in order to fill in their "blank spots." Thus, we simply suggest some general areas that you may need to cover. Here, it is up to you to plan your own questions ahead of time. Please write them directly on the interview schedule. For the second part of the interview, we have specific questions that we would like you to ask. Please "personalize" these to fit your specific situations but don't tamper with the intent of the question.

As with the Science Teacher Interview (Section Three), we would like you to tape-record the interview if the teacher grants permission. Also, we would like you to write down brief notes on the interview form.

12/7/83
Updated

COVER SHEET: TARGET STUDENT INTERVIEW

Student's ID: ____________________

School: ____________________

Interviewer ID: ____________________

Date: ____________________

TARGET STUDENT INTERVIEW SCHEDULE

Introduction

Discuss the Lesson Summary Sheet with the student and check for recollection and understanding of week's activities. Draw the student's attention to every academic activity segment which occurred during the past week. Discuss one day at a time, and stop at the end of each day to make sure the student remembers what happened.

Proceed as in the following example.

BEGIN WITH AN INTRODUCTORY STATEMENT THAT ORIENTS THE STUDENT AND GIVES A GENERAL IDEA OF WHAT THE INTERVIEW IS ABOUT.

> "I's going to ask you some questions about the things you did in class last week, and I'd like you to think hard and remember what Mrs. Jone's life science class was like last week." (Be sure to use the actual name of the class.)

TAKE OUT LESSON SUMMARY CHART AND PLACE IT DIRECTLY IN FRONT OF INTERVIEWEE. GO THROUGH THE ACTIVITIES DAY BY DAY.

> "Now (Student's name), on Monday, Mrs. Jones discussed with the class what the word, niche, meant and how it was an important concept in ecology. This discussion continued for about half of the class, and then students did workbook exercises about the concept of niche. Do you remember the discussion and doing the exercises?

IF THE STUDENT DOES NOT REMEMBER, PROVIDE MORE DETAIL TO JOG HER/HIS MEMORY. DON'T PROCEED TO THE NEXT DAY UNTIL THE STUDENT APPEARS TO REMEMBER WHAT HAPPENED.

CONTINUE THROUGH THE REMAINDER OF THE WEEK.

END THIS INTRODUCTORY SECTION BY CHECKING THE STUDENT'S MEMORY WITH A BRIEF QUESTION ABOUT ONE OF THE DAYS. FOR EXAMPLE:

> "I'm going to check your memory before we go on. What were some of the animals besides sea anenomes that were shown in the tidepool movie?

IF THE STUDENT'S RESPONSE INDICATES S/HE DOES NOT REMEMBER VERY MUCH, FIND OUT WHAT THE STUDENT DOES REMEMBER AND BUILD FROM THERE, ASKING QUESTIONS, AND PROVIDING FACTUAL DETAILS OF EACH DAY'S ACTIVITIES.

Part 1: Student's Perceptions of the Past Week's Lessons

1. We've just been talking about the things you did last week. Which of these was the most interesting? Would you like to do it again? (WRITE ANSWER BELOW)

Do Again? ___Yes ___No

2. What was it about ____________ that made it interesting? What was that? What else? What would you say to a friend who asked you why it was interesting? (CODE ANSWERS BELOW BY PLACING A "1" NEXT TO THE FIRST ANSWER GIVEN, A "2" NEXT TO THE SECOND, ETC.)

Task Form Dimension	Answer Given
Content	____ SUBJECT MATTER
	____ I LEARNED ABOUT MYSELF
	____ THERE WAS NO RIGHT ANSWER
	____ OTHER CONTENT ____________
Teacher	____ TEACHER CHARACTERISTICS
	____ DEMONSTRATION
	____ OTHER TEACHER ____________
Task	____ DIFFERENT, UNUSUAL, NOVEL, UNEXPECTED
	____ HANDS-ON, MANIPULATORY ACTIVITY
	____ OUTDOOR ACTIVITY/FIELD TRIP
	____ I WORKED WITH MY FRIENDS
	____ OTHER TASK ____________

Task Form Dimension	Answer Given
Perceived Accomplishment	____ IT WAS EASY
	____ I DID WELL
	____ OTHER ACCOMPLISHMENT ____________
Miscellaneous	____ OTHER ____________________
	____ OTHER ____________________

3. You've mentioned that ____________, and ____________, and ____________ all helped to make ________________ interesting. Which was the most important thing? (CIRCLE THE APPROPRIATE ANSWER)

4. Now using the scale on the back of this page, show me exactly how interesting ______________ was. (CIRCLE STUDENT'S RESPONSE BELOW)

1 2 3 4 5

5. Did you feel you were learning something while you were doing this? How did you know that? (Why or why not? Tell me more about how you knew this.) What were you learning?

6. Now think again about all of the things you did last week (POINT TO THE TEMPLATE). When did you feel you were learning the most? Why was that?

7. Now using the scale on the back of this page, show me exactly how much you learned. (CIRCLE STUDENT'S RESPONSE BELOW)

1 2 3 4 5

8. Would you say the things you did in class last week were the same sorts of things you usually do in a week, or were they different in some way? (How were they different?) (PROBE AND INDICATE RESPONSE BELOW)

_____ SAME _____ DIFFERENT _____ BOTH

Part 2:

Student's Understanding of Past Week's Material

9. (EXPLAINING QUESTION) You remember that on (DAY OF THE WEEK), (TEACHER'S NAME) talked about ____________. I missed part of that. Could you tell me what she said? (CONTINUE TO PROBE TO GET AT STUDENT'S UNDERSTANDING OF THE CONTENT PRESENTED)

10. (RELATING QUESTION) On (DAY OF THE WEEK), (TEACHER'S NAME) talked about ____________. What exactly was she saying? (CONTINUE TO PROBE TO GET AT STUDENT'S UNDERSTANDING OF THE RELATING ASPECT OF THE PRESENTATION)

Part 3:

Student Response to the Semester's Lessons

11. OK, (STUDENT'S NAME), now I am going to ask you some questions about what you have done so far this year in Life Science. This back about everything you have done in Life Science since school started in September. What DAY was the most interesting? (PROBE FOR THE ACTIVITY, LECTURE, DISCUSSION, DEMONSTRATION, FILM, SPEAKER, ETC., THAT CAUGHT STUDENT'S INTEREST. WRITE ANSWER BELOW.)

12. What was it about ______________ that made it interesting? What was that? What else? What would you say to a friend who asked you why it was interesting? (CODE ANSWERS BELOW BY PLACING A "1" NEXT TO THE FIRST ANSWER GIVEN, A "2" NEXT TO THE SECOND, ETC.)

Task Form Dimension	Answer Given
Content	_____ SUBJECT MATTER
	_____ I LEARNED ABOUT MYSELF
	_____ THERE WAS NO RIGHT ANSWER
	_____ OTHER CONTENT ______________
Teacher	_____ TEACHER CHARACTERISTICS
	_____ DEMONSTRATION
	_____ OTHER TEACHER ______________
Task	_____ DIFFERENT, UNUSUAL, NOVEL, UNEXPECTED
	_____ HANDS-ON, MANIPULATORY ACTIVITY
	_____ OUTDOOR ACTIVITY/FIELD TRIP
	_____ I WORKED WITH MY FRIENDS
	_____ OTHER TASK ______________

Task Form Dimension	Answer Given
Perceived Accomplishment	____ IT WAS EASY
	____ I DID WELL
	____ OTHER ACCOMPLISHMENT ____________
Miscellaneous	____ OTHER ____________
	____ OTHER ____________

13. You've mentioned that ____________, and ____________, and ____________ all helped make ____________ intersting. Which was the most important thing? (CIRCLE THE APPROPRIATE ANSWER ABOVE)

OK

14. If you were the teacher, and wanted to teach a science class that students thought was interesting what would you do? What else? Why?

Concluding Statement

Thank you ____________, for talking with me. I've been asking all of the questions; do you have any for me? (ANSWER QUESTIONS. GIVE STUDENT THE $5 HONORARIUM.)

Rating Scales

15. Interviewer's rating of student's understanding of the EXPLAINED CONTENT discussed in Qeustion 13.

1	2	3	4	5
Confused; Understood nothing of teacher's explanation	Some understanding of teacher's explanation	Surface understanding of teacher's explanation	In-depth understanding of teacher's explanation	Articulate understanding grather than the teacher

Comments:

16. Interviewer's rating of student's understanding of the RELATING CONTENT discussed in Question 14.

1	2	3	4	5
Confused; Understood nothing of teacher's explanation	Some understanding of teacher's explanation	Surface understanding of teacher's explanation	In-depth understanding of teacher's explanation	Articulate understanding grather than the teacher

Comments:

17. Overall, this interview was

_____ EXCELLENT _____ SATISFACTORY _____ UNSATISFACTORY

General Comments on Interview:

COVER SHEET: TEACHER POST-TOPIC INTERVIEW

Teacher's ID: ______________________

School: ______________________

Interviewer's ID: ______________________

Date: ______________________

Topic: ______________________

PART ONE

Directions: Review your teacher's responses to the Teacher Topic Questionnaire. Note if there are any questions that were not answered adequately. Here, you should focus mainly on any questions that would increase your understanding of how the teacher originally planned the topic lessons. Use the space below to write down any questions you have.

Next, review the Narrative Summary Sheets and the Science Class Description (SCD) forms that you completed during the topic observations. Again, note any questions that you have. Pay particular attention to whether you have complete information about the class tasks. Again, use the space below to write down any questions in these areas that you have.

Introductory Remarks

Hello, (Mrs. Jones). I wanted to have this opportunity to talk with you for two reasons. First, there were some questions that arose during my observations that I didn't have a chance to ask you at the time. Second, I'd like to get some of your overall impressions of the lessons I observed. I started observing on (day of week) and finished on (day of week). To simplify things, I will call all of your lessons on ______________________, the topic lessons.

1.1

1.2.

1.3

1.4

1.5

1.6

1.7

PART TWO

Now I would like to ask you a few questions about the ____ days when you covered the topic of ____________________.

2.1. Looking back, is there anything in particular you planned to do with the topic this time that you were unable to do? If so, what?

2.2. Are there any parts of the topic lessons that you thought went especially well? If so, what were they?

2.3. Are there any parts of the topic lessons that did not go as well as you expected? If so, what were they? Why do you think this happened?

2.4. Do you feel that students learned what you wanted them to learn about the topic when you talked to the class and when they did seatwork? Can you tell me more about this?

2.5. Do you feel that students learned what you wanted them to learn about the topic <u>when they did laboratory activities</u>? Can you tell me more about this?

2.6. (OPTIONAL) Do you feel that students learned what you wanted them to learn about the topic when [describe any other major activity, e.g., they saw films]? Can you tell me more about this?

2.7. If you were to teach this topic again next year, is there anything you would do differently from what you did this time? If so, what?

2.8. Is there anything else that comes to mind when you think about the topic lessons?

2.9. Are there any questions you would like to ask me?

Again, I thank you very much for your help and your willingness to spend this time with me.

APPENDIX B

IDEAS ABOUT SCIENCE SURVEY

Directions: The questions in this section ask you about your science class this year. For each question, circle the answer that best describes this class. There are no right or wrong answers. Don't worry about what others might expect you to say. Your answers will remain confidential.

PART I.

IN SCIENCE CLASS THIS YEAR, HOW OFTEN DID THE TEACHER TALK ABOUT:

	Very Often	Often	Sometimes	Seldom	Never
1. the way that science affects you in everyday life?	1	2	3	4	5
2. the lives of important scientists?	1	2	3	4	5
3. how to observe the natural world?	1	2	3	4	5
4. definitions of science words?	1	2	3	4	5
5. how the work of future scientists may change ideas about nature that we have today?	1	2	3	4	5
6. possible careers in science?	1	2	3	4	5
7. the way to develop and test a hypothesis?	1	2	3	4	5
8. how things we use each day depend on science?	1	2	3	4	5
9. how scientific discoveries change how we live?	1	2	3	4	5
10. how to do experiments?	1	2	3	4	5
11. the names for different parts of animals and plants?	1	2	3	4	5
12. how science can be a fun hobby?	1	2	3	4	5

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	Very Often	Often	Sometimes	Seldom	Never
13. science facts?	1	2	3	4	5
14. how the work of men and women results in scientific ideas?	1	2	3	4	5
15. how exciting discoveries are always being made by scientists?	1	2	3	4	5

PART II.

	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
16. The teacher gives clear directions.	1	2	3	4	5
17. It is easy to know who the smartest kids are.	1	2	3	4	5
18. Sometimes we talk about things that have little to do with science.	1	2	3	4	5
19. When the teacher asks questions, students answer without raising hands.	1	2	3	4	5
20. We often run out of things to do.	1	2	3	4	5
21. The teacher lets too many students misbehave.	1	2	3	4	5
22. There are clear rules for handing out and passing in papers.	1	2	3	4	5
23. The same kids always talk.	1	2	3	4	5
24. We waste a lot of time in this class.	1	2	3	4	5

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	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
25. The teacher grades fairly.	1	2	3	4	5
26. I am often confused after the teacher explains something.	1	2	3	4	5
27. The teacher makes me want to learn about science.	1	2	3	4	5
28. I always know what I am supposed to do.	1	2	3	4	5
29. The teacher thinks that I can learn science.	1	2	3	4	5
30. The teacher always calls on the same students.	1	2	3	4	5
31. We often leave work unfinished.	1	2	3	4	5
32. It is too noisy to think.	1	2	3	4	5
33. There is always something interesting to do.	1	2	3	4	5
34. I often am not sure what I should be working on.	1	2	3	4	5
35. The teacher grades our work quickly.	1	2	3	4	5
36. The same kids always get good grades.	1	2	3	4	5
37. I know I can do well in this class.	1	2	3	4	5

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PART III.

38. WHEN I DO HOMEWORK, I GET THE RIGHT ANSWERS BY:

	Always	Often	Sometimes	Seldom	Never
a. looking them up in the textbook.	1	2	3	4	5
b. remembering them from class discussion.	1	2	3	4	5
c. thinking about them.	1	2	3	4	5
d. asking the teacher.	1	2	3	4	5
e. looking them up in my notes.	1	2	3	4	5
f. asking my friends.	1	2	3	4	5

39. WHEN I DO WORKSHEETS, I GET THE RIGHT ANSWERS BY:

	Always	Often	Sometimes	Seldom	Never
a. looking them up in the textbook.	1	2	3	4	5
b. remembering them from class discussion.	1	2	3	4	5
c. thinking about them.	1	2	3	4	5
d. asking the teacher.	1	2	3	4	5
e. looking them up in my notes.	1	2	3	4	5
f. asking my friends.	1	2	3	4	5

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40. WHEN I FILL OUT LAB WORKSHEETS, I GET THE RIGHT ANSWERS BY:

	Always	Often	Sometimes	Seldom	Never
a. looking them up in the textbook.	1	2	3	4	5
b. remembering them from class discussion.	1	2	3	4	5
c. thinking about what I saw during the lab activity.	1	2	3	4	5
d. asking the teacher.	1	2	3	4	5
e. looking them up in my notes.	1	2	3	4	5
f. asking my friends or lab partners.	1	2	3	4	5

41. IF YOU WANT TO LEARN ABOUT SCIENCE, HOW IMPORTANT ARE THE FOLLOWING?

	Very Important	Important	Not too Important	Not at all Important
a. asking yourself your own questions about what you are learning	1	2	3	4
b. memorizing science vocabulary words	1	2	3	4
c. thinking about the meaning of what you are studying	1	2	3	4
d. memorizing science facts	1	2	3	4
e. thinking about how you would solve problems if you were a scientist	1	2	3	4
f. remembering how to classify living things	1	2	3	4
g. thinking about the main ideas of a lesson	1	2	3	4

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42. WHAT COUNTS TOWARD YOUR GRADE IN SCIENCE?

	Doesn't Count At All	Counts A Little	Counts Some	Counts A Lot
a. filling out worksheets	1	2	3	4
b. doing lab activities	1	2	3	4
c. filling out lab worksheets	1	2	3	4
d. watching movies or filmstrips	1	2	3	4
e. answering the teacher's questions during class discussions	1	2	3	4
f. taking quizzes and tests	1	2	3	4

43. HOW CAREFULLY DO YOU THINK ABOUT SCIENCE WHEN YOU:

	Very Carefully	Carefully	Not too Carefully	Not at all Carefully
a. listen to the teacher talk about science?	1	2	3	4
b. fill out worksheets?	1	2	3	4
c. do lab activities?	1	2	3	4
d. fill out lab worksheets?	1	2	3	4
e. watch movies or filmstrips	1	2	3	4
f. answer the teacher's questions during class discussions?	1	2	3	4
g. take quizzes or tests?	1	2	3	4

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44. HOW MUCH DO YOU LEARN WHEN YOU ARE:

	I Learn Nothing	I Learn A Little	I Learn Some	I Learn A Lot
a. listening to the teacher talk about science?	1	2	3	4
b. filling out worksheets?	1	2	3	4
c. doing lab activities?	1	2	3	4
d. filling out lab worksheets?	1	2	3	4
e. watching movies or filmstrips?	1	2	3	4
f. taking quizzes or tests?	1	2	3	4

45. IN THIS SCIENCE CLASS:

	Very Hard	Hard	Just Right	Easy	Very Easy
a. the things we read about science are:	1	2	3	4	5
b. the worksheets we fill out are:	1	2	3	4	5
c. the lab activities we do are:	1	2	3	4	5
d. the lab worksheets we fill out are:	1	2	3	4	5
e. the movies and filmstrips we watch are:	1	2	3	4	5
f. the quizzes and test we take are:	1	2	3	4	5

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46. HOW INTERESTING ARE THE FOLLOWING CLASS ACTIVITIES?

	Very Interesting	Interesting	OK	Not Interesting	Not at all Interesting
a. listening to the teacher talk about science	1	2	3	4	5
b. filling out worksheets	1	2	3	4	5
c. doing lab activities	1	2	3	4	5
d. filling out lab worksheets	1	2	3	4	5
e. watching movies or filmstrips	1	2	3	4	5
f. answering the teacher's questions during class discussion	1	2	3	4	5
g. taking quizzes or tests	1	2	3	4	5

47. DO YOU KNOW WHAT YOU ARE SUPPOSED TO LEARN WHEN YOU:

	Always	Often	Sometimes	Seldom	Never
a. listen to the teacher talk about science?	1	2	3	4	5
b. fill out worksheets?	1	2	3	4	5
c. do lab activities?	1	2	3	4	5
d. fill out lab worksheets?	1	2	3	4	5
e. watch movies or filmstrips?	1	2	3	4	5
f. answer the teacher's questions during class discussions?	1	2	3	4	5
g. take quizzes or tests?	1	2	3	4	5

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	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
48. I OFTEN KNOW THE RIGHT ANSWERS, BUT I HAVE TROUBLE WRITING THEM DOWN:					
a. on homework assignments.	1	2	3	4	5
b. on worksheets.	1	2	3	4	5
c. on lab worksheets.	1	2	3	4	5
d. on tests and quizzes.	1	2	3	4	5
49. I OFTEN KNOW THE RIGHT ANSWERS, BUT I HAVE TROUBLE SAYING THEM:					
a. in class discussions.	1	2	3	4	5
b. when the teacher asks me a question.	1	2	3	4	5
50. I ALWAYS KNOW WHAT THE TEACHER IS LOOKING FOR WHEN SHE GRADES:					
a. my homework.	1	2	3	4	5
b. my worksheets.	1	2	3	4	5
c. what I say in class.	1	2	3	4	5
d. my lab sheets.	1	2	3	4	5
e. my quizzes and tests.	1	2	3	4	5

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	Very Important	Important	Not Very Important	Not at all Important
51. ON HOMEWORK, HOW IMPORTANT IS IT:				
a. to be neat?	1	2	3	4
b. to have the right answers?	1	2	3	4
c. to turn it in on time?	1	2	3	4
d. to think carefully about what you are learning?	1	2	3	4
52. ON WORKSHEETS, HOW IMPORTANT IS IT:				
a. to be neat?	1	2	3	4
b. to have the right answers?	1	2	3	4
c. to turn it in on time?	1	2	3	4
d. to think carefully about what you are learning?	1	2	3	4
53. ON LAB WORKSHEETS, HOW IMPORTANT IS IT:				
a. to be neat?	1	2	3	4
b. to do the experiment right?	1	2	3	4
c. to write down the right answers?	1	2	3	4
d. to turn it in on time?	1	2	3	4
e. to think carefully about what you are learning?	1	2	3	4
54. DURING CLASS DISCUSSIONS, HOW IMPORTANT IS IT:				
a. to say something, even if it is not about science?	1	2	3	4
b. to give right answers to the teacher's questions?	1	2	3	4
c. to raise your hand before you speak out?	1	2	3	4
d. to not say wrong answers?	1	2	3	4

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55. IN THIS CLASS:

	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
a. I wish we did more laboratory activities.	1	2	3	4	5
b. I wish we did more different kinds of activities.	1	2	3	4	5
c. turning in your work quickly is more important than having all the answers right.	1	2	3	4	5
d. doing extra credit work is more important than regular work.	1	2	3	4	5
e. really understanding science is more important than getting all the answers right.	1	2	3	4	5

56. IN THIS CLASS, ABOUT HOW MANY STUDENTS PAY ATTENTION THE WHOLE TIME WHEN THEY:

	Everyone	Almost Everyone	About Half	Almost Nobody	Nobody
a. listen to the teacher talk about science?	1	2	3	4	5
b. fill out worksheets?	1	2	3	4	5
c. do lab activities?	1	2	3	4	5
d. fill out lab worksheets?	1	2	3	4	5
e. watch movies or filmstrips?	1	2	3	4	5
f. participate in class discussions?	1	2	3	4	5
g. take quizzes or tests?	1	2	3	4	5

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57. THINKING OF THE TEXTBOOK USED THE MOST IN THIS CLASS:

	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
a. the textbook describes the lives of many scientists.	1	2	3	4	5
b. the textbook is easy to read.	1	2	3	4	5
c. the textbook makes me want to learn more about science.	1	2	3	4	5
d. the textbook is boring.	1	2	3	4	5
e. we all concentrate when we read the textbook.	1	2	3	4	5
f. the textbook has lots of examples of how science affect our daily lives.	1	2	3	4	5
g. the textbook is mostly definitions and facts.	1	2	3	4	5
h. the textbook often describes the methods scientists use to learn about living things.	1	2	3	4	5
i. we spend too much time using the textbook.	1	2	3	4	5

STOP HERE.

APPENDIX C

TEACHER ACTIVITIES FOR TOPICS 1 AND 2

Table 1. Duration of Classroom Activities During Reproduction and Heredity Unit (Teacher 1)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Class Begins	Opening Transition	Recitation: Genetics History Directions for Assignment	Recitation: Asexual Reproduc. Opening Transition	Review Recitation: Asexual Reproduction	Statement on Discipline
5 min.	Teacher Recitation: Spontaneous Generation	Recitation: Asexual Reproduction	Procedures, Directions for Day	Directions for Group Presentation	Procedures for Yeast Observation
10 min.	Review Cell Division		Group Seatwork: Methods of Asexual Reproduction	Group Presentations on Methods of Asexual Reproduction	Seatwork on Asexual Reproduction
15 min.		Transition to Groups Group Seatwork; Methods of Asexual Reproduction			Yeast Observation
	Teacher Recitation: Preview of New Unit				
25 min.	Quiz on Prior Unit: Cell Division				Grade Seatwork
30 min.			Microscope Observation Budding Yeast		Recitation on Asexual Reproduction Teacher Explains and Records Grades on Worksheet
35 min.	Correcting Quiz				
40 min.				Review of Methods of Asexual Reproduction	Directions for Planaria Laboratory
45 min.			DISMISSAL		
50 min.	DISMISSAL	DISMISSAL		DISMISSAL	DISMISSAL

Table 1 (continued). Duration of Classroom Activities During Reproduction and Heredity Unit (Teacher 1

	DAY 6	DAY 7	DAY 8	DAY 9	DAY 10
Class Begins	Opening Transition	Opening Transition	Opening Transition	Opening Transition Vegetable Reproduction Assignment	Opening Transition
5 min.	Recitation: Regeneration in Planaria		Continued Planarian Lab	Recitation: Vegetative Reproduction	Recitation: Heredity
10 min.	Procedures for Planaria Study	Recitation on Sexual Reproduction		Directions for Seatwork; Crossword Puzzle	Procedures for Seatwork
15 min.			Directions for "Takehome Test": Reproduction: Logistics and Procedures		Film on Inherited Traits
20 min.	Planaria Regeneration Lab			Seatwork: Crossword Puzzle on Reproduction Vocabulary	
25 min.			Recitation on Cell Division		Recitation on Inherited Traits
30 min.		Seatwork	Additional Directions for "Takehome Test"		Procedures for Seatwork
35 min.		Continued Recitation-Discussion on Sexual Reproduction			
40 min.	Clean-up		Seatwork: "Takehome Test" on Reproduction		Seatwork-Lab: Checklists of Inherited Traits
45 min.	Review Lab Sheet Recitation on Grafting	Videotape on Sexual Reproduction in Sea Urchins	Review on Reproduction	Review Game on Unit Vocabulary	
50 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

Table 2. Duration of Classroom Activities During Ecology Unit (Teacher 1)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Class Begins	Opening Transition Recitation: Ecology	Recitation on Ecosystems	Opening Transition, Procedures Bobcat Assignment	Opening Transition Vocabulary Review	Opening Transition Recitation: Vocabulary
5 min.	Transition Pretest: Ecology	Directions on Seatwork	Directions on Unit Objectives	Procedures, Directions for Bear Concept Dramatization	Directions for Day, Owl Pellet Activity
10 min.	Vocabulary	Seatwork:	Seatwork: Inferences from Animal Tracks		
15 min.	Transition	Ecosystem Vocabulary	Students Report	Transition Bear Concept Dramatization, Outside	One-half of Class Works on Fishkill
20 min.	Recitation: The Environment	and Food Webs	Soil Lab Instructions	Transition, Data Writing	Seatwork; One-half on
25 min.		Recitation: Communities	Recitation-Instructions: Soil Lab	Class Talks About Concept Dramatization	Owl Pellet Activity
30 min.	Transition Concept Dramatization: Introduction	Seatwork Continued: Ecosystem		Procedures for Seatwork	
35 min.	Recitation	Vocabulary and	Soil Lab	Seatwork: Moose Population	
40 min.	Concept Dramatization: Space Needs	Food Webs	Correct Soil Lab	Dynamics	
45 min.	Recitation: Space Needs, Review of Vocabulary Dramatization: Space Needs	Transitions	Procedures, Transitions	Transitions, Procedures	Transitions, Clean-up, Directions
50 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

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Table 2 (continued). Duration of Classroom Activities During Ecology Unit (Teacher 1)

	DAY 6	DAY 7	DAY 8	DAY 9
Class Begins	Opening Transition Recitation: Owl Habits	Opening Transition Discussion, Reviews of Ecology Concepts, Vocabulary	Opening Transition Review of Ecology Concepts, Vocabulary	Opening Transition Students Report on Science Fair Projects
5 min.	Directions on Completing Past Assignments Seatwork Fishkill and Owl Pellets			Directions on Completing Assignments
10 min.		Review of Natural Resources; Students Complete Worksheets		Discussion: Environment
15 min.	Recitation: Rodent Skulls	Film Strip: Natural Resources	Guest Speaker on Hazardous Wastes	Videotape on Bighorn Sheep
20 min.	Seatwork Owl Pellets			Review of Videotape Seatwork on Vocabulary
25 min.				Directions for Crosswork Puzzle
30 min.				Crossword Puzzle Seatwork
35 min.				
40 min.	Correcting Papers	Students Answer Questions on Filmstrip		
45 min.		Review of Next Day's Activities	Review on Hazardous Wastes	
50 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

Table 1. Duration of Classroom Activities During Protists Unit (Teacher 2)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Class Begins	Opening Transition and Collection of Notebooks	Opening Transition	Opening Transition		Opening Transition
5 min.	Seat Reassignment Review for Final Test	Studnets work in groups, each group has their own activitiy: 1. Observation Lab: Euglena, [illegible], Blue-Green Algae 2. Crossword Puzzle 3. Reading Catalog and Completing Worksheets 4. Reading pp. 194-204 and Answering Worksheet Questions 5. Watching Video on Bacteria: Friend or Foe 6. Reading pp. 204-09 and Answering Worksheet Questions 7. Microscope Safari: Finding and Identifying Micro-organisms 8. Vocabulary Worksheets, using each word in a sentence	Students Work In Groups on the Activities Defined on Day 2		Students Work In Groups on the Activities Defined on Day 2
10 min.	Students Take Test on Previous Unit: Food Chain			Opening Transition Students Work In Groups on the Activities Defined on Day 2	
15 min.					
20 min.					
25 min.	Pretests on Protists Passed Out Students Take Pretest on Protists				
30 min.					
35 min.	Teacher and Students Students Review and Correct Tests				
40 min.	Teacher Reorganizes Students into Groups				Students Take Class Surveys
45 min.	Students Read Chapter 10: Protists	Students Clean-up Wait for Bell to Ring			Students Have Free-Time
50 min.	DISMISSAL	DISMISSAL	DISMISSAL		DISMISSAL

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Table 1 (continued). Duration of Classroom Activities During Protists Unit (Teacher 2)

Class Begins	DAY 6	DAY 7	DAY 8	DAY 9	DAY 10	DAY 11
	Opening Transition	Opening Transition	Opening Transition	Opening Transition	Opening Transition	Opening Transition
5 min.	Students Work In Groups on the Activities Defined on Day 2	Students Work In Groups on the Activities Defined on Day 2	Students Work In Groups on the Activities Defined on Day 2	Students Work In Groups on the Activities Defined on Day 2	Teacher and Students Review Protists; Students Who Have Been Absent Catch-Up on Missed Work	Students Take Test on Protists and Correct It With Teacher; Students Turn In Notebooks
10 min.						
15 min.						
20 min.						
25 min.						
30 min.						
35 min.						
40 min.						
45 min.						
50 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

Table 2. Duration of Classroom Activities During Digestive Systems Unit (Teacher 2)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Class Begins	Students Take Pretest on Digestive Systems	Students Pass-Out Papers Recitation on Worksheets	Opening Transition; Vocabulary Tests Handed Out	Opening Transition	Opening Transition
5 min.			Students Take Vocabulary Test	Students Do Individual Seatwork, Reading to Find Answers To Teacher-Made Questions; Wait for Teacher Before Moving to Next Question	Seatwork: Students Read From Packets
10 min.	Seatwork: Students do Vocabulary Work-sheets on Digestive Systems Defining and Alphabetizing Words; Students Pick Up Calendar and Review	Students Complete Writing Assignments			
15 min.		Recitation on Worksheets. Teacher Questions Individual Students About the Reading	Review of Porifera, Osmosis, Coelenterates, Hydra from Packets		Directions for Observation Laboratory One-Half of Class Observes Various Phylum Representations, Labelling Parts and Answering Questions in Their Packets; One-Half of Class Complete Seatwork from Their Packets
20 min.					
25 min.					
30 min.		Students Complete Writing Assignment.	Students do Recitation and Teacher Questions Them on Their Reading		
35 min.			Students Complete Writing Assignment from Recitation Work		
40 min.		Teacher Questions Students About What They Have Read and Written in a Game Format			
45 min.					
50 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

Table 2 (continued). Duration of Classroom Activities During Digestive Systems Unit (Teacher 2)

Class Begins	DAY 6	DAY 7	DAY 8	DAY 9	DAY 10
	Opening Transition Students Correct Pre-Tests With Teacher	Opening Transition Recitation on Various Phylum and Their Characteristics	Students Take Vocabulary Test	Opening Transition Teacher Reviews Digestive Systems	Opening Transition Teacher Collects Notebooks Students Take Final Test on Digestive Systems
5 min.	Students Complete Packet Chart as Sample with the Teacher		Laboratory Preparation		
10 min.	Students Rotate in Observation Lab; Other Students Complete Packet Materials	Students Work at Laboratory or at Their Seats to Complete Their Assignments	Laboratory on Dissecting Worms	Teacher Asks Students About Digestive Systems Playing "Pass The Nerf Ball" to the Next Student to Respond	
15 min.					
20 min.					Students Exchange and Correct Tests; Teacher Records Grades and Collects Tests
25 min.					
30 min.					
35 min.					
40 min.			Clean Up DISMISSAL	Teacher Returns Corrected Papers; Students Have Free Time	Students Complete Evaluative Questionnaire on Unit
45 min.					
50 min.	DISMISSAL	DISMISSAL		DISMISSAL	DISMISSAL

Table 1. Duration of Classroom Activities During Porifera and Coelenterata Unit (Teacher 3)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7
Class Begins	Intercom Announcements	Intercom Announcements by Principal	Intercom Annoucements by Principal	Intercom Annoucements by Principal	Intercom Annoucements by Principal	Intercom Annoucements by Principal	Intercom Annoucements
5 min.	by Principal	Teacher Takes Attendance	Teacher Takes	Teacher	Teacher Takes Attendance		by Principal
10 min.	Teacher	Teacher Passes Out Worksheets,	Attendance	Reviews Symmetry with	Teacher Introduces Preserved Specimens, and	Teacher Leads Review	Students Study while Teacher Finishes Test
15 min.	Reviews Assertive Discipline	Gives Directions	Teacher Reviews	Students	Passes them Down the Rows	for Test	Teacher Distributes Test, Gives Directions
20 min.	Introduction	Seatwork: Students	Chapter 15 with Students		Directions for Finishing Assignments		
25 min.	to New Unit	Work on		Seatwork: Copy			Students Take
30 min.	(Chapter 15) Seatwork:	Word Search, Color and	Seatwork: Students	Coral Diagram; Complete	Seatwork: Complete Diagrams,		Test
35 min.	Word Search	Label Diagram of	Color Sponge and Hydra,	Other Diagrams	Answer Chapter-end Questions		
40 min.	Teacher Takes	Sponge and	Copy Animal			Students Complete Survey	DISMISSAL
45 min.	Attendance Grade Conferences	Hydra	Kingdom Diagram			Science Fair	
50 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	

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Table 2. Duration of Classroom Activities During Protection, Support, and Movement Unit (Teacher 3)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Class Begins	Intercom Annoucements by Principal	Intercom Annoucements by Principal	Intercom Announcements by Principal	Intercom Annoucements by Principal	Intercom Annouce-ments by Principal Review
5 min.	Recitation	Review of Skeleton	Teacher Takes Attendance	Recitation: Review of Bones	Teacher Gives Students Data from Lab
10 min.			Recitation: Pre-Lab Review "Bones"	Students in Small Groups; Teacher Gives Data for Lab Sheets	
15 min.	Introduction to Chapter 10: Skull, Skeleton of Frog and Man, Joints, Muscles, Ears, the Knee, Jaw and Teeth, Tendons, Vertebrae				Seatwork: Copy, Color, and Label Diagrams; Complete Skeleton Puzzle; Finish Lab Sheet
20 min.		Seatwork: Copy, Color, and Label Diagrams	Students in Small Groups for Laboratory		
25 min.				Students Finish Lab Sheets	
30 min.			Housekeeping and Seatwork	Seatwork: Copy and Color Diagrams	
35 min.					
40 min.			DISMISSAL		Class Review of Lab Sheet
45 min.					Seatwork
50 min.	DISMISSAL	DISMISSAL		DISMISSAL	DISMISSAL

Table 2 (continued). Duration of Classroom Activities During Protection, Support, and Movement Unit (Teacher 3)

Class Begins	DAY 6	DAY 7	DAY 8	DAY 9	DAY 10
	Intercom Annoucements by Principal; Students in	Intercom Annoucements by Principal	Intercom Annoucements by Principal Teacher	Intercom Annoucements by Principal	Intercom Annoucements by Principal
5 min.	Advisory Groups Receive Instructions for the Day		Takes Attendance; Review of	Teacher Passes	Teacher Takes Attendance; Hands out Tests
10 min.	Class Begins; Teacher Takes	Review of	Homework Assignments	Skulls Down the Rows	
15 min.	Attendance; Gives Directions for the Day	Skeleton	Seatwork: Students		Students Take
20 min.	Seatwork While		Work in Pairs; Finish	Review	Test
25 min.	Teacher Completes	Review	Homework and	for Test:	
30 min.	and Hands out Grade	of Seatwork	Quiz Each Other	Chapter-end Questions, Bones	
35 min.	Reports	Assignment	Teacher Passes out Paper Students	Puzzle, Diagrams,	
40 min.	Grade Conferences	Students Take	Take Quiz	Laboratory	
45 min.		Quiz			
50 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

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Table 1. Duration of Classroom Activities During Protists Unit (Teacher 4)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Class Begins	Opening Transition	Opening Transition	Opening Transition Teacher Collects Assignments	Opening Transition	Opening Transition Teacher Passes
5 min.	Teacher Reviews	Teacher and Students work Together to Define Protists and Provide Examples	Students read Names Protists Found as Extra Credit Assignment	Teacher Gives Directions for Quiz	back Student Papers Teacher Explains how
10 min.	Plant and Animal	Teacher Gives Instructions	Students	Students take Quiz	Papers were Graded Teacher Explains Continuation of
15 min.	Characteristics with Students Teacher Passes out Worksheets	for Lab on Protists Students	Read and Talk About	Students Exchange Papers and	Yesterday's Lab Students
20 min.	Teacher continues to Review Animal Characteristics with Students	Look at Slides of	Worksheet on	Correct Test Items with Teacher; Teacher Records Scores and Collects	Continue Yesterday's
25 min.	Students	Paramecium, Euglena, Volvox	Monerans	Papers Teacher Gives	Lab on Protists
30 min.	Work on	and Reproduce them on		Instructions for Lab on Finding Protists	
35 min.	Protist Worksheet	Paper, Coloring them and Describing		Students Prepare Slides and Look	Students Clean
40 min.		Movements, Reproduction,		for Protists, Writing Names of What They	up Students View Video: Bacteria:
45 min.		and Food Intake Students Clean up		See Students Clean up	Friend and Foe
50 min.	DISMISSAL	DISMISSAL		DISMISSAL	DISMISSAL

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Table 1 (continued). Duration of Classroom Activities During Protists Unit (Teacher 4)

	DAY 6	DAY 7	DAY 8	DAY 9
Class Begins	Opening Transition	Opening Transition	Opening Transition	Opening Transition Teacher Passes out Corrected Tests
5 min.	Students View Video: Bacteria: Friend and Foe	Teacher and Students Discuss Bacteria	Students Trade Homework Papers and Correct them with the Teacher; Scores are Recorded and Papers are Collected	Teacher and Students Review Test Items Together
10 min.				
15 min.	Teacher Reviews Imp. Names Teacher Explains and Gives Instructions for Lab on how to do Surgical Scrub and Collect Bacteria		Teacher Passes out Tests	
20 min.			Students Take Test	Teacher Explains Grading of Tests and Assigns Homework Teacher gives Instr. for lab & Passes out Mater.
25 min.				
30 min.	Students Conduct Lab	Students View Video: Bacteria: Helpful or Harmful?		Students Conduct lab on Bacteria
35 min.				
40 min.		Students Complete Surveys and Receive Homework Assignment		
45 min.	Students Clean up Teacher Reviews lab		Teacher Collects Tests	Students Clean up
50 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

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Table 2. Duration of Classroom Activities During Heredity and Change Unit (Teacher 4)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5*
Class Begins	Opening Transition	Opening Transition Teacher	Opening Transition Students Assigned to Board	Teacher Outlines Student Activity Teacher Passes Out	Opening Transition Student-Teacher Reviews Mendel,
5 min.	Review: Living Things (Mitosis, Cells, Nucleus)	Reviews Genetics Information	Assigned Students put Homework on Board (Punnet Square Problems)	PTC Paper; Students Conduct Activity to Check for:	Generation Traits, F_1, F_2, Alleles, Chromosomes, and Mitosis
10 min.	Teacher Gives	with Students, Practices	Students	Taster of PTC Attached Earlobes Widow's Peak Tongue Roller	Student-Teacher Lectures on
15 min.	Introductory Lecture on: Genetics:	Punnet Squares, Introducesd Co-dominance	Review Problems on Board	Teacher Assigns Homework DISMISSAL	Meiosis. Students Fill in
20 min.	Mendel Alleles	(Incomplete Dominance),	with Teacher		Meiosis Worksheets
25 min.	Genes, Homozygous Heterozygous	Phenotype, and Genotype, F_1 and F_2	and Correct Worksheets		During Lecture, Copying
30 min.	Punnet Squares, Dominant,	Students Practice Making Cross on Punnet Square, Tchr			Information From Board.
35 min.	Recessive	Passes out Homework Tchr Reviews Above by Putting on Board Tchr Works Through a Problem and Assigns Homework			Topic Concludes with
40 min.		DISMISSAL	Teacher Reviews Phenotype and Genotype Students Work Prob. From Board		Introduction of Down's Syndrome
45 min.	Students Copy Homework Problems From Board Work on Problems DISMISSAL		Teacher Talks Abouy Incomplete Dominance DISMISSAL		Students Finish Drawing on Worksheets and are Given Assignment DISMISSAL
50 min.					

*A student-teacher instructs the class today while the regular teacher supervises a school activity.

Table 2 (continued). Duration of Classroom Activities During Heredity and Change Unit (Teacher 4)

	DAY 6	DAY 7	DAY 8
Class Begins	Opening Transition	Opening Transition	Opening Transition
5 min.	Teacher	Teacher Reviews Determination of Sex, Punnet Squares Teacher Passes Back Student	Teacher
10 min.	Reviews and	Activity Paper Teacher Reviews Punnet Squares Transition to	Reviews Test
15 min.	Expands on Genetic Replication	Prepare to Take Test	Items With Students
20 min.	and DNA, Chromatids,	Students Take	
25 min.	Centromere, Spindle Fibers,	Genetics Test; Hand in	Teacher Collects Test Booklets
30 min.	Centriole	Papers as They	Students Sign Yearbooks and
35 min.	Discussion of Mutations, Twins,	Finish, Sit at	Socialize Students Clean Up and Prepare
40 min.	Siamese Twins, Mongolism, and	Desks	to Leave DISMISSAL
45 min.	Effects of Drugs Student Surveys Administered	Students Hand In Misc. Papers	
50 min.	DISMISSAL	DISMISSAL	

Table 1. Duration of Classroom Activities During Protozoans Unit (Teacher 5)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7
Class Begins	Opening Transition	Opening Transition	Opening Transition	Opening Transition	Opening Transition	Opening	Opening Transition
5 min.	Students Pick Up Books	Students Pick Up Books	Students View	Teacher Explains Lab on Protists	Teacher Explains Lab on Protists Students	Transition Students Get Books	Students Study Individually and in Groups for Test
10 min.			Filmstrip Narrated	Students Look at	Prepare Slides and Look For	Students Review Chapter 19 Indi-	Teacher Passes Out Tests Students Take
15 min.	Seatwork: Students	Students Continue	by Teacher: Protozoans Student Passes	Prepared Slides of	Protists, Drawing	vidually and in Groups, Preparing	Tests on Protists Students Trade
20 min.	Read Chapter 19 (Protozoans)	Reading Chapter 19 and Complete	Out Materials Teacher Explains Materials Students Get Books and	Paramecium, Amoeba, Euglena,	What They See, Labelling it, and	for Test Teacher	Tests and Correct Them with Teacher Teacher
25 min.		Work Quiz in Book	Form Groups Students Continue to	Reproduce What They See on Their	Indicating the Magnification	Reviews With Students for Test	Collects Tests
30 min.	Teacher Reviews Various		Answer Assigned Questions From Yesterday	Worksheet, Labelling	Students Clean up	Students Complete	Students
35 min.	Protozoans with Students: Amoeba, Paramecium, Euglena	Students Return Books	Students Return Books,	Each Example Students Clean up; Teacher Reviews	and Turn in Papers	Surveys	Have Free Time
40 min.	Students Return Books	Teacher Reviews Vocabulary with Students	Hand in Work; Free Time	Lab Teacher	Students Excused to Assembly	Students Have Free Time	
45 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

Table 2. Duration of Classroom Activities During Genetics Unit (Teacher 5)

Class Begins	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
	Opening Transition	Opening Transition		Opening Transition	Opening Transition
5 min.	Teacher Introduces Genetics, Including Various Traits: Attached Earlobes, "Hitchhiker" Thumb, Hairy Toes, Curling Tongue	Teacher Introduces Guest Speaker	NO CLASSES TODAY PARENT TEACHER CONFERENCES		
10 min.		Guest Speaker Shows Slides and Lectures on Animals Seen in Kenya		Students get Books	Teacher gives Instructions for Color-Blindness Test
15 min.	Students get Book			Students Continue Reading Chapter 10, Students then do "Word Quiz" and "Check Your Facts" in Textbook	Students Test Themselves for Colorblindess
20 min.	Students Read Chapter 10 (Heredity)				
25 min.					Continue to Answer "Word Quiz" and "Check Your Facts"
30 min.	Teacher Discusses Terms: Hybrids Homozygous, Heterogeneous, and Animal and Plant Characteristics				
35 min.				Students Return Books	
40 min.				Teacher Reviews Questions from "Check Your Facts" with Students	Students Have Free Time
45 min.	DISMISSAL	DISMISSAL		DISMISSAL	DISMISSAL

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Table 2 (continued). Duration of Classroom Activities During Genetics Unit (Teacher 5)

Class Begins	DAY 6	DAY 7	DAY 8	DAY 9	Day 10
	Opening Transition	Opening Transition	Opening Transition Teacher Introduces	Students Opening Transition	Students get Books Students Study for Test
5 min.	Teacher Lectures on:	Students Continue to	Guest Speaker	Teacher Puts 8 Review Questions on Board	Opening Transition Students Continue to Study for Test
10 min.	Punnet Squares, Dominance,	Work on Assigned Problems from	Guest Speaker Lectures	Students get Books Students Answer	Teacher Passes
15 min.	Recessiveness, F_1, F_2,	Yesterday Assigned Students put Homework on the Board (Punnet	On Animal	Board Questions in Preparation for Test	Out Tests and
20 min.	Down's Syndrome, and Mongolism	Square Problems) Students Review	Adaptation and Classification,	Teacher Dramatizes Mendel by Wearing Monk's Suit	Students Take
25 min.	Teacher Passes Out Worksheet and Gives Directions	Problems on Board with	Showing Various Animals	Students Continue Working on	Exam
30 min.	Students Work on Assigned	Teacher and Correct their Worksheets	From the	Review Questions Teacher Reviews	
35 min.	Work, Filling out	Students Pass In Worksheets Students	Local Zoo	Questions Orally with Students	Students Exchange Tests, then Correct Exams with Teacher, who Records Scores
40 min.	Punnet Squares	Have Free Time		Students Complete Surveys	Teacher Collects Tests
45 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

Table 1. Duration of Classroom Activities During Bacteria and Viruses Unit (Teacher 6)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7
Class Begins	Teacher Rearranges Seating	Roll Call	Roll Call Students View Videotape on Bacteria and Viruses.	Roll Call	Roll Call	Roll Call	Roll Call
5 min.		Students Copy Bacteria Shapes from Transparencies		Students Correct Study Guide Questions	Laboratory: Students Observe and Record Characteristics of Bacteria Samples and Estimate the Number in Colony	Students View Videotape on Bacteria and Viruses for Unit Test	Students and Teacher Correct Unit Test
10 min.							
15 min.	Teacher Lectures and Students Take Notes on Bacteria and Viruses	Teacher Lectures on Aerobic & Anaerobic Bacteria.	Teacher Lectures and Students Take Notes on Bacteria and Viruses; Students Copy Nitrogen Cycle from Diagram			Students Study Notes for Unit Test	Teacher Records Grades
20 min.		Students Answer Questions in Study Guide		Teacher Lectures and Students Take Notes on Bacteria and Viruses		Students Take Unit Test	
25 min.					Students Review for Next Day's Test		Students Complete Survey
30 min.							
35 min.		Clean Up	Teacher Collects Bacteria Samples on Petri Dishes				Teacher Lectures and Students Take Notes on Next Unit
40 min.		Review Study Guide Questions				Teacher Lectures and Students Take Notes on Fungus	
45 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

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Table 2. Duration of Classroom Activities During Birds and Mammals Unit (Teacher 6)

Class Begins	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
	Teacher Reviews Questions on Board	Students Answer End of Chapter Questions on Birds and Mammals	Students Complete End of Chapter Questions	Teacher Rearranges Seating	No Class Assignment
5 min.	Students Outline Chapter 19: Birds and Mammals			Students View Videotape on the Circulatory System	
10 min.			Students Correct Questions		Students Talk and Return Textbooks to Storage
15 min.			Students Complete Surveys		
20 min.				Teacher Lectures and Students Take Notes on Circulatory System	
25 min.					
30 min.			Reivew of the Questions on Chalkboard about Birds and Mammals		
35 min.					
40 min.					
45 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

Table 1. Duration of Activities for Topic One (Teacher 7)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6
Class Begins		Opening	Opening			
5 min.	Opening Transition Correct	Transition	Transition Laboratory Instructions	Opening Transition	Opening Transition	Opening Transition Lab Instructions
10 min.	Tests from Prior	Demonstrations of Air	Laboratory:	Recitation on Temperature and	Recitation: Caloric Content of Food and Animal Heat;	Laboratory:
15 min.	Unit Record Scores	Pressure: Candles,	Boiling Point and Freezing	Living Things	Lab Preparation	Caloric Content of
20 min.	Individual Reading	Jar, Balloons on Scale,	Point of Water	Transition to Lab	Laboratory:	Various Foods
25 min.	Class Reads	Air Pump, Collapsing	Teacher Describes Lab;	Laboratory: Counting	Caloric Content	
30 min.	and Talks About Physical	Can, Card Under	Introduces Film	Fish Gill Rates with	Of Various Foods	Transition
35 min.	Factors in Environment	Water	Film on Differences	Varied Temperature		Teacher Recitation on Calories,
40 min.	Individual Reading		Between Warm-Blooded and	Data Analysis;		Food Use, and
45 min.	Demonstration: Air-burning Candle, water, and Jar DISMISSAL	Transition; Individual Reading DISMISSAL	Cold-Blooded Animals DISMISSAL	Group Discussion about Lab DISMISSAL	Transitions & Cleanup DISMISSAL	Warm-bloodedness DISMISSAL

Table 1 (Continued). Duration of Activities for Topic One (Teacher 7)

Class Begins	DAY 7	DAY 8	DAY 9	DAY 10	DAY 11
5 min. 10 min. 15 min. 20 min. 25 min. 30 min. 35 min. 40 min. in.	Opening Transition Recitation: Water in the Physical Environment Videotape: the Shoreline and Ecosystem DISMISSAL	Salt Water Opening Transition Recitation: Water in the Environment Demonstration: Food Water Preparation, Questions for Videotape on Utah Water Videotape on Utah Water Supplies, Problems Recitation: Utah Water Cycles Individual Seatwork: Water Cycle Questions DISMISSAL	Opening Transition Laboratory on Soil Composition Data Tabulating on Soil Composition Demonstration, Recitation on Soil Composition Recitation: Soil Cycles, Soil Types DISMISSAL	Opening Transition Rectiation: Water in the Ecosystem; Reading Passages Game to Review Unit Vocabulary: Team Answers DISMISSAL	Opening Transition Unit Test DISMISSAL

Table 2. Duration of Activities for Topic Two (Teacher 7)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Class Begins	Opening Transition Intro: Human Traits & Heredity Activity	Opening Transition Review Genetics	Opening Transition Text Reading on	Opening Transition Lab Procedures:	Opening
5 min.	Human Traits and Heredity:	Vocabulary Seatwork: Vocabulary	Cell Division Teacher	Microscopes & Cell Division 1/2 Class does	Transition Demonstration of Colorblindness
10 min.	Family Tree Identification Group Activity	Recitation: Inherited vs. Acquired Traits Illustration	Recitation: Heredity, Genes,	Seatwork (Genetics Vocabulary Puzzle) Other Half Views Mitosis Micro-	Diagnosis Charts Recitation:
15 min.	Teacher Recitation on	(Demonstration) of Dominant and	and Chromosomes	scope Slides Groups Reverse:	Colorblindness and
20 min.	Human Trait Inheritence in Families	Recessive Genes		Seatwork/ Microscope	Other Sex-linked Hereditary
25 min.	Seatwork on Inherited Traits	Recitation: Dominance		Observations	Traits
30 min.	Teacher Recitation on	and Recessiveness in Genetics	Procedures for Seat Work Seatwork: Stages of Mitosis	Recitation:	Combination:
35 min.	Dominant and Recessive	Seatwork/ Recitation	Recitation on	Vocabulary Concepts from Seatwork:	Seatwork/ Recitation; Worksheet on
40 min.	Human Traits	Worktime: Dominance and Recessiveness	Cell Division Seatwork: Stages of Cell Division	Chromosomes and Heredity	Sex-linked Heredity
45 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

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Table 2 (Continued). Duration of Activities for Topic Two (Teacher 7)

	DAY 6	DAY 7	DAY 8	DAY 9
Class Begins	Opening Transition	Opening Transition Individual Text Reading: Twins	Opening Transition	Opening Transition
5 min.	Reading/ Recitation on Chromosomes	Teacher Recitation on Twins: Identical, Fraternal, Siamese	Recording Grades	
10 min.	Film on Heredity, Genes, and Chromosomes		Recitation and Reading on Incomplete Dominance	Unit Test
15 min.				
20 min.				
25 min.	Recitation: Mutations, Albinism		Seatwork/ Discussion of Handout Answer Genetics Questions	
30 min.		Seatwork: Vocabulary	Review Game for Unit	
35 min.		Correcting Papers in Journals		
40 min.	Seatwork: Vocabulary Definitions			
45 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

Table 1. Duration of Activities for Topic One (Teacher 8)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Class Begins	Opening Transition Students Monitor Ongoing Plant Projects	Opening Transition Return Photosynth. Test; Students Monitor Projects	Opening Transition Students Monitor Plant Projects	Opening Transition Announcements Return Protozoa Worksheet Hand Out Lab Exercise	Opening Transition Students Monitor Plant Project
5 min.	Teacher Recitation Introducing Protozoa; Filmstrip Presentation on Protozoa	Review Photosynthesis Test	Seatwork: Students Complete Protozoa Worksheet Working Individually Using Supplementary Textbook	Review Procedures for Lab Exercise on Protozoa	Multiple-Choice Test on Protozoa
10 min.		Review Extra Credit Procedures			
15 min.		Teacher Recitation On Characteristics of Protozoan Classes		Students Begin Lab Exercise: Observation of Protozoa in Pondwater	Students Talk About Protozoan Lab
20 min.					Students Finish Lab Exercise on Observation of Protozoa
25 min.			Students Read Answers From Protozoa Worksheet & Answer Teacher Questions Orally		
30 min.					Students Turn in Labsheets
35 min.	Seatwork: Protozoa Vocabulary Using Textbooks	Seatwork: Filling in Protozoa Worksheet Using Supplementary Text	Oral (Inter-table) Protozoa Quiz-Contest	Clean-Up and Announcements	Students Complete FML Survey
40 min.					
43 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

Table 2. Duration of Activities for Topic Two (Teacher 8)

	DAY 1*	DAY 2	DAY 3	DAY 4	DAY 5
Class Begins	Opening Transition	Opening Transition	Return and Correct Circulation Test	Opening Transition	Opening Transition
5 min.	Circulation Test	Review Yesterday's Lecture on Digestion Students Read and Review Lab 1 Procedures	Recitation on Structure and Fucntion of: the Mouth, Esophagus, and Stomach; Reading from Text	Digestion Vocabulary Seatwork and Discussion	Record and Talk About Final Observations from Demonstration Lab 2 (See Day 4
10 min.	Introduce Topic On Digestion			Finish Stomach Notes	Teacher Recitation on Digestion of Fats
15 min.	Review Text on Digestion	Students Do Lab 1: Action of Saliva on Oats		Teacher Performs Demonstration Lab 2: Digestion in The Stomach	Read and Review Procedures for Lab 3 Digestion of Fats
20 min.					
25 min.			DISMISSAL	Record and Talk About Preliminary Observations from Demonstration Lab 2 (Above)	Class Talks About Lab 3 in Groups
30 min.	Student Seatwork On Digestion Vocabulary Using Textbooks	Lab Cleanup; Transition			
35 min.		Review Lab 1 Results		Teacher Recitation on Structure and Function of Small Intestine	Discussion of Lab 3 Results
40 min.		Collect Lab 1			Cleanup
43 min.	DISMISSAL	DISMISSAL		DISMISSAL	DISMISSAL

*Duration of Activities on Day 1 are approximate.

Table 2. Duration of Activities for Topic Two (Teacher 8)

	DAY 6	DAY 7	DAY 8
Class Begins	Opening Transition (Regular Teacher Absent Today), Rolltaking	Question-and-Answer Style Review of Digestion by Small Intestine	Opening Transition Continue Lecture on Calories
5 min.		Review Digestion, Villi (Slide)	
10 min.	Seatwork Assignment: Copy and Answer all Digestion Review Questions at end of Chapter	Lecture on Large Intestine, Importance of Water, & Cramps	Transition to Seatwork
15 min.		Question-and-Answer Period On Above	Seatwork Activity #2: "Food and Energy" (Text)
20 min.		Seatwork: Functions & Examples of Six Classes of Nutrients Using Text	
25 min.			Students Complete FWL Survey
30 min.			
35 min.	Substitute Reads Correct Answers and Collects Papers	Review Answers Read and Review Paragraph on Nutrients	DISMISSAL
40 min.		Lecture on Calories	
43 min.	DISMISSAL	DISMISSAL	

Table 1. Duration of Activities for Topic One (Teacher 9)

Class Begins	DAY 6	DAY 7	DAY 8	DAY 9	DAY 10
	Opening Transition	Opening Transition	Opening Transition	Opening Transition	Opening Transition
5 min.	Teacher Returns Homework and Talks about the Exam	Teacher Lectures on Test Topics and Lab Organisms		Teacher Reviews Mitosis	Teacher Reviews Mitosis and the Day's Lab
10 min.			Teacher Lectures on Mitosis		Microscope Lab: Preserved Slides of Salamander Tail Showing the Phases of Mitosis
15 min.	Microscope Lab: Observation of Live Amoeba, Euglena, and Volvox	Microscope Lab: Observation of Live Stentor, Blephorisma, and Vortacilla		Microviewers: the Phases of Mitosis	
20 min.					
25 min.					Students Complete FWL Survey
30 min.				Paper for Homework is Passed Out	
35 min.		Teacher Reviews Lab and Previews Tomorrow			Teacher Previews Tomorrow's Activities
40 min.				Teacher Previews Tomorrow	
43 min.	DISMISSAL	DISMISSAL*	DISMISSAL	DISMISSAL	DISMISSAL

*Rainy day schedule: Class dismissed after 54 minutes.

Table 1 (Continued). Duration of Activities for Topic One (Teacher 9)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Class Begins	Opening Transition	Opening Transition	Opening Transition	Opening Transition; Students Observe Live Amoeba at Front of Class	Opening Transition
5 min.	Teacher Reviews Cytology Concepts	Teacher Reviews Paramecium from Yesterday's Lab	Teacher Lectures on the Importance of Science	Teacher Reviews Cytology Concepts	Exam on Cytology
10 min.		Teacher Lectures on the Structure of Euglena	Microscope Lab: Chloroplast Slides	Homework Collection; 3 Microbe Drawings	
15 min.	Teacher Lectures on Single-Celled Organisms			Microscope Lab: Observe Live Paramecium	
20 min.		Film about Various Protists	Teacher Lectures on the Cross Section of the Leaf		
25 min.					
30 min.					
35 min.					Microscope Lab: Observation of Live Amoeba
40 min.				Teacher Previews Tomorrow's Test	
43 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

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Table 2. Duration of Activities for Topic Two (Teacher 9)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6
Class Begins	Opening Transition	Opening Transition	Opening Transition	Opening Transition	Opening Transition	Opening Transition
5 min.	Teacher Lectures on the Circulatory System		Teacher Lectures on the Importance of Memorization	Teacher Reviews Heart Circulation	Teacher Lectures on Blood Typing Lab	Teacher Announcements
10 min.		Teacher Reviews Botany Exam				Rh Factor Lab Activity
15 min.			Teacher Lectures on Heart Circulation	Oral Exam on Heart Circulation; 7 of 34 Students are Tested	Blood Typing Lab: Students Test for Their Own Blood Type	
20 min.		Teacher Lectures on the Circulatory System				
25 min.				Teacher Previews Tomorrow's Blood Typing Lab		
30 min.					Teacher Lectures on the Rh Factor	Students Complete FML Survey
35 min.						
40 min.						Teacher Previews Tomorrow
43 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

Table 1. Duration of Activities for Topic One (Teacher 10)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6
Class Begins	Teacher reviews procedures; students copy notes from board	Opening Transition	Opening Transition	Opening Transition	Opening Transition Science World Magazine Passed Out	Opening Transition; Students Copy From Board
5 min.			Teacher Reviews Assignments, Due Dates, and Class Rules	Students Fill Out Worksheet, "What are Genes?"	Students read Article on Barbara McClintock and Answer 4 Questions About her that are on the Board	Teacher Introduces and Shows Film, "From One Cell"
10 min.	Teacher Recitation on Cell Division; Introduction to Mitosis and Meiosis	Teacher Recitation on Chromosomes and Phases of Mitosis		Teacher Goes Over Worksheet Answers		
15 min.				Teacher Guides Class as They Look at Mitosis Slide-Strips in Microviewers	Teacher Goes Over Answers to 4 questions	
20 min.			Teacher Reviews Cell Structure and Stages of Mitosis		Teacher Recitation on Phases of Meiosis	Teacher Introduces "Gene Monster" Lab for Next Week
25 min.						Teacher Recitation on Genetics Vocabulary Words
30 min.						
35 min.					Teacher Reviews Some Questions that will be on Topic Test	
40 min.	Closing Transition	Teacher hands out ditto and introduces ditto on mitosis phases		Closing Transition		
45 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

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Table 1 (Continued). Duration of Activities for Topic One (Teacher 10)

	DAY 7	DAY 8*	DAY 9	DAY 10	DAY 11	DAY 12
Class Begins	Opening Transition; Graded Papers Returned, PTC Paper Handed Out; Students Copy Notes from Board	Opening Transition	Opening Transition; "Gene Monster" Dittos Handed out	Opening Transition	Opening Transition; Students Copy Notes From Board	Opening Transition
5 min.	Teacher Recitation on More Genetics Vocabulary Words; Teacher Points out Some Genetic Features on Which Students Differ, Including Test of PTC Paper	Teacher Introduces and Shows Film on X and Y Chromosomes	Teacher Describes Procedures for "Gene Monster" Lab	Teacher Describes next Procedures for "Gene Monster" Lab	Teacher Recitation on Human Dominant and Recessive Traits	Teacher Reviews Procedures for Winding up Unit
10 min.				Students Continue Work on Gene Monster Lab, Filling Out Dittos as They Work	Teacher Reviews Gene Monster Procedures and Assigns Test Review Sheet	Teacher Goes Over Test Review Sheet With Class
15 min.						
20 min.		Teacher Recitation on More Genetics Vocabulary Words	Students Work on Gene Monster Lab, Filling out Dittos as They Work		Students Continue Work on Gene Monster Lab, Filling Out Dittos As They Work	
25 min.						
30 min.						
35 min.	Students Complete FWL Student Class Survey					
40 min.				Closing Transition	Closing Transition	Students Hand in "Gene ster" Lab
45 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

*Duration of activities of Day 8 are approximate.

Table 2. Duration of Activities for Topic Two (Teacher 10)

	DAY 1	DAY 2	DAY 3	DAY 4*	DAY 5	DAY 6
Class Begins	Opening Transition; Teacher Reviews Activities for the Day and Assignment on the Board	Opening Transition	Opening Transition; Teacher Previews Directions on Board	Opening Transition; Students Copy Notes on Board	Teacher Describes Activities and Procedures for Next 1 1/2 Weeks	Graded Papers Handed Back From Last Unit; Teacher Goes Around and Grades "Edna" Teacher Reviews Ditto Listing Assignments for next 2 Weeks
5 min.		Students Copy Down Notes on Circulatory System from Board	Student Seatwork Labeling a Dittoed Heart Diagram, with Text as Resource	Teacher Recitation on the Composition of Blood		
10 min.	Students Take Test on Previous Unit, the Frog System	Teacher Hands Out 2 Dittos and Assigns "Edna" as Homework	Teacher Recitation on Parts and Functioning of Heart, Providing Answers to Ditto; Teacher Gives Additional Directions		Teacher Orally Quizzes Three Rows on Circulatory System	Teacher Recitation on Sample Quiz Items
15 min.		Teacher Introduces Part of Film, "Mr. Hemo"			Teacher Recitation On Blood Types	
20 min.	Students Fill in Seatwork Ditto on Human Systems, Using Text as Supplement					Teacher Reviews More on Assignments
25 min.			Teacher Shows Second Part of Film, "Mr. Hemo"			Teacher Recitation on Skeletal System
30 min.				Students can Look at Bone Sample DISMISSAL		
35 min.					Teacher Prepares to do Blood Test Demonstration	
40 min.	Teacher Previews Unit Activities				Blood Test Demonstration With 2 Volunteers	
45 min.	DISMISSAL	DISMISSAL	DISMISSAL		DISMISSAL	DISMISSAL

*Minimum day.

Table 2 (Continued). Duration of Activities for Topic Two (Teacher 10)

	DAY 7	DAY 8	DAY 9
Class Begins	Teacher Hands Out Test Students Take Test on Human Systems	Opening Transition	Teacher Gives Directions for Test and Reading Science World; Hands Test out
5 min.	Teacher Explains Lab Procedures: Rotating to 9 Activity Stations	Students Take FWL Posttest	Students Take Test on Circulatory System; Read Article in Science World if finished early
10 min.	Student Lab, Rotating in Groups to 9 Activity Stations on Human Systems		
15 min.			
20 min.			
25 min.		Teacher Recitation; Reviewing for Test On Circulatory System by Orally Quizzing Students	Teacher Recitation; Reviewing for Tomorrow's Test on Skeletal System
30 min.			
35 min.	Students Complete FWL Student Survey		
40 min.			Teacher Describes Film He'll Show Later this week
45 min.	DISMISSAL	DISMISSAL	DISMISSAL

Table 1. Duration of Activities for Topic One (Teacher 11)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Class Begins	Opening Transition	Opening Transition	Opening Transition	Opening Transition Teacher Corrects Vocabulary Words Orally	Opening Transition
5 min.	Students Read and Talk About Text pp. 420-426 (Tundra and Deserts)	Students Read and Talk About Text pp. 426-432 (Grasslands and Coniferous Forests)	Students Call on Other Students And Ask Them Questions Based on the 20 Facts Recorded Yesterday	Students Complete Review Questions and Study Sheets	Teacher Corrects Review Questions and Study Sheets Orally
10 min.					
20 min.			Students Read and Talk About Text pp. 432-436 (Deciduous Forests)		Students Watch Synchronized Slide and Audiotape Presentation On Adaptation
30 min.	Students View Filmstrip: Ecology Prairie	Students Write 20 Questions About: Tundra Deserts Grasslands Coniferous Forests			
40 min.			Students Write the Definition of Vocabulary Words Appearing on p. 436 of Text	Students Complete Survey	Teacher Lectures on Grunion
48 min.	DISMISSAL	DISMISSAL	Obs. talks to class DISMISSAL	Obs. talks to class DISMISSAL	DISMISSAL

*Duration of Activities on Day 1 are Approximate

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Table 2. Duration of Activities for Topic Two (Teacher 11)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Class Begins	Opening Transition	Opening Transition	Opening Transition Review Tests; Teacher Gives Answers	Opening Transition Talk About Science Fair	Opening Transition
5 mins	Students Read and Talk About Text pp. 273-276 (Viruses)	Students Read and Talk About Text pp. 277-283 (Protists)	Brian Shows Class Hexcell	Talk About and Questions on Hexcell	Teacher Explains Science Fair
10 min.			Questions and Answers About Lab Sheet and Procedures Lab: Students Look at Paramecium on Slide; Fill out Lab Sheet	Review Lab Sheets Students Read and Talk About Text pp. 286-288 (Protists and Algae)	Study Questions on pp. 279-288 Students work at Seats
20 min.	Filmstrip on Causes of Cancer			Seatwork: Vocabulary (288) Questions (289) Finish Lab 10 Questions	DISMISSAL
30 min.		Lab Procedures pp. 284-285 Read, Questions, and Answers		Students Complete FWL Survey	
40 min.	Questions and Answers about Filmstrip	Slides, Reading Script	Clean-Up		
4	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	

Table 2 (Continued). Duration of Activities for Topic Two (Teacher 11)

	DAY 6	DAY 7
Class Begins	Opening Transition	Opening Transition Talk About Science Fair
5 min. min.	Teacher Reviews Science Fair	Teacher Leads Correction of Student Sheets
	Class Talks About Student Council	Transition to Text
20 min. 30 min.	Students Finish Questions on pp. 289; Students Receive Extra Credit if Seatwork is Completed	Students Take Test
		Teacher Tells Students if Assignments Are Missing
40 min.	Correction of Questions	Students Chat
48 min.	DISMISSAL	DISMISSAL