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ABSTRACT

The development of a category scheme for the systematic analysis of science classroom discourse is described. Three teaching models are discussed: the Impression Model, which depicts the mind of a student as receiving and storing external impressions; the Insight Model, which denies the possibility that ideas or knowledge can be conveyed by language, and describes knowledge to be the result of insight into meaning; and the Rule Model, which describes the intent of teaching to be the acquisition of knowledge. The characteristic features of these models constitute the analytical scheme which is used to identify the teaching models in transcribed chemistry and physics lessons in grades 11, 12, and 13. (MH)

ANALYZING SCIENCE TEACHING: A CASE STUDY BASED ON
THREE PHILOSOPHICAL MODELS OF TEACHING

A. Hugh Munby

Adapted from the author's M.A. Thesis,
"The Use of Three-Philosophical Models of Teaching
to Analyze Selected Science Lessons"
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FOREWORD

The Explanatory Modes Project is a research and development effort in science education sponsored by the Department of Curriculum in The Ontario Institute for Studies in Education. The intent of the project is to further a highly promising but relatively undeveloped area of investigation: philosophical analysis applied to several aspects of science education, including the defensibility of objectives, the characterization of classroom discourse, and the design of teaching materials. The series of Background Papers presents a variety of theoretical considerations and practical applications of systematic information from such areas of scholarly endeavor as philosophy of science, epistemology, and philosophical analysis of teaching. The sample Teaching Materials for secondary school are being designed to illustrate aspects of the nature of knowledge and the processes of explanation, as these are reflected in science especially (but not exclusively).

This paper by Hugh Munby, "Analyzing Science Teaching: A Case Study Based on Three Philosophical Models of Teaching," has been selected as one of the Background Papers because of its potential usefulness to science teachers and teacher educators alike. It is a significant piece of work because Munby develops a category scheme for analyzing science classroom discourse, with specific attention to provision made for students to come to know the science under consideration during a given lesson. This is in contrast to the many available category schemes which are content free, focusing on such matters as who speaks, and in response to whom. These may be helpful for characterizing classroom climate, or indeed (as in the case of Bellack's work) for obtaining a concise description of teaching "moves" (structuring, soliciting information, etc.). However, they miss the essence of the way in which science is represented, the need for evidence and confirmation, and a number of other matters which are best approached from the vantage point of philosophical considerations which give due weight to the specifics of science itself.

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Munby's scheme is sound, and his sample applications are thoroughly and clearly presented. This paper should be a useful aid to any science teacher or teacher educator wishing to become more skilled at detecting various means for ensuring that teaching acts in science lessons are appropriate to the task students face in coming to know science.

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CHAPTER I

OVERVIEW

Some Introductory Comments

This paper is about the development of a category scheme for systematic analysis of science classroom discourse. Formulation of the scheme is discussed at some length, to permit the reader to examine both theoretical and methodological considerations in detail, and two recorded science lessons are analyzed to illustrate its use in practice.

In recent years many category schemes have been developed for analyzing classroom discourse.[1] For the most part, these are "content free"--that is, not bound to the analysis of teaching any specific subject. Thus the scheme developed in this paper is unusual. It is formulated around issues concerning techniques and goals appropriate to science teaching, without explicit regard for issues in the teaching of other subjects.

Investigators have centered attention on a wide variety of aspects of teaching, in developing category schemes. Among these are such diverse vantage points as social-psychological analysis of classroom interaction and elements of formal logic. The present scheme is based on vantage points from analytic philosophy. It draws on philosophical analysis of the concept of teaching itself, and on philosophical considerations of what it

[1] The multi-volume series titled Mirrors for Behavior (Philadelphia: Research for Better Schools, Inc., 1967 and later), edited by Anita Simon and E. Gil Boyer, lists dozens of category schemes. The editors report on the use of these instruments in research, in teacher education, and in supervision. Indeed, some have been used to analyze science teaching, though not specifically designed for that purpose. See, for example, J. S. Parakh, "A Study of Teacher-Pupil Interaction in High School Biology Classes, Part II: Description and Analysis," Journal of Research in Science Teaching 5 (1967-68), pp. 183-192; or Ralph Yulo, "An Exploration of the Flanders System of Interaction Analysis as a Supervisory Device with Science Interns" (Ed.D. thesis, Harvard University, 1967).

means to "know" in science. The purpose of the scheme, then, is to make it possible to detect and analyze the provision made by a teacher for his students to come to "know" the science which is under consideration in a given lesson.

Two further points deserve mention in these introductory remarks. First, the emphasis of this work is consistent with goals and aims of science teaching expressed very forcefully (though by no means exclusively) over the past two decades. This is the now familiar orientation toward having students understand the nature of scientific inquiry and scientific knowledge. However (the second point), while its emphasis on understanding science is familiar, the research style of this paper is unusual. Most science education studies dealing with an understanding of science focus attention on the learner in an attempt to attribute increased student understanding of science to the use of particular curriculum materials or a vaguely described teaching style. Unfortunately, such studies offer little of value to practicing teachers, chiefly because the actions within the teacher's control are inadequately defined, or stated in abstract terms, or both ("inquiry" emphasis vs. "traditional" emphasis in a textbook, for instance, or "lecture" vs. "demonstration/discussion" as labels for teaching style). It is quite difficult to translate such global abstractions into a framework helpful for reexamining one's own teaching or reorienting one's classroom materials. By contrast, the study presented here concentrates on fine-structure analysis of teaching acts, guided by a consistent philosophical position.[1] Thus the research underlying this paper is intended to be as immediately useful to science teachers as possible.[2]

About the Analytical Scheme

Formulation of the category scheme (or "analytical scheme") developed in this paper required systematic answers to two questions.

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[1]A companion to the present study is helpful for similar analysis of teaching materials. See the paper by Brent Kilbourn, Analyzing the Basis for Knowledge Claims in Science Textbooks: A Method and a Case Study, Background Paper No. 6, The Explanatory Modes Project (Toronto: Ontario Institute for Studies in Education, 1971).

[2]Further discussion of this and similar issues in science education research can be found in a paper by Roberts and Russell, "An Alternative Approach to Science Education Research: Drawing from Philosophical Analysis to Examine Practice," in Curriculum Theory Network 5:2 (1975), pp. 107-125.

(1) *What does it mean when we say someone knows a propostion in science?*

Systematic work from epistemology (theory of knowledge) provides a way to deal with this question, especially if coupled with some considerations from philosophy of science. Here the investigator's pedagogical concern is with the extent to which students are granted the prerogative of having scientific knowledge claims substantiated by classroom discourse. That leads to the next question.

(2) *How can we assess the extent to which classroom discourse makes provision for students to know propositions in science?*

To explore this problem, the investigator turned to the literature on philosophical analysis of the concept of teaching, and especially on the relationship of epistemology to teaching acts.

Among other writers in educational philosophy, Israel Scheffler has concerned himself with the implications of epistemological matters for education.[1] Extending that concern further, he has used epistemology as one focal point for distinguishing among three "models" of teaching, which he terms the Impression Model, the Insight Model, and the Rule Model.[2] The investigator thus adopted Scheffler's work as a starting point for developing the analytical scheme in this study.

The scheme itself consists of characteristic features by which one can distinguish among Scheffler's three models in actual practice, within the context of science teaching. These features, developed by the investigator, necessarily expand somewhat on Scheffler's account of the models in order to attend thoroughly to the concerns expressed in the two questions stated above.

Limitations of the Study

Any exploratory case study of this type has limitations. The investigator wishes to call attention to the following in particular.

First, while the scheme is theoretically useful for analyzing science teaching at all levels, this case study shows its actual application to only two full-length lesson transcriptions. Both happen to be in chemistry

[1] Israel Scheffler, Conditions of Knowledge: An Introduction to Epistemology and Education (Glenview, Ill.: Scott, Foresman and Company, 1965).

[2] Israel Scheffler, "Philosophical Models of Teaching." Harvard Educational Review 35 (Spring 1965), pp. 131-143.

(Ontario Grade 12 and Grade 13). They were selected for this demonstration of the use of the scheme because they intuitively suggested two very different approaches to the teaching of science.

Second, the investigator has not discussed the historical antecedents of Scheffler's three philosophical models of teaching. That is a limitation because the discussion of knowledge in this paper entails use of such concepts as "truth," "reality," "authority," and "knowledge" itself. It is entirely possible that the meanings of these concepts are not constant among the three models. Scheffler ascribes the Impression Model to Locke, the Insight Model to Plato and St. Augustine, and the Rule Model to Kant.[1] An analysis of the meaning of the several knowledge-related concepts for these writers might provide further distinguishing features of the three models of teaching.

Third, analysis of the transcribed science lessons is intended to reveal the provision made by classroom discourse for the student to know the science under consideration. It is probable that teachers and students rely on forms of communication other than verbal. Movements of the teacher, facial expression, and tone of voice are examples of nonverbal communications which might in some way influence the manner in which students respond and the knowledge which they acquire. Nonverbal communications could be of some consequence to the provision made for the acquisition of knowledge; other observers have noted students making use of a teacher's nonverbal communications.[2] However, in this study such communications have not been recorded, and the analysis consequently is restricted to an examination of transcribed verbal communications.

Fourth, it will be apparent from the transcribed lessons that the students have been exposed previously to varying amounts of scientific information. No attempt has been made to determine how this information was imparted. For example, the analysis does not take curriculum materials into account. The analysis is confined to the immediate teaching which has been recorded.

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[1] Scheffler, "Philosophical Models." Further discussion of these historical antecedents may be found in two separate letters to the editor by Robert D. Heslop and Israel Scheffler, titled "Philosophical Models of Teaching," appearing in Harvard Educational Review 35 (Summer 1965), pp. 363-367.

[2] John Holt relates an instance in which children seem to be using movements of their teacher to achieve correct answers in How Children Fail (New York: Pitman Publishing Company, 1961), pp. 14-16.

Finally, the investigator has noted already that the emphasis in the present study is consistent with goals and aims of science teaching oriented toward student understanding of the nature of scientific inquiry and scientific knowledge. However, no claim is made that epistemological considerations alone are sufficient to meet such goals and aims. Rather, this case study is reported in the spirit of contributing to one aspect of a complex but exciting area of investigation and practical concern in science education.

CHAPTER II

THEORETICAL BACKGROUND

This chapter and the next one deal with theoretical considerations encountered in formulating the analytical scheme, while the last two chapters are devoted to methodological considerations encountered in its practical application. The flow of ideas in the two theoretical chapters is as follows. First an account is given of Scheffler's three philosophical models of teaching. Following this is a discussion of conditions that must be fulfilled before we are willing to grant that something is known in science. Next is a discussion of prerogatives that must be granted to the student in a classroom if provision is made for him to come to know the science under discussion. Finally, the three models are examined to see if they make provision for the student to know in science, and characteristic features of each model are identified.

An Account of the Three Models

A synopsis of Scheffler's three philosophical models of teaching is presented in this section. The intent is to underscore distinctions between the models which are seen to be most pertinent to development of the analytical scheme. As indicated previously, no account is given of the historical antecedents of these models. However, the meaning of the Insight Model will be clarified by reference to the portion of the Platonic dialogue, the Meno, in which Socrates teaches a slave boy a geometric theorem.[1]

The Impression Model

The Impression Model depicts the mind of a student as receiving and storing external impressions. These impressions of the basic elements of

[1] The parallel between the Insight Model and this portion of the Meno has been confirmed by Scheffler in a personal communication.

knowledge are fad in, organized, and processed. Thus the teaching act is here concerned with exercising "mental processes" of perception, discrimination, retention, combination, abstraction, and representation. The teacher is responsible for selecting and organizing information which the students are to receive, and which is "collectively rich enough to support the progressive growth of adult knowledge in the learner's mind."[1] According to this model, knowledge is acquired and organized through standard operations of accepted theory. Teaching is thus the imparting of knowledge which is a public and recorded possession of culture.

Scheffler finds three deficiencies in the Impression Model. First, he contends that knowledge presupposes the imposition of conceptual frameworks upon sensory data. A conceptual framework consists of underlying axioms, generalizations, principles, and postulates of accepted theory. Thus, exposure of the underlying conceptual framework is a necessary condi'ion for imparting knowledge. However, the Impression Model does not require that such an underlying framework be evaluated. Second, the absorption of information by a student does not imply that he understands the information received. In this model, students are not required to correlate given theory with sense data, nor to appreciate either the grounds for accepting theory or the evidence upon which theory rests. Third, the model does not require students to make personal judgments about given theory, and thereby generate new knowledge.

The Insight Model

The Insight Model denies the possibility that ideas or knowledge can be conveyed by language, and describes knowledge to be the result of insight into meaning which "makes the crucial difference between simply storing and reproducing learned sentences, on the one hand, and understanding their basis and application, on the other."[2]

According to Augustine, the words of the teacher prompt the student to search for realities not known to him previously. Scheffler notes the presence of a paradox in Augustine's use of words as cues for the student, pointing out that words alone are useless as cues to unknowns since the

[1] Scheffler, "Philosophical Models," p. 133.

[2] Ibid., p. 135.

student would need to know the meaning of the word prior to using it in his search. In turn, the meaning of the word is obtained only by knowing the reality to which the word referred. The paradox is resolved by Scheffler when he argues that the cues consist of statements instead of words. A student may be provided with a statement whose meaning he knows, but whose truth or falsity he determines by an acquaintance with reality.[1]

According to the Insight Model, learning is acquired through a personal engagement with reality. Thus the student can appreciate the compatibility of theories or statements with reality. These statements might be his own or those of a teacher.

For Scheffler, the inadequacies of this model are two. The first resides in its simplistic account of the testing of a theory against reality--its construction of this testing "in terms of an intellectual inspection of reality."[2] This account omits any concern for "the processes of deliberation, argument, judgment, appraisal of reasons pro and con, weighing of evidence, appeal to principles, and decision-making."[3] The second deficiency is that the model makes no provision for teaching the habits and capabilities required for making judgments. Thus the model ignores the importance of the concepts "reasons" and "principles" which, for Scheffler, "underlie not only the notions of rational deliberation and critical judgment, but also the notions of rational and moral conduct."[4]

The Rule Model

The Rule Model describes the intent of teaching to be the acquisition of knowledge.[5] It is suggested that "the knower must typically earn the right to confidence in his belief by acquiring the capacity to make a

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[1]The term "reality" in this description will later be extended to include those theoretical representations of phenomena which are visible to the students. This will be seen in accordance with the use of a geometrical figure in the *Meno*.

[2]*Ibid.*, p. 138.

[3]*Ibid.* Emphasis in original.

[4]*Ibid.*, p. 139.

[5]The phrase "acquisition of knowledge" is intended to signal the three conditions explicated in the section which follows.

reasonable case for the belief in question."[1] This capacity would include the ability to treat equal reasons equally and to judge issues in the context of general principles to which the individual has bound himself. Exclusive to this model, then, is the "inculcation of principled judgment and conduct."[2]

As a description of teaching, Scheffler states: "Teaching may be characterized as an activity aimed at the achievement of learning, and practiced in such manner as to respect the student's intellectual integrity and capacity for independent judgment."[3] This distinguishes teaching from other acts such as indoctrination which deny students the opportunity of making judgments. It is clear that only Rule Model teaching has the characteristics which satisfy Scheffler's definition of teaching.

Considerations of Epistemology

In determining epistemological features of an analytical scheme based on Scheffler's three models, it is helpful initially to distinguish between "public knowledge" and "personal knowledge." Possession of the latter is what constitutes for the individual the conditions for claiming that he knows a proposition to be the case. Public knowledge appears to be qualitatively different. For example, it may be public knowledge that blue litmus paper turns red in solutions of substances which are termed "acids." But providing a student with a statement which conveys this public knowledge does not imply that the student has acquired personal knowledge of this proposition. Instead, we may accurately assert only that the student has been informed that someone thinks this proposition is the case. The two types of knowledge are discussed separately, for the differences between them are important to this study.

Public Knowledge Viewed as "Paradigm Knowledge"

Public knowledge (in science) is conveyed by propositions concerning the natural environment derived through procedures (rules) acceptable to the scientific community for interpreting observations. The apparent

[1] Scheffler, "Philosophical Models," p. 140.

[2] _Ibid._, p. 141.

[3] _Ibid._, p. 131.

success of both the interpretations and the rules seems to result in their becoming institutionalized, as suggested by Kuhn's concept of "paradigm science." A paradigm, in the sense used by Kuhn, is understood as the conceptual framework which is contemporaneously acceptable to the entire scientific community.[1] Scientific investigations and activities operating within a paradigm are termed "normal science," the activities of which are restricted by: (1) the intellectual operations prescribed by the paradigm, (2) the theoretical constructs which are consonant with the paradigm, and (3) the contemporaneous practical limitations (such as measurement technology).

Thus public knowledge appears to consist of acceptable information derived from acceptable intellectual processes. Since both appear to be restricted by a paradigm, then public knowledge may be recognized as paradigm knowledge, and scientific information concerning paradigm knowledge as paradigm information.

The impartation of paradigm knowledge by statements of paradigm information neither implies nor demands that the recipient of the information do more than receive the imparted information. If a student who receives information is asked questions concerning that information, his responses might indicate whether or not he had retained the information. Alternatively, as noted by Martin, a student demonstrating that he knows the response to a question is not necessarily demonstrating more than that he knows how to respond correctly.[2] Therefore, however appropriate the

[1]Thomas S. Kuhn, The Structure of Scientific Revolutions (Chicago: University of Chicago Press, 1962). Kuhn describes scientific revolutions as paradigm changes which occur when a previously accepted paradigm is publicly recognized as failing to account for phenomena, and so is overthrown. In Science and Subjectivity (New York: Bobbs-Merrill Company, 1967), Scheffler presents a critique of Kuhn's concept of "paradigm." He argues that Kuhn is promoting the stance that science is subjective. Scheffler's objection to the concept "paradigm" appears to be in conflict with the use of the concept in this study, which is based on other works by Scheffler. However, this study is not concerned with arguing whether science is subjective or objective. It is concerned with the way in which science is presented to students, and with the provisions made for students to acquire personal knowledge as opposed to public knowledge. The clarity provided by use of the concept "paradigm" appears to justify its inclusion in this paper.

[2]Jane Roland Martin, "On the Reduction of 'Knowing That' to 'Knowing How'," in Language and Concepts in Education, ed. B. Othanel Smith and Robert H. Ennis (Chicago: Rand McNally & Company, 1961).

response, responding per se does not guarantee that personal knowledge has been acquired according to the conditions described below. It could be that the student is demonstrating that he has received paradigm information. For example, a student who demonstrates that he knows how to balance a chemical equation might do so without knowing what the symbols represent, and without understanding the adequacy of the equation in representing what it purports to represent.

It is apparent, then, that what is known publicly does not automatically become the personal knowledge of an individual who is merely informed by statements conveying paradigm knowledge. Personal knowledge may be thought of as knowledge which is acquired so that an individual can claim that he knows a proposition to be the case. This is explicated in the following paragraphs.

Three Conditions of Personal Knowledge

Scheffler describes three conditions which must be satisfied if an individual is to claim that he knows a proposition to be the case.[1] The conditions are known as the belief condition, the evidence condition, and the truth condition. These conditions will be satisfied in a lesson, if provision is being made for the students to acquire personal knowledge.

The Belief Condition

Personal knowledge of a proposition requires personal belief in the truth of that proposition. Scheffler defines belief to be "a disposition to offer an affirmative response to certain sentences under appropriate conditions--for example, under systematic questioning."[2] However, a person could attest to the truth of a proposition despite the presence of conflicting evidence. Thus belief is a necessary but not a sufficient condition for knowledge.

In the classroom an assertion made by students or teachers concerning a proposition might be interpreted in three ways. First, it could represent a restatement of paradigm information; second, it might be an indica-

[1] A detailed account of these three conditions is found in Scheffler, Conditions of Knowledge.

[2] Ibid., p. 77.

tion that one or more of the three conditions of knowledge is satisfied; or third, it might be an expression of a personal or social opinion (where an opinion is defined as an assertion lacking substantiation). Thus statements of belief could be misleading to the identification of a teaching model unless the context is clear. It should be noted that the intensity with which a belief is held is irrelevant to the present discussion.

The Evidence Condition

A proposition may be substantiated by using evidence, logical proof, or personal faith. Evidence can be obtained from reports of direct observations, or from direct observations per se. Reports of direct observations are usually offered as statements of an authority. The reliability of an authority is a function of the replicability of his observations by others, not necessarily a function of the authority's position or competence, which the term "authority" sometimes connotes. Evidence resulting from direct observations may be subjective, for perceptions may be clouded by the preconceptions and/or expectations generated by the paradigm or personal disposition.

In this document personal faith is considered to be similar to belief. Substantiation resulting from logical proof is judged according to the evidence accumulated to support the premises of the argument. Thus evidence is a necessary but not a sufficient condition for the acquisition of personal knowledge.

The Truth Condition

Ultimately, acquisition of personal knowledge is achieved by determining the truth of a proposition. For Scheffler, the truth of a proposition is determined only by recognizing the limits within which the proposition is said to be true.[1] Thus the statement "According to Dalton's theory, all matter is composed of atoms" is true, because it states the conceptual framework or paradigm which governs "all matter is composed of atoms," and because Dalton's theory contains that assertion.

The significance of fulfilling the truth condition in classroom discourse is evident from the following illustration. A teacher might state,

[1] This argument is presented in detail by Scheffler, <u>ibid.</u>, pp. 44-54.

"All matter is composed of atoms." If both student and teacher are operating conceptually within the same paradigm, then the student is able to comprehend precisely the meaning intended by the teacher. However, the teacher might be using a paradigm in which atoms are recognized as postulated entities, whereas the student unbeknown to the teacher, could be using a paradigm in which postulated entities have a one-to-one correspondence with observable entities. Thus the student could misunderstand the representation of science conveyed by the teacher's statement. This problem can be obviated if the teacher explicitly refers to the paradigm he is using (that is, if the teacher fulfills the truth condition).

Prerogatives Governed by the Epistemology of Classroom Discourse

Verbal interactions necessarily are characterized by the intrusion of the speakers upon each other's perceptions. In general, the participants of such interactions are at liberty to prevent further intrusion by requesting that the interaction cease. Another characteristic of general verbal interaction is that it carries with it no coercion for taking physical or intellectual action upon the request of a participant; that is, neither participant is empowered with prerogatives which would permit him to coerce the other into taking any form of action. The absence of any legal or logical permission to coerce allows several grounds for legitimately refusing to take such action.

In some societal institutions there are instances of verbal interaction in which a participant may exercise certain prerogatives over another participant. In law courts there is a complex hierarchy of prerogatives which are designed to administer justice and to protect the innocent. Upon taking the oath, a witness is compelled to answer questions. This compulsion may be thought of as a manifestation of a contractual prerogative by which the witness has bound himself to the truthful answering of questions. The witness is protected by other members of court who are bound to ensure that the questioning is relevant to the process of the court. Alternative examples of prerogatives may be found in the military service. An individual enrolled in a service has entered a contractual prerogative which binds him to obey the orders of his superiors.

It is possible to detect the existence of a contractual prerogative in classrooms which is distinct from the legal obligations of students to be present and of teachers to teach. A feature which distinguishes this contractual prerogative from those of other societal institutions is its seeming undisclosed nature. The student may be seen as entering a contract with a teacher to have something done to him. At the time when the student enters the contract, he is not aware of what is to be done to him, and probably he will remain ignorant of what it is until the outcome of teaching is attained, at which time the contract expires. Whatever the content of this contract, a teacher is legitimately exercising his prerogative by insisting that a student submit himself to the terms of the contract, of which the latter may be unaware. Thus a teacher seems to be in a position to require students to take intellectual action (and physical action where prescribed by school regulations), while the student appears to be unable to resist such requests. Alone, this suggests that a student has no recourse to counteracting the intrusion of teaching upon his perceptions.[1] The following characterization of teaching is included to indicate that the intrusion may be counteracted.

If the teaching act is considered as aimed at the student to facilitate the processing of his experiences, then a further prerogative emerges. Within the classroom, the ultimate person responsible for processing a student's experiences is the student himself; for whatever is attempted, it is not possible for a teacher to have complete control over the processing of a student's perceptions. The choice of how to process his experiences remains the prerogative of the student. Since this choice is the prerogative of the student, it is apparent that teaching should be directed at making provision for the choice to be the result of judgment, rather than arbitrary opining. The making of critical judgments, we have seen, requires that the student adopt the dispositions and capabilities necessary for principled deliberation.

In the next chapter, the three models of teaching are examined to determine which prerogatives are inherent in each model, thus clarifying further this discussion of the nature of contractual prerogatives in classrooms.

[1]Komisar makes the point that teaching is intrusive upon the perceptions of the student, in "Is Teaching Phoney?", Teachers College Record 52 (February 1969), p. 409.

CHAPTER III

THEORETICAL DEVELOPMENT OF THE ANALYTICAL SCHEME

The theoretical considerations of the previous chapter are used here to determine the characteristic features of the three models of teaching. These features constitute the analytical scheme which is used to identify the models in the transcribed lessons. Determination of these features is facilitated by the use of a specific terminology which is described below, with reference to the discipline of physical science. This terminology is used consistently throughout the remainder of the paper.

Definitions

Physical science is taken to mean a system of laws, theories, generalizations, and principles which are used to explain natural phenomena. It is helpful to identify three distinct components within this way of explaining: observable phenomena; an explanatory system; and logical rules which permit one to link phenomena with the explanatory system, or to move within the system per se. These components are not exclusive to physical science. However, the attribute of physical science, which distinguishes it from other ways of explaining phenomena, is that explanations using magic, religion, animism, and the willful behavior of inanimate substances are not permitted in science.

In this paper logical rules are termed "logical procedures" (thus avoiding unintended associations with the Rule Model). Logical procedures which are seen to link phenomena with the explanatory system are termed "logical-empiric procedures." Logical procedures which represent a movement within the system are termed "logical-analytic procedures."

It is anticipated that in the lessons some confusion may be evidenced between observable entities and postulated entities. The former are visible, or potentially visible, to the students. The latter are postulated to explain observable phenomena; they are thus abstractions. This possible confusion may be explained by referring to the scientific paradigm. Within the contemporary paradigm it is legitimate to speak about atoms as though one were reporting about states-of-affairs. However, a correct representation of science would require that some reference be made to the paradigm. Omission of this reference results in a misrepresentation of what is known about phenomena. Since the present study is concerned with the manner in which science is represented or misrepresented to students, it is necessary to specify a terminology which will permit identification of such misrepresentations, and which may be used consistently for all three models without conflicting with their historical antecedents. For this reason the terms "reality" and "fact" will be avoided in the development and use of the analytical scheme.

In lessons, abstractions might be represented as reports of states-of-affairs. These are termed "postulated entities" and "observable entities" respectively, in order to assist the identification of any misrepresentations. In science, inferences are made concerning the behavior of postulated entities and observable entities. Although such inferences rest on evidence and paradigm rules, they are at times represented in lessons as reports of states-of-affairs. This may occur with or without reference to the paradigm in which the inferences are recognized as useful.

"Authority" is used to refer to one who is in a position to know, who has recognized expertise in the pertinent area of knowledge, and whose observations are replicable by others. It is anticipated that the following points, germane to authority, will be useful for identifying different models. Students could be provided with the evidence afforded by an authority, or the evidence could be paraphrased. A reference to the source in which the authority presents the evidence would permit students to examine the source, and thence to make some assessment of its reliability.

In the previous section it was shown that the presence of evidence is necessary for the acquisition of personal knowledge. Any statement which makes reference to observable phenomena will be termed an "empirical reference." The presence of an empirical reference does not necessarily establish that the evidence condition has been satisfied. It is necessary that the phenomena referred to by the empirical reference are visible to the students, or have the potential for being visible to the students (for instance, there may be references to common phenomena). In the analysis note will be made of whether or not an empirical reference is considered as providing evidence.

The term "representation" will be used to denote chemical symbols, equations, diagrams, and other collections of symbols which represent states-of-affairs. Representations are themselves abstractions, and are used to explain or clarify states-of-affairs or other abstractions. Consequently, representations have some correlation to states-of-affairs. It is anticipated that the way in which this correlation is explicated will be a useful indicator of the model evident in a portion of a lesson.

Identification of the Features

In the remainder of this chapter, the models are examined separately to determine their characteristic features. A summary of these features can be found at the end of the following chapter.

The Impression Model

According to the Impression Model, the teacher selects the information which is imparted as knowledge. This is to be accepted by the student without question. The student is not afforded the opportunity for putting the received paradigm knowledge to the test of his experiences; nor is he encouraged to exercise his prerogative of personal choice concerning the acceptance of what he is told and any actions related to it. Thus there are no grounds for assuming that the student acquires personal knowledge. Instead, the contractual prerogative inherent in this model appears to be that the student accept paradigm knowledge as personal knowledge.

This requirement provides an indication of the types of questions and responses which characterize Impression Model teaching. Since students are to receive information without judgment or argument, there will be no attempt by the teacher to ask questions requiring more than a recall of information which has been given previously. Consequently, the responses characteristic of this model will contain recalled information.

The knowledge imparted by this model is described accurately as paradigm knowledge. This description has two implications: first, the information is presented as true without either reference to the rules and assumptions of the paradigm, or provision of empirical references; and second, the presentation of information as true does not permit students to make judgments concerning its acceptability. By definition, a truth is not negotiable--it connotes finality; and without the provision for consideration of alternative explanations, there is no occasion for students to make judgments.

The features of this model are discernible from the inherent intention to present paradigm knowledge.[1] The presentation of paradigmatic truths without reference to the paradigm entails an inattention to correct epistemology in science. Thus there will be evidence of the presentation of inferences as observable phenomena, and postulated entities will be described in a manner similar to that used for observable entities, both without reference to the paradigm and description of the paradigm.

For a student to judge a logical procedure, the procedure must be depicted so that the appropriateness of its use can be assessed. Further, the appropriateness of a representation cannot be judged logically unless the representation is presented so as to clearly indicate that it is an abstraction. In this way the teacher makes provision for the consideration of alternative representations. Teaching by the Impression Model makes no provision for students to form judgments. Thus depiction of logical procedures, and provision for the consideration of alternatives are not characteristic of Impression Model teaching.

The use of representations and explanations need not be substantiated for they are presented as accepted truths. Consequently, there is no need to provide empirical references nor to expose the students to observable phenomena. Evidence from authority may be used without reference to its source. Neither is it necessary for the evidence to be cited accurately.

The Insight Model

Characteristic of the Insight Model is the teacher's use of verbal cues to prompt the student. The student uses these cues to acquire knowledge through his perceptions of observable phenomena. This method of eliciting

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[1]It should be noted that the paradigm being taught need not be the currently accepted paradigm. The Impression Model would permit the teaching of eighteenth-century paradigms, and would permit a teacher to require the students to accept them as truth.

knowledge is analogous to that used by Socrates in a portion of the Meno dialogue.[1] In this portion of the dialogue, Socrates elicits a geometrical theorem from a slave boy, by asking questions concerning drawn diagrams. The boy uses Socrates' cues and the diagrams to respond, and finally he is able to state the theorem. The diagram may be thought of as a representation; thus it seems permissible to extend the characterization of the model to include a search within a representation, in addition to a search in states-of-affairs.[2] The logical procedures which are used in the Meno dialogue can now be identified as logical-analytic procedures. If the student were acquiring knowledge from states-of-affairs, a logical-empiric procedure would be evident.

A further point can be made from the Meno dialogue. The drawing of the diagram initially establishes that the logical procedures to be used are those of Euclidean geometry. However, there are alternative geometries, such as those of Lobachevsky and Riemann; and, although the use of these in the Meno is an historical impossibility, it is useful to note that the Euclidean paradigm is established without provision for the consideration of any possible alternatives.

Empirically, it seems that the manner in which science is represented in the Insight Model is no different from that in the Impression Model. The models are similar in their omission to prescribe that the teacher provide the students with means for judging the appropriateness of the inferences, explanations, and logical procedures within a paradigm. Therefore, postulated entities will be presented as observable entities, and inferences will be presented as reports of observable phenomena. There is no need for the teacher to make provision for the consideration of alternatives, because neither model makes reference to judgment. The evidence of an authority may be used as a means of support for a statement, but there is no need to refer specifically to the authority, nor to cite the statements of the authority.

The difference between the two models is evident in the manner in which students are expected to react to stimuli provided by a teacher. On

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[1] Plato Meno 82B-85C. As noted earlier, the appropriateness of this analogy has been confirmed by Scheffler in a personal communication.

[2] This extension of the Insight Model has been allowed by Scheffler in a personal communication.

the one hand, the Impression Model represents the student's mind as a tabula rasa, receiving stimuli. The Insight Model, on the other hand, depicts the mind as having prior knowledge which is elicited by stimuli in the form of cues. The student uses these cues to examine representations or observable phenomena, and thereby to provide new information. His responses are restricted by the cues provided, and by the phenomena or representations used in constructing those responses. Thus the student is not expected to exercise judgment; he is expected only to demonstrate his understanding of a logical procedure by responding appropriately to the teacher's cues. This appears to describe the nature of the contractual prerogative in the Insight Model.

It is not possible to predict precisely the types of cues which are identifiable with Insight Model teaching. They will be characterized by their intention to elicit new information; and they will form part of a logical procedure which the student will follow in order to respond correctly. On occasion it is possible that the teacher's cues appear irrelevant to the logical procedure which a student is apparently intended to understand. In the analysis, such instances will be noted, and arguments will be presented to demonstrate that such teaching can be regarded as Insight Model teaching.

The Rule Model

The Rule Model is distinct from the other models in the provision it makes for students to acquire personal knowledge, and to make judgments. Thus it is insufficient for a teacher to supply information and to demonstrate logical procedures. Instead, logical procedures must be described in such a way that provision is made for the consideration of alternative procedures and explanations. This may be recognized as the fulfillment of the truth condition, a necessary condition for the acquisition of personal knowledge.

If teaching by the Rule Model requires fulfillment of the truth condition, then scientific knowledge will be represented as relative to a paradigm. That is, inferences used to formulate abstractions, and the abstractions themselves, will be accompanied by reference to a paradigm. Alternatively, the inferences and abstractions will be stated in such a way that they are seen to be clearly dependent upon a paradigm, and that the use of alternative paradigms might result in alternative inferences and abstractions.

If an inference is prefaced with a word which connotes that alternatives are possible, then this would permit a student to request substantiation or alternatives, and to judge the acceptability of the inference. This provision for consideration of alternatives does not imply the need for provision of alternatives. Such a requirement would place considerable stress on the practicality of Rule Model teaching.[1]

The Rule Model prescribes that the paradigm be either exposed or referred to in such a way that students may judge the appropriateness of the inferences and explanations which the paradigm offers.

A teacher will introduce a logical-analytic procedure in such a way that its use is both explicated and justified. By definition, the use of a logical-empiric procedure is accompanied by an empirical reference. Since the Rule Model requires the students to acquire personal knowledge, then the teacher is required to provide evidence for the students. Thus, objects or events to which empirical references refer must be visible to the students, or be such that they are within common experience so that they are potentially visible to the students. For instance, there might be a reference to a previous demonstration, or to some common natural phenomenon.

Evidence derived from an authoritative source will be accompanied by some reference to its origin so that students are provided with some grounds for judging the reliability of the authoritative source. The evidence will be cited from the source, or the teacher will provide a paraphrase and indicate that he is doing so.

Typically, transcriptions of Rule Model teaching will show inferences to be distinct from reports of observable phenomena, and postulated entities will be shown distinct from observable entities. If this is not explicitly stated, then there will be a reference to the paradigm used at that time (implicit references are noted in the analysis wherever possible). Logical procedures will be described in such a way that provision for alternatives is being made. Alternative explanations need not be provided, but the teaching will be seen to provide for the consideration of alternatives.

In terms of prerogatives, the teacher can legitimately insist that students be exposed to explanations and to their means of support. But the

[1]In a personal communication, Scheffler has acknowledged that the requirement "provision of alternatives" is too stringent an interpretation of Rule Model teaching.

teacher has no right to require students to accept a proposition as true. Ascribing a truth value to a proposition is the prerogative of students. Previously it was noted that the ultimate responsibility for the processing of personal experience rests with the individual. Teaching by the Rule Model permits students to exercise the prerogatives associated with this. In addition, students are permitted to partly counteract the intrusiveness of teaching either by requesting support for the teacher's claims, or by providing arguments for not accepting them.

Questions characteristic of the Rule Model will reflect the intention that students make judgments. Thus questions might require the provision of evidence, argument or judgment. The responses will fulfill these requests appropriately.

CHAPTER IV

EMPIRICAL PROCEDURES OF THE ANALYSIS

This chapter and the final one deal with methodological considerations encountered in application of the analytical scheme. The present chapter describes the manner in which lessons were collected and the format in which they are presented. Also, procedures for selecting portions of lessons for analysis are detailed, and some mechanical procedures of analysis are noted. A concise version of the analytical scheme is then provided at the end of the chapter.

Collection of Lessons

The analytical scheme theoretically should be applicable to all levels and types of science lessons. For purposes of this case study, it was believed that useful transcriptions might be obtained from recordings of chemistry and physics lessons in Grades 11, 12, and 13.

Permission to record was obtained from four science teachers whose schools are within the metropolitan Toronto area. The teachers were informed that the recordings were not for the purpose of evaluating teachers, but of demonstrating the application of an analytical scheme. In all, ten lessons were recorded: one lesson from Teacher W, and three consecutive lessons from each of the other teachers X, Y, and Z.[1] The recordings were made with a monaural tape recorder and a single microphone which was placed near the front of each classroom. During the lessons, notes were made of blackboard writing, references to textbooks, and other pertinent details. No records were kept of class size, student variables, teacher variables, or lesson duration. Such factors are of no importance to the present study, for obvious reasons.

[1] Following the first recording, Teacher W expressed the belief that the material he was teaching was too theoretical to be of use to the study. In order to prevent any possible uneasiness, it was agreed that the class would not be recorded again.

All ten lessons were recorded within a period of two weeks. Whenever feasible, each recording was transcribed immediately after it was made. Ultimately two lessons were selected for presentation in this paper--one by Teacher W (his first and only lesson) and the other by Teacher X (his third lesson). Both happen to be in chemistry. Teacher W is teaching a Grade 13 class, while Teacher X is teaching a Grade 12, nonacademic group (called, at the time, the "four-year stream"). The lessons were chosen because intuitively they seemed to represent two different approaches to the teaching of science.

Presentation of Transcriptions

The lessons and their analysis are presented in the Appendix, but it would probably be most appropriate if the reader delayed examining that material for the moment. The discussion in the remainder of the present chapter is helpful in understanding and following the analysis, and it is suggested that the reader actually examine both lessons and analysis upon beginning the next chapter.

Lessons are displayed with the transcribed discourse confined to half the page on the left-hand side. This format provides space for the analysis to be written opposite that portion to which it refers. Students are identified by name whenever it is evident from the discourse; otherwise they are identified simply as "Student." The teacher is always identified as "Teacher." The lines of discourse on each page are numbered in multiples of five to facilitate reference to specific lines; these numbers appear at the left of the page. Explanatory comments, chemical equations, and similar blackboard work are enclosed within parentheses and included in the body of the transcription. The one larger table in Teacher W's lesson is reproduced at the end, and the reader is referred to it by a footnote at the point where it was first used in the lesson. Each lesson is identified at the beginning of the transcription.

Procedure of Analysis

Grouping Utterances

An important methodological consideration encountered was to decide which portions of the transcriptions would be analyzed, and to justify the exclusion of the remainder. It seemed useful, for this purpose, to divide the classroom discourse into four types of utterances.

Group 1

This group includes all statements and questions which relate directly to knowledge. These utterances would include assertions about phenomena, abstractions, explanations, etc., and questions relating to these.

Group 2

A number of utterances have an indirect relation to knowledge. These make reference to past or future work, assignments, tests, the opening of textbooks, the copying of material, and others. For instance, the statement, "You will remember this from last week" would indicate that the topic referred to had been mentioned previously. "Open your books at page ten" is a further example of a Group 2 utterance.

Group 3

Utterances in this group have a minimal relation to knowledge. Rather, they concern the maintenance of classroom order and personal conduct of the students. Normally such statements are not analyzed, but if relationships between classroom discipline and inferred teaching model are evident, they are noted.

Group 4

This group includes utterances such as overtures ("Hello," "Good morning," etc.), remonstrations, asides, jokes, laughter, and similar irrelevancies. These are not analyzed, although they remain in the transcriptions. It is understood that noises of assent or dissent, relating to questions of knowledge, are considered as Group 1 utterances.

Choice of Utterances

Since this study is restricted to the knowledge dimension of teaching, the analysis is directed at Group 1 utterances. In the analysis, utterances of Group 1 are not identified by the description "Group 1"; instead, the utterances of the other groups are ignored. In a few cases it is found useful to explain other utterances. These are clearly identified as belonging to one of the other groups.

Identification of Episodes

Each lesson is analyzed as a discrete unit of teaching. Any departures from this procedure are justified within the analysis. For convenience, each lesson is divided into consecutively numbered episodes. These episodes will be seen as distinct parts of lessons; they may represent stages of a teacher's argument, or they may contain different topics taught within the lesson. No attempt is made to justify the divisions used in distinguishing the episodes, beyond their apparent usefulness. (There are fifteen episodes in Teacher W's lesson and eight in Teacher X's lesson.)

Indicating Episodes in the Analysis

Episodes are designated by underlining, and their limits are indicated by line numbers and page numbers (where appropriate). For instance, "Episode 1. LL.1-8 (p.A3)" indicates that the first episode commences on the current page at line one, and ends on line eight of page A3. Should an episode begin and end on the same page, then the page reference is omitted. The symbols "L" for "line" and "LL" for "lines" are adopted to avoid confusion between the number "1" and the letter "l."

Designation of Model of Teaching

The model of teaching evidenced in an episode is identified by placing the name in upper-case letters immediately following the commencement of the episode. Any departures from this procedure are clearly indicated. Whenever the name of a model of teaching is used to denote its apparent presence, the name is placed in upper-case letters; for instance, a question which is characteristic of the Impression Model is identified as an "IMPRESSION question." In some episodes more than one model of teaching appears to be evidenced. These instances are noted appropriately.

Location of Analysis

The analysis includes justifications for classifying episodes as instances of teaching models. Therefore, the analysis appears opposite that portion of the discourse to which it refers. Reference to specific parts of the discourse is achieved by using the notation "L" followed by the appropriate line number.

Summary of the Analytical Scheme

The arguments in the analysis are used to identify the models by indicating their characteristic features which are evident in episodes of the lesson transcriptions. These features are listed below in summary form. The terminology is consistent with that used in the analysis, and of course with the theoretical development presented earlier.

The Impression Model

a) There will be no reference to paradigms so the inferences of a paradigm will be presented as reports of observable phenomena.
b) No distinctions will be made between postulated and observable entities.
c) Empirical references are not necessarily provided, nor is the phenomenon necessarily visible to the students.
d) Logical procedures need not be explicated nor need their use be justified.
e) There is no provision for the consideration of alternative procedures or explanations.
f) The evidence of an authority need not be cited, nor need there be reference to the source of this evidence.
g) The teacher's questions intend to elicit the recall of information given previously.
h) The students' responses will contain information given previously.

The Insight Model

The presentation of science in this model is similar to that in the Impression Model.

a) There will be no reference to paradigms, so the inferences of a paradigm will be presented as reports of observable phenomena.
b) Postulated entities will not be distinguished from observable entities.
c) Empirical references are not necessarily provided, nor is the phenomenon necessarily visible or potentially visible to the students.
d) There is no provision for the consideration of alternative procedures or explanations.
e) The evidence of an authority need not be cited, nor need there be a reference to the source of this evidence.
f) The teacher's questions, which are referred to as "cues," are intended to elicit new information.

g) Cues may form part of a logical procedure which students must follow if they are to derive the required new information.

h) Some cues may be seen as irrelevant to the responses required or the logical procedure intended.

i) The responses of students will provide new information. The responses are derived from the teacher's cues.

The Rule Model

a) Paradigms are exposed or referred to, so that the inferences of a paradigm are presented in such a way that they are clearly to be associated with a paradigm.

b) Postulated entities are distinguished from observable entities.

c) Logical procedures are clearly explicated, and provision is made for their use to be questioned.

d) There is provision for the consideration of alternatives.

e) Empirical references are provided; the phenomena are visible or potentially visible to the students.

f) The use of an authoritative source is accompanied by a reference to the authority; the authority's statements are provided, or the teacher indicates that he is presenting a paraphrase.

g) Characteristic Rule Model questions would contain requests for judgments, evidence, substantiation, or alternatives. These requests will be answered appropriately.

CHAPTER V

IMPLICATIONS OF THE STUDY

The first section of this chapter specifies methodological difficulties experienced in practical application of the analytical scheme.[1] In the second section, some theoretical implications and practical consequences of teaching according to the models are discussed from both the foregoing theoretical considerations and the evidence provided in the Appendix.[2] The final section contains some concluding remarks.

Practical Limitations of the Analytical Scheme

A deficiency in the use of the analytical scheme is the difficulty experienced in identifying which information the students have been acquainted with previously. This limitation was noted in Chapter I: the user of a scheme such as this one is obliged to analyze the immediate discourse without referring to what has been taught in a prior lesson.

The first episode of Teacher W's lesson (L.1 [p.A2] to L.8 [p.A3]) affords an illustration of the type of difficulty resulting from this limitation. Clearly, the structural representations and logical procedures referred to here have been introduced to the students in a preceding lesson. If there were some indication of how these were initially taught, the lesson might have been analyzed differently. It is noted, however, that there is no reference in this part of the lesson to the paradigm which permits the representations to be spoken of as states-of-affairs. The episode is described as Insight Model teaching for two reasons. First, no distinctions are made between representations and reports of states-of-affairs; and second, there is no provision of means for judging the adequacy of these representations.

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[1]At this point the reader is urged to read the appended lessons and their analyses.

[2]Reference is made to the Appendix by appropriate page and line numbers.

A similar difficulty is apparent in the final episode of Teacher X's lesson (Episode 8. L.27 [p.A37] to L.30 [p.A39]). The episode evidently constitutes an introduction to the next topic for the class; one might, therefore, infer that the omitted sources of evidence and logical procedures will be supplied in following lessons. There is a reference to some forthcoming evidence (L.40 [p.A38]) but there is no indication that all the relevant information will be presented. Since the analysis is directed at the immediate provision for students to know, the episode is identified as Impression Model teaching.

There are instances in which the identification of an episode as evidencing one of the models is confused by the existence of features of other models within the same episode. Episode 5 in Teacher X's lesson (L.48 [p.A29] to L.33 [p.A32]) is identified as Rule Model teaching. However, it is seen to contain a portion of Insight Model teaching (LL.34-39 [p.A31]). The resulting confusion might be removed by reducing the length of episodes and increasing their frequency, yet this might render the analysis overly complicated. Another solution might be to classify episodes according to the model predominantly evidenced, yet this would require some means of assessing the quality and quantity of each model present in any one episode. The resolution of problems emanating from such assessments would not add to the purpose of the analysis, which is to identify the models and assess the provision for students to know. Similarly, it would be meaningless, for instance, to judge Teacher X to be a "Rule Model Teacher." Instead, it is possible to examine the transcript without making such a judgment, and detect the evident consequences of Teacher X's use of any one of the models.

Precise classification of some portions of episodes was hindered both by a paucity of identifiable features, and by the lack of any procedures for quantification in the analytical scheme. In all such portions, classification was finally achieved, but in some it required lengthy argument. (A consequent disadvantage of the scheme is that it could not be used for an instant analysis of lessons, thereby limiting its use for purposes of classroom supervision. Undertaking a comprehensive analysis requires a considerable amount of time, and the product is almost as long as the original lesson transcription.) The following instances are discussed to clarify difficulties in resolving some of the problems encountered.

Episode 8 in Teacher W's lesson (L.32 [p.A12] to L.9 [p.A14]) is identified as Impression Model teaching, despite the presence of some Rule Model features (notably the justification for the use of iodine). In order to derive this identification it was necessary to analyze the justification per se, rather than merely acknowledge its presence.

Difficulty was experienced in analyzing a section on page A27 (LL.10-13). Here the teacher names the odor (L.13) without explicit justification from the students' observations. This statement cannot therefore be attributed properly to Rule Model teaching. The student's response (L.12) can be interpreted in one of two ways. Either it is a report of an observation, namely, that a smell was evident; or it is a response to the teacher's preceding statement, to the effect that another sense is "sense of smell." If the latter is the case, and the response was prompted by the teacher's statement, then the student could be providing new information, which would suggest that the teacher's statement is an Insight Model cue. Alternatively, the student could be recalling information given in a prior lesson, which would imply that this section is more accurately described as Impression Model teaching. The presence of other recognizable features would facilitate solution of this problem. As it is, the analytical scheme in its present form cannot be used to solve the dilemma satisfactorily. The present analysis is insufficient here.

The analysis on page A36 demonstrates the difficulty in determining what may be taken legitimately to constitute the provision of evidence. Some quantification within the analytical scheme might be of help, but it is unlikely that statements referring to experience can be quantified both meaningfully and comprehensively. In this part of the discourse, the problem is one of establishing the sufficiency of the mention of Sunlight soap (L.15) as constituting evidence, and of determining the probability that the referenced phenomena are visible or potentially visible to the students. If this were established, one could then determine whether this reference constitutes the provision of evidence. The response of one student (LL.17-18 [p.A36]) cannot be interpreted as acknowledging familiarity for the whole class. Neither does an acknowledgment of familiarity with the soap guarantee that the student is familiar with the drying out of the soap. To look at a bar of soap is not necessarily to observe the bar drying and becoming hard; this requires that observations be made at appropriate times and under appropriate conditions.

A similar problem occurs in the analysis of an earlier portion of the same lesson. On page A32 (LL.14-20) the teacher makes a reference to some physical characteristics of ice. Again, the phenomena referred to are probably within the experience of the students. But without polling the class it is not possible to assert that the reference constitutes evidence for all of the students.

In both these instances, the students are obliged to rely upon the reported observations of the teacher. Thus one could state that this is the provision of evidence from authority. Unfortunately, this would require the writer to assert that the students regard the teacher as an authority in the knowledgeable sense, and not in the sense of one having the power to influence thought, opinion, or action. It is not possible to detect which is the case. The analytical scheme is deficient in these and similar instances.

Thus the analytical scheme has been used with some success. But the discussions above illustrate that it is unsatisfactory in the analysis of some portions of the lessons. Some of the problems might be minimized by developing a more detailed analytical framework from which the scheme could be derived. Such a framework would have to incorporate at least a more thorough analysis of what constitutes evidence.

Implications and Consequences of the Use of the Models

At this point it is possible to take note of a few implications and consequences which are derived from the theoretical considerations of previous chapters, and from the analyzed lessons. The evidence is limited, as is characteristic of a case study.

Mention has already been made that the Impression and Insight Models do not represent science accurately. The misrepresentation of science was associated with the teaching of a paradigm without indicating the nature of the paradigm. This omission has possible implications. Within the analytical scheme, misrepresentations of science are described as "the presentation of postulated entities as observable entities" and "the presentation of inferences as reports of observable phenomena." Such misrepresentations are exemplified by statements in the analyzed lessons--for instance: "The fluoride ion has one more electron than protons . . ." (LL.6-7 [p.A5]), and ". . . the atoms . . . have formed new and different partnerships" (LL.32-33 [p.A32]). These statements have forms similar to those of statements describing phenomena, such as: "This car has two more pistons than wheels" and "The artist formed new and different designs." The accuracy of the second two statements could be determined by direct observation. Presumably, the accuracy of the first two statements could be determinable in the same way since they have similar forms; this implies that the entities referred to are observable. But ions, electrons, protons, and atoms are not observable, for their existence is postulated only. If students are provided with such statements alone, they might believe that the entities are observable. Consequently, there would be no logical grounds for questioning their use as explanations of states-of-affairs.

There appear to be at least two further implications of misrepresenting science in this way. First, it could result in an incomprehensible contradiction. For instance, a student might be told that light consists of particles, then he might be told that light consists of waves. If he is not assisted in the resolution of this contradiction, he would be obliged to mistrust his experiences or the experiences of others. The apparent contradiction is reconciled if the statements are rewritten so that the distinction between postulated and observable entities is explicit, thus: "Certain behaviors of light may be explained by considering it to consist of particles (waves)." In this way the student has provision for understanding that the phenomena are not disputed, but that the explanations of the phenomena are disputable.

The second implication refers to the way in which misrepresentation of science could distort the history of science. If a student is taught that some atoms are capable of undergoing fission when previously he learned Dalton's atomic theory, then he is given grounds for doubting Dalton's intellectual competence. It seems important for students to understand that Dalton developed an explanation which was satisfactory for the phenomena he observed, and that more phenomena are observed now, which require different or more complex explanations. Since the teaching of science by the Rule Model is associated with an accurate presentation of science, the teacher would not be responsible for this type of distortion.

Significant implications of using the models may be derived from the ways in which teachers permit students to respond. It has been found in this study that the Impression Model provides for no overt response other than the recall of information. According to the Insight Model, students respond in ways determined by teachers' cues. In neither of these models are students permitted to question imparted information. An attribute of the Rule Model is the provision made for students to make judgments, and for their judgments to be respected. Teaching according to this model permits students to question the accuracy of information they are given.

Two examples are included here to illustrate differences in the ways students are permitted to respond. The different reactions of teachers to student questioning are partly responsible for the identification of these portions of the lessons as representative of different models.

The first example commences with the objection raised by Julie (L42 [p.A30]). Here she is questioning the attributes of chemical and physical changes; and she implies that the points made by the teacher are not exclusive. Her objection is honored, and the teacher performs a demonstration which yields further evidence. This section is identified as Rule Model teaching.

The first example is to be compared with the second, in which a student attempts to answer a question concerning which substance may be used to reduce iodine. In this episode (L.30 [p.A17] to L.37 [p.A18]), the student provides an answer which is rejected by the teacher. The student provides reasoning to support his answer; but the teacher fails to justify its rejection. Finally, the student is interrupted by the teacher's irrational assertion (L.27 [p.A18]). This episode is identified as Impression Model teaching.

Scheffler points out that the Rule Model makes provision for certain rights of students to be respected. He states:

> What is in point here is simply the autonomy of the student's judgment, his right to seek reasons in support of claims upon his credibilities and loyalties, and his correlative obligation to deal with such reasons in a principled manner.[1]

Determining whether or not these rights <u>should</u> be respected requires consideration of philosophical issues which are outside the scope of this paper.

Some Concluding Remarks

The two analyzed science lessons illustrate that the concept of teaching has at least three distinct manifestations, which are described by the three

[1] Scheffler, "Philosophical Models," p. 141.

philosophical models. In the two lessons the students are undergoing experiences which are different apart from the material being presented and its different levels of conceptual complexity. The study has enabled some of these differences to be documented. There are differences in presentations of science, in permitted intellectual response, and in support provided for the teachers' assertions. However, there is no doubt that both Teacher W and Teacher X are engaged in some form of teaching.

Teaching according to alternative models seems to have consequences other than the information which students are to learn. There appears to be a need for some method whereby these consequences could be documented more precisely. Prior to this, some revision of the analytical scheme in the present paper might assist in the elimination of some of the problems noted in its use. Then the study could be used as a component of teacher education, so that teachers-in-training might be alerted to different philosophical models of teaching, and to some of the consequences of their use.

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APPENDIX

TEACHER W LESSON 1

GRADE 13. CHEMISTRY (FIVE-YEAR STREAM)

Teacher: Let's take a look at problems one to six. Number one. Does anybody have the answer, or if nobody has the answer does anybody have a problem? (Pause--students opening books, etc.) If you're going to write the electronic configuration for the fluoride ion, neon and the sodium ion, what will they look like?

Student: $2s^2$ $2p^5$?

Teacher: $2s^2$ $2p^5$ we've had before that . . .

Student: Oh! $1s^2$ . . .

Teacher: $1s^2$ $2s^2$ $2p^5$. And what will that be?

Student: Fluorine?

Teacher: That would be the fluorine atom, eh? And so the fluoride ion? (There is a pause--a few indistinguishable mumblings.)

Student: Six.

Teacher: Six. Neon? Lois, since you're doing so well.

Lois: It will be . . . er . . . $1s^2$ . . . $2s^2$ . . . $2p^7$?

Teacher: Just neon--not the neon positive ion.

Lois: Uh . . . just a six.

Teacher: And finally sodium? Oscar?

Oscar: Uhm, . . . be er, $1s^2$ $2s^2$ . . . er . . . $2p^6$, and er $3s^1$. (Teacher writes these

<u>Episode 1</u>. LL.1-8 (p.A3): INSIGHT, with an exception which is noted. The representations of electronic structure are postulations derived from certain abstract principles, e.g. Schrodinger Equation, Aufbau Principle, and Pauli Exclusion Principle. The relationship of those representations to states-of-affairs is not explicated; neither is there provision in this lesson for these representations to be justified as suitable representations of states-of-affairs. At this point, there is no means for determining if such provision was made in a previous lesson.

In this episode the students use the logical-analytic procedures which are prescribed by the above-mentioned principles, and determine the structural representations of the ions.

LL.13-18: The incorrect responses suggest that the relationship of the postulated species to the structural representations is not fully understood.

L.20: The teacher continues to ask for the structural representation of the ions and atoms. At this point he has not emphasized the procedure by which the students could determine the representation of the ion by knowing that of the atom. This may have been emphasized in a prior lesson.

Lois' response suggests that the logical-analytic procedure is not fully understood.

LL.30-31: The teacher provides a cue which does not explicate the difference he apparently intends to elicit. Lois' response may imply that the procedure has been given in a prior lesson.

Oscar gives the configuration for the atom, whereas in L.11 the teacher asked for the configuration for the ion. This structures on the board.)

Teacher: . . . and $3s^1$ for sodium, so the sodium positive ion, Oscar, will be what? (Pause--a student says something.) Oscar's definition is what we're after.

Student: We could just forget about the $3s^1$, and . . .

Teacher: Okay. So, what can you say then about these three species? Tom?

Tom: Same electronic structure.

Teacher: And what word, we haven't used the word very much--just terminology, but what word do you apply when three species of particles have the same number of electrons? It's said to be what?

Student: Iso-electronic?

Teacher: Yeh, so that's just for information. Now. Then they ask you what would the three of chloride negative, argon, potassium positive, you can take a look at these and see if they follow the periodic table pages 17, 18, 19. And, er, bromide, krypton, and rubidium positive. Now how do their configurations compare? (Pause--teacher calls on a student.)

Student: They'll be the same?

Teacher: The same, and again, what will be the only difference between the fluoride ion, which is $2s^2$ $2p^6$, and the bromide ion? (Pause) The chloride--the fluoride rather--is this what would

may be the result of the teacher's ambiguous question in L.33 p.A2. The teacher could mean either the sodium atom or the sodium ion.

L.10: The teacher requires the students to note the similarity of the derived structural representations. Tom makes the desired connection; his response is to be termed INSIGHT response.

LL.14-23: IMPRESSION. The recall of previously given information is typically associated with IMPRESSION teaching.

L.24: INSIGHT continues. The same logical-analytic procedures are to be used, under the same conditions, to determine the structural representations of other postulated entities. There is no empirical referent, although this may have been given in a prior lesson. Nor is there any attempt to distinguish the postulated entities from observable entities.

L.35: This response is tentative. The teacher indicates that it is correct, but provides no justification for its correctness.

L.37: The teacher uses the word "only." The difference which he appears to require is in the numbering of the 's' and 'p' orbital representations.

be the chloride, as far as valence electrons? Chris?

Chris: $3s^2$ $3p^6$.

Teacher: $3p^6$. And the bromide ion?

Student: $4s^2 \cdot 4p^6$. Or . . . Yeh, that's right. (Some students agree.)

Teacher: Okay. That's question number one. Now a question down there along the line someplace, says: since these all have the same number of electrons, then why don't they have the same sizes? And, we can take a look at the relative sizes of fluoride ion, neon atom, and the sodium ion. So if you'll just take a look then. This is the neutral fluorine atom, this is the fluoride ion, the neon atom, neutral sodium atom, and then the sodium positive one ion. (The teacher is pointing to a chart entitled "Relative Sizes of Atoms and Ions in the Periodic Table.") Now why does the sodium positive one ion differ from the neon atom, which again differs from the fluoride ion? No idea? Rick? (Rick makes some response.) Well, what was it?

Rick: You're talking about the fluorine, the neon, and the sodium . . .

Teacher: Right.

Rick: Um, fluorine has um, one less proton than it does . . . fluorine negative has one less proton than electron; neon has the same number of protons, sodium has one more.

Chris' response and the response in L.6 indicate that the students have understood the logical-analytic procedure. These responses are considered as INSIGHT responses, for they demonstrate correct interpretation of the cue (L.1-2), and correct use of the logical-analytic procedure.

Episode 2. LL.10-37 (p.A5): This episode to L.45 is identified as INSIGHT.

There is no reference to the paradigm; thus the differences in sizes of the postulated entities are presented as observable phenomena.

There is no explication of the inferences which lead to the determination of the sizes of the species. The students might assume from this portion of the dialogue that the sizes are measured directly. It is possible that the determination of the sizes has been discussed in a previous lesson.

L.28: In this portion the teacher has provided no information from which the students may answer this question. This might explain Rick's statement in L.35. Also, the question is similar to the one asked in L.37 p.A3. One might infer that the cueing is insufficient and consequently is misleading. The logical-analytic procedures for relating the variation of size to the position of the atom on the Periodic Table is not explicated in this section (LL.10-34).

Rick is either recalling information concerning the postulated structures of the species, or he is working toward the solution of the question by first stating some differences. The teacher interrupts him, possibly because Rick is not providing the intended response concerning the variation in size.

Teacher: Number of protons in the nucleus is 9, 10, 11; give off an electron in one case, gain an electron in the other case, so in this case the fluoride ion has one more electron than protons and so hence the hold isn't so great and they can spread out. And the sodium ion has one more proton than electrons, the pull is quite a bit greater so they come together. Now, that answers question number six. Question number five does anybody have? (Pause) The bond lengths of these four molecules. (Long pause.) Okay. So you have SiF_4, $SiCl_4$, $SiBr_4$, and SiI_4 and what about their bond lengths?

Student: 1.88 for SiF_4. And, er, 1.71 for . . .

Teacher: 1.71?

Student: 2.15.

Teacher: 2.15. They have to get larger. The covalent radius is larger for the chlorine.

Student: and, er, 2.30.

Teacher: Is that right? (Student: Yeh) And the next one?

Student: 2.49.

Teacher: 2.49. Okay, you all see how they're done? Now, this is all they ask you to do, but maybe we can do a little bit more. If you're going to experiment to determine these things, then how would you predict, if you can recall what we talked about the other day,

LL.1-36: IMPRESSION. In this portion the teacher provides the logical-analytic procedure for relating the inferred size of the species to its postulated structure. The explanation for the variation in size is an instance of inferences of a paradigm being presented as reports of observable phenomena with no explicit reference to the paradigm. The students are not privileged to any substantiation for what the teacher asserts to be the case.

LL.22-25: The values have been calculated in a previous homework assignment. There is an example of this type of calculation in the textbook. The example uses the carbon compounds of the halogens. This might explain Lois' response in L.6 p.A6.

L.26: The assertion of the teacher is the only source of support for this statement in the present dialogue.

LL.35-36: One might infer some significance from the lack of response to this question; or it could simply be that the teacher does not allow time for the students to respond.

<u>Episode 3</u>. LL.37-6 (p.A7): IMPRESSION.

L.44: This statement indicates that the students are to recall information.

how would you predict they would correspond to the actual experimental bond lengths? (Long pause) Lois?

Lois: They react quickly in the carbon, the last two--er--they're closer and the first one is way off, because (Teacher: Okay) they had ionic bonds.

Bonds are postulated entities; here they are presented as something real or "actual"; there is no reference to the paradigm which permits this. No attempt is made to explain the inferences used in the determination of "bond lengths." This may have been discussed in a previous lesson. The question asked of Lois is for recall; thus it is recognized as an IMPRESSION question. Lois' response is unclear. She may be referring to the example cited in her textbook. This has been suggested in the analysis opposite L.21 p.A5. (The values of bond lengths are reproduced on p.A7.)

Teacher: Let's take a look. (He writes up some values.) The experimental bond lengths of these--er--so. Lois said that as you go down them, what you predicted would be that the difference would decrease as you go down, or increase--or as you go down the group, eh, in the periodic table. And, we tried to explain it the other day. So, do we have an explanation for it today? Why should the difference be greater with the fluoride, or the silicon fluoride rather, than the silicon iodide, just take the top and the bottom. (Long pause) Don't know why it's so difficult. Yes?

Both sets of data are derived from a number of inferences which are not explicated here. The teacher presents the experimental values as if they are direct observations of states-of-affairs. This implies that the bonds may be seen and that their lengths may be measured.

L.23: The question appears to be one which elicits the recall of an explanation given previously; therefore it is an IMPRESSION question.

Student: Because, there is more of an electron shift, because it is held closer together?

Teacher: Right. This is . . .

Student: Because, there's stronger bonding in the . . .

L.31: The student refers to an explanation as a report of an observable phenomenon. The use of "it" is ambiguous, referring to the fluoride or the iodide.
L.34: The teacher condones the ambiguity of "it."
L.35: The student is not permitted to complete his recall of information.

Teacher: The ionic nature increases as you go up here eh? And there's more ionic character of the bond, then the closer they are (Student: Yeah) or the further theyare away --then--the greater the strength of the bond, then the closer they are, and the further they are from the calculated values.

LL.37-45: IMPRESSION. The teacher's explanation is based on the postulates "ionic character" and "bond strength." These are not distinguished from observable entities; neither does the teacher explicate the arguments which connect the two postulated entities. From L.22 one could infer that this has been covered in a previous lesson.

Right?

(On the board:

	calculated	experimental
SiF_4	1.88	1.59
$SiCl_4$	2.15	2.01
$SiBr_4$	2.30	2.15
SiI_4	2.49	2.43)

Now really, I'm serious, I hope that you people get going for the next chapters, nineteen and twenty. Because, if not, you may not write, but you're going to end up with fifty-eight per cent instead of what you should be getting. So, anyway, let's go on to section two, and I think, we can best do this by looking up appendix three[1]--the oxidation potentials, for one molar concentrations. (Long pause) As a starting point, will you find the four halogens' oxidation reactions, and give me them in order of their E^0 values. Which is the first one you come to on this list? That's the standard oxidation potentials--appendix three. Judy?

(LL.7-16: These statements are identified as Group 2 statements. A student who attains satisfactory standing in the first two terms may be exempted from writing the final examination. In these cases the year's mark is partly dependent on the student's classwork in the third term. This lesson occurred in the third term.)

Episode 4. LL.16-8 (p.A8): IMPRESSION. The students are to read the table and identify the position of the halogens in the table. In this lesson there is no attempt to relate the data (E^0 values) to states-of-affairs. It is implied that the equations truthfully represent states-of-affairs. There is no explication of the logical procedures which are used to construct these representations, and by which they are found to be useful.

Judy: Iodine.

L.32: Judy identifies the position of iodine in the table. This is to be considered as an IMPRESSION response, for she is relating information which is available in the table.

Teacher: So, the first one you have is the iodide ion going to iodine. Then, way over on the other page, down near the bottom we have bromide going to bromine; right below that fluoride going to fluorine. (He writes the half-equations on the board.) These are

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[1]The pertinent parts of this appendix are reproduced on p.A22.

the values: for iodine, -.53 volts; for fluorine, -2.87 volts; for bromine, -1.06 volts; and what's chlorine?

Student: -1.36.

Teacher: (Writes the values on the board.) Now, looking at these things we should be able to talk about the relative oxidizing strengths then, of the halogens. And what can you tell me about the relative oxidizing strengths of these various halogens? June?

June: They're increasing as you go down.

Teacher: This increases as you go down. Now, what would you say about fluorine? Mark?

Mark: It's the strongest oxidizing agent.

Teacher: It's the strongest. Can you find anything on this table which could reduce the fluoride ion to fluorine? Could you try to pick out something for me which will reduce fluoride to fluorine? (A student remarks.) Pardon?

Student: Anything.

Teacher: Anything? If fluoride ion can be oxidized to fluorine by anything . . .

Student: Oh! Wait now . . . (some comment)

Teacher: It's at the bottom of the list, and therefore as far as the list is concerned, and this is all we're concerned with, this is pretty universal anyway, er . . . the fluoride ion cannot be oxidized to fluorine,

L.6: This information is related from the table. This response is termed an IMPRESSION response.

Episode 5. LL.8-9 (p.A9): INSIGHT. The intentions of this episode appear to be first, establishing a relationship between "relative oxidizing strength" and the position of the species in the table; second, determining which species oxidizes which other species, according to their relative positions in the table. The postulated entities used in this episode are always presented as observable entities.

Mark's response is recognized as an IMPRESSION response. The information he provides is clearly stated in the table.

LL.22-28: These questions require the students to use a logical-analytic procedure which is not explicated here--that is, how the table might be used to find a species which will reduce the fluoride ion. INSIGHT appears to be intended; but the cueing is minimal.

L.30: The student's response is incorrect. At this point the teacher does not explicate the logical-analytic procedure which he wishes the students to use.

LL.36-9 p.A9: The teacher explicates the logical-analytic procedure to be used. He uses one example to show that substances will oxidize those that appear above them in the table. It is useful to note that the teacher is beginning to stress the importance of position according to any substance on this list. We haven't found any substance on this list that is a strong enough oxidizing agent to ozidize fluoride to fluorine. So we have, in the case of rluorine, we have the strongest oxidizing agent. What would you say about the relative strengths of chlorine and bromine? (Pause, teacher names a student.)

Student: Er, chlorine is a much stronger - er, than, er, bromine.

Teacher: Well, I don't know. We're talking about oxidizing as concerned, would you say it's much stronger?

Student: No it's . . . er . . . more, yes, pretty strong.

Teacher: Just qualitatively, forgetting about E^0 values, as you look at the table, the positions of fluorine, chlorine, and bromine, what would you say about them? Fluorine is the strongest oxidizing agent. Carol? What would you say about chlorine and bromine just qualitatively, you don't have to say . . .

Carol: Well, they're less of an oxidizing agent than fluorine.

Teacher: And?

Carol: Well, therefore, there's going to be more oxidizing than by . . .

Teacher: The negative ion is going to be more easily

in the table, without reference to the specific E^0 values. E^0 values are measures of the postulated oxidizing strength, and are compared to that of hydrogen. Hence, the rank order of the species is of little importance.

<u>Episode 6</u>. LL.9-8 (p.A11): INSIGHT. This episode is characterized by the presentation of postulated entities as observable entities or phenomena. The teacher uses cues to elicit information from the students. The intent appears to be that the students understand the use of the table. The teacher relies on the rank order of the species in the table; thus the cueing may be judged irrelevant.

L.15: The response "much stronger" cannot be judged correct or incorrect without reference to specific E^0 values. L.17: The teacher indicates that the previous response was incorrect.

LL.23-28: It is meaningless to forget about the E^0 values, and attempt to qualify the oxidizing strengths. The cueing may be judged irrelevant; in addition, there are no procedures which would precisely determine which description is most appropriate.

Carol responds correctly. She appears to be using the logical-analytic procedure involving rank order in the table.

L.38: The response intended by this question is unclear. Carol appears to be rewording her original response.

LL.42-1 p.A10: This reference to a negative ion is ambiguous; the negative ions of all the species are provided in the table.

oxidized. Just qualitatively, what would you say about the oxidizing strengths or capabilities? Just from the table, Judy?

Judy: You could say they're pretty much the same.

Teacher: And what relation to other substances? (Calls on a student.)

Student: They oxidize just about everything.

Teacher: So, therefore, what would you say about them?

Student: Well, they're very strong . . .

Teacher: Very strong. Okay. What about iodine? What would you say about iodine? Where is it on the table? Where?

Student: It's about halfway between the zero point of H_2 and the bromine.

Teacher: Suppose you say about its probable oxidizing strength . . .

Student: Well, (unclear) it's . . .

Teacher: According to everything else, it's the weakest oxidizer of these halogens, but relative though to these others . . .

Student: Well it's very good.

Teacher: Very good? Okay. What might you say, what word are we going to use?

Student: Medium?

LL.1-4: This cue may be judged irrelevant because E^0 values are not expressible in qualitative terms.

Judy's response appears to be an INSIGHT response. She is using the logical procedure concerning the position of species in the table. In fact, E^0 values permit one to distinguish between the relative oxidizing strengths of bromine and chlorine.

L.11: This response is recognized as an INSIGHT response. It uses a logical procedure which was developed earlier, on p.A9.

L.17: Earlier (L.8 p.A9) fluorine was described as the strongest oxidizing agent. The E^0 values indicate that the strength of fluorine is twice that of bromine. The question concerning iodine is a further example of a cue which may be judged irrelevant.
L.22: It appears that this student is using E^0 values.

LL.25-38: In this portion the students are to find a word to qualitatively describe the oxidizing strength of iodine. There is no provision of a logical procedure by which the students could find the word that the teacher requires. Consequently, the responses of the students may be considered as guesses.

L.34: With the information available to the students, this response is valid.
L.35: The teacher acknowledges the response but it does not appear to be the one he requires. No logical procedure is offered.
L.38: This response appea[illegible] to be valid.

Teacher: Medium or moderate agent. Because, really it's not all that far from half-way in that table, when you get to it. It's above some metals--not very many--but above some. It's a moderate oxidizing agent, what about the iodide ion? Iodine is a moderate oxidizing agent . . . the iodide ion, what would you say about it?

L.1: The teacher supplies the desired word. He justifies its use by virtue of the position of iodine in the table; he does not refer to the E^0 values. Consequently his justification appears arbitrary, e.g. "not very many."

Episode 7. LL.9-32 (p.A12): INSIGHT. In this episode the students use a logical-analytic procedure which relates oxidation and reduction to the rank order of species in the table.

Student: Would it be a moderate reducing agent?

L.13: This response suggests that the students are familiar with the logical procedure which finds oxidation to be the reverse of reduction.

Teacher: Would you pick out something that would oxidize the iodide ion? Anything that would oxidize the iodide ion . . . Craig?

L.15: This cue seems to intend that the students use the logical-analytic procedure concerning position of the species in the table.

Craig: H_2O_2.

Teacher: H_2O_2, where did you find that?

Craig may be basing his response on experience. Hydrogen peroxide is known as an oxidizing agent, and one needs to know nothing about E^0 to say so.

Craig: Right underneath.

Teacher: Right underneath. Does everybody agree with that? (Pause) What's wrong with that answer? (Pause) First of all, is he looking in the right place? (Student: Oh.) Should he be looking below? Um? Should he be looking below or above? (Calls on a student.)

LL.24-33: The teacher provides many cues for the students to correct Craig's error. The cues relate to the position of the species in the table. Logically, there are only two possible answers to the question posed in LL.31-32. For these two reasons the cueing might be judged irrelevant.

Student: Above.

L.34: One of the possible answers is given.

Teacher: Why?

L.34: The teacher's response might be taken to imply that this answer was wrong.

Student: (Response unclear)

Teacher: Yeah, that's right. But we're looking for something to oxidize the iodine. So he should be looking below. But, you

LL.37-41: The teacher explicates the logical-analytic procedure that a species will be oxidized by those appearing below it in the table.

just don't look below.

Student: But on the other side of the table.

Teacher: Should be looking on the other side, because the reaction that is shown here is the oxidation of hydrogen peroxide; so what should you use then? If you're going to use that example? Rick?

Rick: O_2 gaseous plus 2H.

Teacher: Which is what? Oxygen and what?

Rick: And acid.

Teacher: In acid solution, okay. What else might you use? Well, you've got the whole table now. Shirley?

Shirley: Mercury?

Teacher: Mercury; positive two ion, eh? It would be the ion. All right, what would you use to reduce iodine? (Pause) What would you use to reduce iodine? Could do this (unclear) in your sleep. Alfred?

Alfred: Copper.

Teacher: Copper; or any of the metals above the I_2/iodide half reaction. Now, the point though, the main point of this chapter is that iodine is a moderate reducing agent or moderate oxidizing agent. The iodide ion is a moderate reducing agent, and hence there are many substances which can oxidize the iodide ion, and there are many

L.1: This cue has only one response.

L.2 Spatially, this is the only remaining possibility. Thus one cannot infer that the response indicates an understanding of the logical procedure.

LL.4-8: The teacher assumes that the above response implies an understanding.

L.12: Rick reverses the equation given in the appendix. This indicates that he knows it must be reversed; but he may not know why. The logical-analytic procedure explaining this has not been given.

L.13: This question appears to be for recall. The teacher assumes that the symbols adequately represent states-of-affairs. This may have been demonstrated in a previous lesson.

LL.18-19: The logical-analytic procedure for using the table is now stated, without reference to E^0 values. Neither is it emphasized that the species must have an E^0 less than that of iodine. The cueing might be judged irrelevant. This might explain why Shirley suggests "mercury" instead of the "ion of mercury."

LL.25-32: The provision of a further cue enables Alfred to respond correctly. In L.30 the teacher finally details the logical-analytic procedure which he has been deriving with the students.

Episode 8. LL.32-9 (p.A14): IMPRESSION. In this episode there are some features of Rule Model teaching. The justification for denoting the episode as IMPRESSION is detailed below. The teacher is promoting the use of iodine in quantitative analysis; he justifies its use in two ways. First, iodine may be considered as both a moderate reducing agent and as a moderate oxidizing agent. Second, the presence of free iodine is readily detectable. The previous part of the lesson was to substances which can reduce the iodine molecules to iodide. And so you end up with a very useful tool or operation in quantitative analysis, called iodimetry; and this is just based on the fact that the iodide ion is oxidized moderately, or by quite a few substances, and the iodine molecule is reduced by several substances. If it were just for this fact alone, then this would be nothing special. What do you know about iodine? How can you detect it? This is for the biologists. How do you detect the presence of iodine? In biology you use it the other way round.

Student: Um, use starch?

Teacher: Use starch indicator, it's a very, very sensitive indicator either one way or the other. It's a very sensitive indicator in the presence of starch, very low quantities. Or if you use starch as the indicator, it shows the presence of iodine in very small quantities. So this is one reason you can very easily see or detect the presence of iodine. And, we are going to try to go through a little quantitative analysis here, just to see, so you can see what we mean. But anyway, this is one reason why you use this fact that iodide is easily oxidized, iodine is readily reduced, because we can detect, we can oxidize the iodide to iodine and we can detect the presence pretty easily. And also, there aren't very many side reactions, quite often you will try to do

establish the first reason. It is disputable whether or not this is satisfactorily established; no empirical referents were provided; and the logical-analytic procedures leading to this determination were based on the rank order of species in the table, not on their E^0 values. (The latter has been discussed in the analysis on p.A8.)

L.2: The teacher implies that the process named reduction actually occurs to the postulated iodine molecules. A similar misrepresentation of a postulated entity as an observable entity is evident in LL.8-11.

L.16: The teacher introduces an empirical referent. This phenomenon is common; thus one may judge that it has potential visibility to the students if they have not previously observed it.

L.21: This response appears to be a recall of previous information; this is termed an IMPRESSION response.

LL.35-38: From the remainder of the lesson it will be seen that to "go through" means using half-equation representations of what is said to occur. It does not mean that any observable phenomena will be demonstrated.

LL.47-48: The students have no means of knowing whether or not there are few side reactions. This justification for using iodine relies solely upon the teacher's authority.

something and something else will occur. In the case of this half-reaction of the iodide ion and going to iodine, we can probably control the hydrogen ion concentration fairly well, since there aren't any side reactions. So, we'll just go through a little experiment here which you will do one very similar to when you get to university, if you get there, and you take chemistry (moans) when you do get there. If you take a further chemistry course, you'll probably run into this. What you may wish to do is to find the amount of iron in a sample. They may have iron (pause), a certain amount taken, or this is iron ore for the sake of example. Anyway, suppose you have a certain amount of iron, which you'd like to find or an ore which you'd like to find the per cent of iron in it. I'm going to give you the first atep. You might, first of all, change metallic iron, into ferric ion. And once we've done this we're going to try to see what we can do. Now, the point is you're doing a quantitative analysis to find the amount of iron in this sample of ore. If we then take iron and put into a solution, say ferric, to make it into the ferric ion, I would like you to see how we could introduce this half-reaction to either convert the iodide ion to iodine or the iodine to iodide ion. Okay, if you had ferric ion, this is really all I'm asking, if you had the ferric ion and you would like to use that

LL.5-7: The teacher impliea that a poatulated entity may be subjected to phyaical manipulation. This would be legitimate if the paradigm were referenced.

LL.8-9: The teacher now aaaerts that there are no side reactions.

To conclude, despite the presence of justifications for the use of iodine, the justifications per ae and the failures to distinguish between postulated and observable entities, are considered aufficient evidence for describing the episode to be IMPRESSION. In addition, the only participation by the students is the recall of information.

Episode 9. LL.18-23 (p.A16): INSIGHT. Apparently this episode is intended to demonstrate the use of iodine in quantitative analysis. To do this, the teacher relies on some of the logical-analytic procedures which have been used previously in this lesson.

LL.25-29: The teacher provides the problem situation. In this episode the teacher does not justify his use of half-equations. It may be that their use as representations of states-of-affairs has been introduced in a previous lesson.

L.42: The teacher implies that the postulated entities are actually made oy some physical process of solution.

L.45: The teacher implies that an abstract representation may have a physical effect which results in the conversion of one postulated entity into another. As noted opposite L.6, both of the references to physical effe ts would be legitimate if the paradigm were mentioned.

iodide/iodine equilibrium set-up to produce one, given the other, which one would you start out with? Would you add iodine to this, or would you add iodide ions? Mark?

Mark: Iodine.

Teacher: Why?

Mark: Well it, because . . . er . . . you've iodine . . .

Teacher: With the species we have . . .

Mark: Yeh, right, and that's positive, so your iodine is going to be negative, right?

Teacher: Iodine or iodide?

Mark: Iodide ion.

Teacher: Iodide ion. Now it's not just because it's positive or negative, really. What you have to look for is the relative oxidizing or reducing strengths of these. Where is this species found on the table with respect to the other?

Mark: Well, it's found above it, that's why the . . . oh, I mean below it.

Teacher: It's found below it.

Mark: It's found below it, because the stronger oxidizing . . .

Teacher: Okay, good.

Mark: That's why you need the iodine.

Teacher: Right. So if you're going to use this half reaction . . . it's not very clear yet but I

LL.4-6: This question may be judged as cueing. Mark is required to provide the answer by using the logical-analytic procedures which have been established previously. These procedures are those which determine which species are said to be oxidized by other species. This information may be obtained from the table of E^0 values.*

L.7: Mark reverses this response in L.17, possibly as a result of the teacher's question in L.16. Alternatively, the reversal could be the result of Mark's explanation in LL.13-15. (The iodide ion is negative.)

Mark's explanation is legitimate in that he appears to have accepted the problem situation as given. That is, knowing that the ferric ion and the iodine half-reaction are involved, Mark may have realized that either something happens or nothing happens. He might guess that the teacher would not use an example in which nothing happens for this would be irrelevant. According to the half-equation in the appendix the ferric ion becomes the ferrous ion. This is shown to be the result of gaining an electron; and the electron could be provided by the negative iodide ion.

L.34: Mark appears to be telling the teacher that the position procedure justifies the use of the iodine half-reaction; but it does not indicate which way around it should be used, for this may be determined otherwise. Consequently one might judge the teacher's cueing as irrelevant in this section.

LL.38-3 p.A16: One might infer this comment as supporting the claim of irrelevant cueing.

hope it will be in the end when we look back over it . . . if you're going to use that half-reaction somehow, the only way you can use it is to add iodide ion, eh? So, then you might add some iodide ion in the form of potassium iodide or whatever the solution, and now you have set up the condition where you have ferric ion and iodide ion; and what's going to happen?

Student: They're going to come to equilibrium.

Teacher: And what are you going to have at the end of the line?

Student: You're going to have . . . er . . . iodine, and . . . er . . . ferrous ion.

Teacher: (Writes equation) Okay. Now can anybody balance that real fast for me? Start off by putting 2 in there. (Suggestions from students.) We need two of these because you have to balance charges as well as atoms, eh? So the electrons gained and lost are the same. (Equation reads:

$2\ Fe^{+3} + 2\ I^{-} = 2\ Fe^{+2} + I_2$)

What would you do then if you added starch solution here then? What would you observe, if you add starch solution?

Student: The iodine would turn . . . um . . . into a brown shade.

Teacher: In iodine? What

LL.3-7: The teacher appears to be reversing his position. On the previous page he argued that the position of the iodine half-reaction in the table indicated that iodide ions should be used. Now he suggests that there is only one way to use this half-reaction. He does not substantiate his assertion in L.6 by reference to the theory describing oxidation as electron transfer.

L.16: The response could have been, "The ferric ion is oxidized." Hence, the cue in L.15 is ambiguous.

LL.18-20: That is, on the right hand side of the equation which the teacher is writing on the blackboard.

LL.24-35: Presumably the procedures for balancing chemical equations have been explicated in a previous lesson. Here there is no attempt to justify the use of these symbols as representations of states-of-affairs.

<u>Episode 10</u>. LL.36-29 (p.A17): IMPRESSION. The questions in this episode seem to intend recall of information.

LL.38-40: There is an assumption here that I_2 represents iodine in this solution.

LL.41-43: The student could mean the brown color of iodine solutions. The intended response may be recognized as a recall of information. Thus, it is to be termed an IMPRESSION response.

happens? You get that dark, midnight blue, almost black, blue-black color when iodine is present with starch. Have you never seen that before? If you add starch indicator to this you get a very dark, almost black, solution. Will that tell you how much iodine you have? Now what do you use, this is a process you haven't used much, but what do you use to qualitatively find the number of moles in one solution? What process that will operate . . .

Student: Titration.

Teacher: Titration. So, what you might do then, you get this dark, midnight blue color with the starch test, if you could react this or titrate this with something that used up iodine, then how would you know when you had just used it all up?

Student: Color is gone.

Teacher: Very good. Now, what would you choose to use it up? What type of substance would you choose to use it up?

Student: Wouldn't you have to use something less than iron, so that it doesn't get reduced at the same time?

Teacher: Well, no. I'm not doing this here, we take this away. (The ferrous/ferric half-equation.) As far as the ferrous ion, this is not a problem anyway, the ferrous ion is not going to . . . it's going off away of these--

LL.1-4: The teacher provides an account of states-of-affairs. His question in L.5 may be an attempt to gain support for his assertion. Alternatively, it could be a rhetorical question.

L.10: The students have not been given sufficient information to answer this question here. However, the question could be rhetorical.

L.15: The mole may have been defined in a previous lesson. It refers to the molecular weight of the species expressed in grams.

L.18: This response appears to be a recall of information. Thus the response is termed an IMPRESSION response.

L.25: This question is recognized as an INSIGHT question, for it requires the students to relate what would occur if the iodine were absent.

Episode 11. LL.30-37 (p.A18): In this episode a student challenges the teacher. From the following analysis one may infer that the student's objections are met with IMPRESSION responses. The analysis includes representations to clarify the chemisty of the arguments.

L.30: That is, to effect:

$$I_2 + e^- \rightarrow 2I^-$$

L.34: The student refers to the table of E^0 values and suggests that the following reaction must be prevented from occurring:

$$Fe^{+3} + e^- \rightarrow Fe^{+2}$$

L.38: In fact, the Fe^{+3} has been "used up" by the addition of iodide ions, as suggested in L.35 p.A16. The teacher the iodine--we're not very worried about this. Assuming we use all of this up, then the only way the ferrous ion can go is to go to ferric, so we don't break that.

Student: Then, the iodine, when it starts to affect the reaction, when you add more Fe^{+2}.

Teacher: If you add more Fe^{+2} but you've got to come back, and you're going to do a large thing, and you'll end up with the iron in there, you're going to end up with the same equilibrium.

Student: Yes, but you're getting rid of the iodine.

Teacher: Yes, but you'd be right back where you started again.

Student: You'd know how much you'd been adding, after . . .

Teacher: You can't play around with the same equilibrium and expect to get any answers. You have to go somewhere else to get the answer; because, if you have more ferrous ion you're putting more ferric ion in here, and this is what you're trying to find in the first place. Okay? Now, what do you have left, what type of agent's here anyway? Let's just say that, and I'll add my own agent.

Student: It'll be an oxidizing agent.

fails to explain this. Instead he states that there is no problem.

L.3: This assumption is not justified here. In L.17 p.A16, the teacher did not deny the possible formation of an equilibrium.

The problem is to effect the reaction:

$$I_2 + e^- \rightarrow 2I^-$$

L.8: The student appears to be suggesting that a known quantity of the Fe^{+2} species could be added. According to the half-reaction this is legitimate, for it would seem to supply the required electron:

$$Fe^{+2} \rightarrow e^- + Fe^{+3}$$

The student makes his suggestion more explicit in LL.19-20 and LL.24-26.

L.21: This is not the case if "we use all of this up." (L.3)

LL.27-30: The teacher provides no grounds for refuting the student's suggestion. The suggestion is incorrect on the grounds of the E^0 values concerned. The teacher makes no reference to this, nor even to the logical-analytic procedure of rank order in the table. The latter would have solved the difficulty. It is not used here, although a previous part of the lesson intended to make this point.

<u>Episode 12</u>. LL.38-6 (p.A19): INSIGHT. It seems that the teacher wishes the students to recognize that the iodine half-reaction (reproduced opposite L.7 above) is known as a reduction, and therefore requires the presence of a reducing agent. The procedure for recognizing this is not given in this lesson.

Teacher: No, you added an oxidizing agent here, this is an oxidizing agent. You want to reduce the iodine to iodide, eh?

Student: Right, yes.

Teacher: Then, the most common solution you use is a thiosulphate solution. Now you prepare, say sodium thiosulphate, you prepare a solution of known concentration sodium thiosulphate and the thiosulphate ion is $S_2O_3^{-2}$. And if you have known concentration of solution, you titrated very carefully and very slowly with this iodine, you'd end up with a new species, and . . .

Student: Iodide ions.

Teacher: Iodide ions. And when you just add enough to use up all of the iodine, then your blue color disappears and you'd know how many moles of thiosulphate you'd used up. So, can you balance that equation. (Pause) You could do it a number of ways. You could do it by oxidation and reduction, which would drive you crazy, we should take a look at that anyway. What's the oxidation number of sulphur in this species ($S_2O_3^{-2}$)? (Students: Four, two, etc.) Two? You've got two sulphur plus, three time negative two is negative six, that's equal to negative two all over, these are charges on the ion. So then, your sulphur is positive two here; and what is it here ($S_4O_6^{-2}$)? (Students make several suggestions.) Well, you have three, this is negative--this is charge on the ion.

LL.1-5: The teacher corrects the student by reference to the reverse reaction which is known as oxidation. Oxidation is generally used to denote the loss of electrons. To judge the substantiation as suitable one must assume that the topic has been discussed in a previous lesson.

Episode 13. LL.7-46 (p.A20): IMPRESSION.

L.9: A justification for using this substance might be obtained from its E^0 value. This does not appear in the table nor is it provided by the teacher.

L.14: There is no provision for the students to judge the appropriateness of this representation.

L.20: It is contestable that this response provides new information. The product of the reduction of iodine has been stated in L.5. Therefore the response appears to be recall. It is identified as an IMPRESSION response.

L.31: "Oxidation" and "reduction" are names representing certain chemical reactions. They are not procedures for balancing chemical equations.
L.35: Assigning an "oxidation number" depends on inferring the oxidation number of oxygen to be negative two. Presumably this has been discussed in a previous lesson.
L.38: The inferred charges on the species are presented as observable entities.
LL.46-47: The students are to assign a number to the sulphur atom in the postulated species using a logical-analytic procedure. In this lesson, the use of the species has not been justified. The logical-analytic procedure is mathematical. The "charge" on the species totals negative two; it is the result of six oxygens having a "charge" (oxidation number) of negative

It's not the oxidation number of oxidation. And this is the charge on the ion. (A bell sounds.)

Student: Two and a half?

Teacher: Two and a half? You have four sulphur, you have six times negative two, so that's negative twelve, is equal to negative two. So that's $4S = 10$, so that's $S = 2\ 1/2$. Your iodine obviously is going from zero here to negative one here. So how many sulphur atoms then have to be oxidized for every iodine atom that is reduced? (Pause) The increase here is what? Just because we have a fraction for a change don't let it worry you. The increase is a half and the decrease is one, so how many would you require? (A bell sounds. Some of the words cannot be heard.) . . . now putting it in here it gets a little complicated for we already have two there. So, you would then put for two of these, you would have to either put one to one and a half, or one to a half, rather; so that you have two sulphur atoms for one iodine atom. And this is about as complicated an example as you can get, here. Or, since you have four over on the other side, you might end up by saying, two of these, one of these which would mean two of those, and two of those. And that should work out.

$(2\ S_2O_3^{-2} + I_2 = S_4O_6^{-2} + 2\ I^-)$

Anyway, that is the balanced equation. Now the important

two, and four sulphur atoms whose "charge" (oxidation number) may be calculated.

L.5: The student uses this procedure to deduce the oxidation number. The response is an INSIGHT response.

LL.6-12: The teacher demonstrates the use of the logical-analytic procedure.

L.12: Uncombined species are assigned the oxidation number of zero. This may have been explained in a previous lesson.

LL.15-18: This question requires the students to relate the oxidation numbers to the balancing of the equation. This question and the statement in LL.34-36 assume that the representation has an exact correspondence with states-of-affairs.

L.18: The pause might be an indication that the students do not understand the logical-analytic procedure they are to use.

LL.30-45: The teacher demonstrates the logical-analytic procedure by balancing the equation.

thing though is to take a look at what you've done-- I still remember doing this for the analysis of copper and it drove me crazy. But anyway, you have taken a known solution of thiosulphate, and titrated it with this. So if you knew the concentration you could do what? What could you calculate as far as thiosulphate ions?

Student: The number of moles.

Teacher: And if you know the number of moles here, and you know the ratio here you can get how many moles of iodine, eh? And then what can you get knowing the number of moles of iodine, eh?

Student: Find the number of moles of ferric ion that were changed.

Teacher: Right, then you can get the number of moles of ferric ion; and then you can calculate the weight of ion or the weight of ferric iron, then you'd know the weight of iron in the sample. So find the composition of the sample. And so that's the type of thing you can go through. Now, the point is though, this is why I've been demonstrating its use in quantitative analysis, simply because of this, wherever you are, equilibrium reaction between iodide and iodine; the iodide is very easily oxidized to iodine; the iodine is very easily reduced to iodide ion. Okay, now. We can have a break for three minutes; see your

<u>Episode 14</u>. LL.5-24: INSIGHT. The students are to use a logical procedure which permits the quantities of substances to be calculated from the chemical equation. This procedure relies on the inference that the equation has an exact correspondence to states-of-affairs.

L.13: The student uses the logical-analytic procedure to link the process of titration with the number of moles. This is considered to be a recall of the information given in LL.9-18 p.A17.

L.15: The ratio referred to here is of the integers preceding the symbols of species in the balanced chemical equation.

L.22: The student continues to use the logical procedure. This response is an INSIGHT response.

<u>Episode 15</u>. LL.24-45: IMPRESSION. The relationship between the number of moles and the measurable weight of substances is not explicated here.

L.43: The teacher elicited the term "moderate" to describe the oxidizing and reducing effect of iodine on L.1 p.All.

LL.45-5 (p.A22): The remainder of this lesson consists of Group 2 statements.

marks on the test if you want, and then come back and do a couple of exercises, and then we have to see a film today because it has to go back.

(The second part of this double lesson begins with an example of balancing half-equations. Then a film is shown, "Bromine: Element from the Sea.")

Appendix Three[1]

Standard Oxidation Potentials for Half-Reactions

Ionic concentrations, 1M in water at 25 degrees Centigrade. All ions are aquated.

		Half-Reaction	E^0 (Volts)[2]	
$H_2(g)$	$\longrightarrow$	$2e^- + 2H^+$	0.00	Oxidizing strength increases ↓
Cu	$\longrightarrow$	$e^- + Cu^+$	-0.52	
$2I^-$	$\longrightarrow$	$2e^- + I_2$	-0.53	
H_2O_2	$\longrightarrow$	$2e^- + O_2(g) + 2H^+$	-0.68	
Fe^{+2}	$\longrightarrow$	$e^- + Fe^{+3}$	-0.77	
Hg(l)	$\longrightarrow$	$2e^- + Hg^{+2}$	-0.78	
$2Br^-$	$\longrightarrow$	$2e^- + Br_2(l)$	-1.06	
$2Cl^-$	$\longrightarrow$	$2e^- + Cl_2(g)$	-1.36	
$2F^-$	$\longrightarrow$	$2e^- + F_2(g)$	-2.87	very strong oxidizing agents

[1]This information is reproduced from Chemistry: An Experimental Science. Prepared by the Chemical Educational Material Study under a grant from the National Science Foundation (San Francisco: W. H. Freeman and Company, 1963), pp. 452-453.

[2]The E^0 value is interpreted as a quantitative measure of the tendency of the half-reaction to proceed as shown, compared to that tendency for the hydrogen half-reaction as shown. (Negative E^0 values indicate non-spontaneous half-reactions.) Germane to the discussion on pp. A8-A9, the oxidizing agent in each half-reaction is the substance shown to the right of the arrow (e.g. $2H^+$, F_2, etc.).

TEACHER X LESSON 3

GRADE 12. CHEMISTRY (FOUR-YEAR STREAM)

(The lesson begins. The students arrive late from their previous class.)

Teacher: While this is fresh in our minds we'll have a test . . . (indistinct) . . . next period.

Student: One?

Teacher: No, it'll be less than a period test, and if you . . . (some students enter). Come on Geoffrey, let's move. (Pause) Now some of the work we did was not covered by the . . . by the textbook, such as the making of hand lotion. So, don't forget that--don't rely completely on your textbook, otherwise . . . if you are familiar with the questions at the end of the chapter, and the summary, you should have a very good chance of doing well. So that is tomorrow. (Pause) Now let's summarize your observations please. What was the appearance of the fat? Incidentally, what was the fat we used?

Student: (Quietly) Lard.

Teacher: I beg your pardon.

Student: Lard.

Teacher: (Throughout this section he writes the observations on the board as the students answer the questions.) And its appearance cold?

This lesson follows one in which the students prepared soap and tested it. They recorded their observations.

LL.1-25: The statements in this portion are identified as Group 2 statements. In L.25 there is a reference to the recorded observations which were made in the laboratory work of the previous lesson.

<u>Episode 1</u>. LL.26-31 (p.A25): RULE. In this episode the teacher requires the students to precisely describe their observations in terms which he introduces. The students substantiate the use of these terms using their observations.

LL.27-28: The name of the fat was not observed; the question requires a recall of information given by the teacher in the previous lesson. Thus, it is an IMPRESSION question.

L.32: This is an IMPRESSION response.

LL.37-38: The question requires the students to communicate their observations of states-of-affairs. The response will not be a recall of previously imparted information, but it will be a report of observations. The question is a RULE question.

Student: White, er, solid . . . white substance.

Teacher: Would it be . . . was it, er, would you classify it as a solid? (Student: Yeah.) Lynne, gum please!

Student: Yeah.

Teacher: It kept its shape reasonably well, it had a definite shape, but was this shape permanent?

Student: No . . . no.

Teacher: It had a plastic quality, it could be deformed; and er, something of this nature is not classified as a . . . completely as a solid, but is known as a semi-solid.

Student: Like ice?

Teacher: No, ice is a solid, you cannot deform ice, it will crack and break up. It's crystalline, it's a regular solid; but something which can be pushed around or is plastic, and er . . .

Student: Jello.

Teacher: . . . is a semi-solid. And, of course, it has an oily feel. The, er, lard that was sold fifteen or twenty years ago was not as pure white. The lard (a student is speaking) we get today is a highly purified . . . what is it Julie.

Julie: I was just trying to find out what that word was . . . (she is pointing at the blackboard).

L.1: The observation is related to the term "solid" which has a precise meaning in chemistry. The term "solid" is an abstraction referring to a classification of substances.
LL.4-5: The teacher challenges the logical-empiric procedure by which the student has classified lard as a solid. This is a RULE question.
L.7: The student's response does not provide substantiation for this classification.
L.8: An attribute of solids is that they have a permanent shape.
LL.10-11: This RULE question requires the student to justify his classification using an empirical reference.
LL.13-18: The teacher uses empirical referents to explain why lard may not be considered as a solid according to the present classification. The phrase "is known as" clearly references the paradigm, and distinguishes an inference from an observable phenomenon.
L.19: This question appears to be an attempt to clarify the use of "semi-solid."
L.20: The teacher does not reference the paradigm, although this was done in L.18. He clarifies the classification using empirical referents. The phenomena he refers to are likely to have been observed by the students. The use of such references is characteristic of RULE model teaching.

LL.30-31 (p.A25): In this portion the teacher distinguishes between the white lard which may be purchased, and the grey lard available previously.

[LL.36-7 (p.A25): This interruption is considered to be Group 2. It appears that Julie cannot read a word which is written on the blackboard. The teacher's exhortation in LL.5-7 p.A25 is regarded as containing Group 3 statements.]

Teacher: White? White semi-solid.

Students: Oh white . . . oh, white. (Some laughter)

Teacher: Let's sharpen up. I know it's period ten, but let's keep on the ball. The lard which we buy today is not the same pork fat that it was a few years ago. It used to be a kind of a pale grey color, and did not have as good shortening qualitities in baking as it has today. What they do today is to hydrogenate it slightly, to filter, and purify it until it's almost a chemical product . . . no longer as natural as it would have been. Now, you can do the same thing by saving pork dripping at home; and you can use it for making pie crusts and biscuits and that sort of thing, but it will not be quite as high quality as the stuff that you can buy. What was the appearance of the lard after it was warmed, Jackson?

Jackson: Er, it looked like oil.

Teacher: And was it colorless?

Student: No . . .

Teacher: Or . . .

Student: Slightly yellowy color.

Teacher: All right. Pale yellow. But it was clear and oily. Okay, pale yellow

L.8: The teacher describes the differences between pork fat and contemporary lard. The reference to hydrogenation may be to link the present discourse with a process which was taught in a previous lesson.

L.24: The reference to dripping makes some provision for the students to verify what the teacher is asserting. This provision is associated with RULE model teaching.

<u>Episode 2</u>. LL.31-18 (p.A26): RULE. In this episode the students are required to describe their observations, and to organize them using a logical-empiric procedure involving classifying on the basis of observed features.

LL.31-42: The questions and responses are used by the teacher to justify the classification of "pale yellow liquid." This use of evidence for justification is associated with RULE model teaching.

LL.44-6 (p.A26): The teacher requires the students to use the attributes of liquid. (Pause) Was it aoluble in alcohol? After both the alcohol and the lard,were heated, did it appear to form, er, a true solution? Lynne.

Lynne: No, it looked like separate parts.

Teacher: I see, so it was actually a mechanical mixture . . . of two liquids, eh? So this pretty well completes our first stage, we just warmed it enough to melt the lard, with the alcohol, and ended up with a mixture of these two liquids. Was there any noticeable change when the base was added--another clear, colorless liquid? (Pause) After heating and stirring did the, er, did the two liquids remain separate or did they . . . did they blend? Lynne.

Lynne: Um, I think they remained separate, and I think the oily stuff started to foam . . . around the beaker? (There is an interruption as a student enters the room and asks whether or not another student is present. The teacher responds, then the lesson continues.)

Teacher: Possibly. Yes.

Student: It sort of became together; and solid, and another lardy type substance . . . (The interruption continues, the student who entered, leaves.)

Teacher: I think, most of the ones that I saw, that

true solutions to determine if this substance may be considered as a solution. This use of a logical-empiric procedure is similar to INSIGHT cueing. However, there appears to be no intention of promoting this classification without making provision for alternatives. This is evidenced by Lynne's response which is acknowledged by the teacher. He then provides an alternative phrase to describe Lynne's observation.

In LL.12-18, the teacher summarizes the experiment and the observations.

<u>Episode 3</u>. LL.18-31 (p.A27): RULE. The teacher continues to aid the students in the organizing of their observations.

LL.18-26: The questions in this section are identified as RULE questions. The words used by the teacher are everyday words. Thus he is not attempting to promote a specific response, but to obtain a report of observations.

Lynne, in L.27, and the student, in L.39, provide conflicting reports. As seen below, in L.1 p.A27, Lynne's observation is not anticipated by the teacher. But his response (L.38) is significant. By honoring Lynne's report, he implies that an observation cannot be wrong. At the same time he makes it clear that there may be alternatives, and that they will be entertained.

LL.45-6 (p.A27): The teacher reports his observations in a way that indicates the division between the two liquids tended to disappear, and it tended to become more uniform. So that it appeared to form an almost uniform solution. And then with continued heating, what was the most apparent thing that you observed? Remember that you have got more senses than just eyesight.

Student: The smell?

Teacher: The odor of alcohol. And visually, what did you observe, besides this uniformity?

Student: Bubbling.

Teacher: Bubbling. And did you notice any change in the quantity, Jackson?

Jackson: Er, well that sort of oily stuff, before it's turned to, er, white solid . . .

Teacher: Okay, was that apparent right at the beginning or was there something that was observed before that?

Student: Evaporation.

Teacher: Evaporation took place, or the volume was reduced. And I think we're approaching the final stage now, which we'll call number three, and this is when the products actually become visible. And how did you describe the products, the appearance at the very end? Did you, er . . .

Student: We (unclear) substance formed together. You get the er, yellowy-like fat kind of a substance--liquid on the bottom.

that they are not unique. Therefore, there is still provision for the consideration of alternatives, which is evidenced by the words "tended" and "appeared." Both words are being used in a tentative sense.

L.10: The reference to senses other than eyesight might be an attempt to demonstrate an accepted use of the term "observe." Alternatively, it could be intended as an INSIGHT cue. The response in L.12 substantiates the latter interpretation. But the cue is insufficient for the student to identify the smell by name. The teacher does not permit the students to supply the name, which allows this portion to be identified as INSIGHT.

LL.19-20: An observed change in quantity might indicate that the phenomenon known as "evaporation" had occurred.

Jackson's observation appears to be of a later stage in the experiment. This is evident from the teacher's response which follows. The teacher does not imply that Jackson's observation is wrong, merely that an important observation has been omitted.

L.28: It is possible that the student believes that he observed evaporation rather than the manifestation of evaporation. The teacher does not correct this possible misconception; but he provides a correct way of describing the observation.

<u>Episode 4</u>. LL.31-48 (p.A29): RULE. The intent of this episode appears to be similar to that of the previous episode.

Teacher: Would "waxy" be an adequate word--did it have kind of a semi-hard wax, waxy appearance? A light colored waxy . . . and you'll notice that this formed even when it was hot. Now, would this lead you to believe that there was a new product formed or that it was just the fat kind of, er, being boiled out of the dish? Did it seem to have the same properties as the original lard?

LL.1-5: The teacher suggests words for characteristics of the product mentioned by the student in LL.40-44 (p.A27). The use of a question indicates that he is making provision for the consideration of alternatives.

LL.8-16: The questions asked require the students to make judgments about claims using evidence which they have obtained previously. This is typical of RULE questions.

Student: No.

Teacher: So, it, er ... and there was some, still some kind of yellow liquid formed, eh? (No response. Pause; he writes on the chalk board.) Now without testing them, we could tell from the behavior of this solid what it was pretty well. There's no way that we could really tell what this is (i.e., the liquid formed) without chemical tests, but it's no secret, this would have to be the other products and some of the leftover water which was present--we didn't evaporate all the water. Yes?

L.25: "Behavior" refers to what occurs when the substance is subjected to the "foam test." This test is described in the analysis on p.A29.

L.27: The teacher appears to be emphasizing that the descriptions of what is observed are confined to the results of the students' experiments. Thus the use of evidence from other chemical tests is not to be relied upon.

Student: The, er, soap like wax, it wouldn't, er, wouldn't hardly, completely mix, like you couldn't squish it all together, it kept in sort of little lumps. It wouldn't--I don't know how you'd . . .

L.38: The student indicates that his product did not demonstrate all the characteristics of soap with which he is familiar. It appears that his sample did not coagulate in the way that household soap does.

Teacher: We didn't bother doing this, but if we had added a little bit of salt

LL.46-15 (p.A29): The teacher provides an explanation. It is implied that the process of coagulation is inhibited by water, like very salty water, it would have helped to separate the soap from the glycerine; but it also would, we would have lost some of the soap. If we put in pure salt, why it might have--sprinkled some pure salt in--it might have done the same thing. But you would probably be able to collect enough of this to test with the, er, water foaming action. (Student yawns; teacher writes on the board.) I asked you to mention the height of the foam above the surface of the water when you did the foam test, I saw one that looked to be about two, two and a half inches, Earl? So, er, did anyone get a height of foam higher than two and a half inches from the water--this was the best one I saw. Maximum then, two and a half inches of foam, and this would compare very favorably with commercial products. So, is there anyone that had less than half an inch of foam? (Some hands are raised.) Anyone less than a quarter of an inch? (Three hands are raised.)

Student: We ended all up liquid.

Teacher: Oh. Well, approximately a quarter of an inch would be the minimum, and I expect there would be every level in between pretty well. Usually, about an inch to an inch and a half is the average. As far as conclusions are concerned, er, would you

the presence of glycerine. It is possible that the students were told the name of this product in a previous lesson. The explanation is intended to show that although coagulation is incomplete, the product may still be identified as soap. The presence of the words "might" and "would" suggest that provision is being made for the consideration of alternatives, which would justify the classification of this portion as RULE.

L.20: The "foam test" involved the addition of distilled water to the product, followed by shaking the mixture in a test tube. The appearance of foam indicates the presence of soap.

LL.23-26: The teacher solicits observations about foam from the pupils. (But in LL.38-39 the student's response is anomalous, as noted below.)

L.38: That is, no foam was observed. In the following line the teacher disregards this anomalous observation. Instead, he asserts what would be observed generally. The students are provided with no support for this allegation. This portion is identified as IMPRESSION.

<u>Episode 5</u>. LL.48-33 (p.A32): This episode is predominantly identified as RULE. There is evidence of some

call this a physical change or a chemical change? (Pause) Yes?	confusion between postulated and observable entities, which is noted in the analysis.
Julie: Physical. Teacher: Mel. Mel: It's a chemical change.	L.1: This question requires the students to use a logical-empiric procedure for classifying the observed change. The procedure involves the identification of attributes of the products. This would suggest that the question is an INSIGHT cue. However, an examination of the evidence and the procedure is forthcoming which suggests that a judgment is intended.
Teacher: I don't know why this class can't get along without controversy. When I ask a question there are at least two answers, and sometimes more. (Some laughter) What, on what basis do we judge whether a change is chemical or physical? What do we look for in a chemical change for instance? Scott.	LL.7-12: This comment is intended to be humorous. The "controversy" may derive from Mel's thinking that the teacher implied that Julie's response was incorrect.
Scott: Well in a chemical change, the atoms completely change, but in a physical change it's just the state . . .	Scott's response refers to abstractions. He defines some characteristics of this classification, but suggests that the postulated entities exist.
Teacher: State is one form of physical change. Can you give me, er . . .	The teacher does not take account of the misrepresentation made by Scott.
Julie: Oh, in a chemical change, the molecules are rearranged or something, and the physical, er, they can't be put back together in the original form.	Julie confuses the attributes. She represents postulated entities as observable entities.
Teacher: I see. Well just think, you told me you thought this was a physical change. Now, do you think that there would be any easily reversible process where we could take this substance that we produce and put it back into the form of, er, alcohol, or pardon me, base and lard?	L.32: The teacher relies on the attribute that a physical change is easily reversed. This might have been the point which Julie was attempting to make in LL.26-31. From the responses on this page, it is inferred that the students are aware of the distinctions between physical and chemical changes in terms of the arrangement of "molecules." There is no explicit reference to this paradigm.
Julie: Well you could, er, you could sep . . . separate	Julie seems to be pointing out that separation of the products would yield

the liquid at the end, and you can, er, cool the water and you get solid.

Teacher: Well, did that substance you produced, did it have the properties of water? Did it, er . . .

Julie: No, it had the properties of a semi-solid?

Teacher: It was kind of a slippery semi-solid, that's true, but, er, it might pay just to take a little lard and try a foam test on lard, see if we've been wasting our time. (There is some noise as he moves behind the bench to get the lard.) Now this probably seems like a useless sort of test; but it is important that we recognize the difference between physical changes and chemical changes. Take about as much lard as most of you took soap, add some water . . . I'll bet I get as much lather as some of you got at that. (He shakes it, no lather forms. Students: No it doesn't.) Well, this is the question. Would the atoms be rearranged into new partnership or would they not? Now that's the, that's the criteria for . . .

Student: In this like they would.

Teacher: Yes. Yes, Julie?

Julie: You mean the atoms, you mean, oh, arrange into oh, you know take on a new form.

a liquid and a semi-solid; and, since these two states were also present initially, then more evidence is needed to judge whether the change is "chemical" or "physical."

LL.4-7: The teacher's question is interpreted as determining the validity of Julie's objection.

Julie emphasizes that both the product, soap, and the reactant, lard, had properties of a semi-solid.

Julie's objection and request for more evidence is typically allowed in the RULE model. The teacher has noted the objection, and provides the necessary evidence by performing the "foam test" on the lard. Thus, he demonstrates that the semi-solid product may be distinguished from the lard. This recourse to direct evidence is a criterion of the RULE model.

LL.34-39: Atoms are postulated entities which are presented here as observable entities. In addition, it is implied that the above demonstration indicates the formation of "new partnerships." They may be inferred; but there is no reference to the paradigm which would permit this. Consequently, the portion cannot be identified as RULE. Instead, the presence of a logical-empiric procedure and the incorrect use of empirical references with no reference to the paradigm is interpreted as INSIGHT.

L.40: The student has no evidence to support the claim for the formation of "new partnerships," although one can infer from Julie's response that the students have previously been given a connection between "chemical changes" and the formation of "new partnerships."

Teacher: Yes. Or another way of saying it is that in a chemical change products are formed, and how would the properties of the products compare with the properties of the original substance.

Student: They're different.

Teacher: They're different. The properties of the products are completely different from the original properties. Now a physical change might be like freezing. If you take a sample of water and freeze it, it takes a new form--a colorless crystal. But it's very easy, simply by heating it up again to get the original water back. So this is a physical change. So we'd better put this down as our conclusions that soap-making is a process which . . . is a chemical change . . . (he repeats the phrase for dictation) The final products--new sentence--the final products . . . have properties . . . completely different . . . from the original substances . . . because the atoms . . . have formed new and different partnerships. (Pause) Any questions on the experiment? (He writes on the board.) Yes.

Student: Oh, er, for the test, do we just have to know the things we took up in class, like ions. We didn't take some of the things that are in the text.

Teacher: No that's right. But, er, the things that we didn't take in class . . . you're only responsible for the answers to the questions which I assigned,

LL.1-12: The teacher introduces a further means for distinguishing between the two types of changes which does not rely on postulated entities, but on the observations of the students.

The example of a "physical change" provided in this section illustrates the use of the logical-empiric procedure involving observable characteristics. The empirical reference (L.15) makes reference to a common phenomenon. However, there is no substantiation for the teacher's assertions about states-of-affairs. Thus this section (LL.9-21) is identified as IMPRESSION.

LL.22-33: Since the contents of a dictation would normally serve to summarize, the following dictation is identified as Group 2. However, it is useful to note which portions of the preceding teaching are summarized; particularly the statement concerning the "formation of new and different partnerships" (LL.32-33). In this lesson the students have not been given sufficient evidence to justify that this inference may be made from their observations; nor is there explicit reference to the paradigm that would permit this inference to be made once the change has been identified as "chemical."

LL.37-5 (p.A33): Group 2. This dialogue concerns the content of a forthcoming test.

because you can get it from discussion. So you're responsible for the information which was required to answer those questions. Any questions on the experiment itself? (No response. Pause.) In the commercial production of soap, the manufacturer makes sure that there is just a little bit too much base; now, he doesn't want to add enough base that it will . . . that he will be wasteful, but he wants to make sure there's enough base that all the fat is converted. Question, Ernie?

Ernie, Ah, er . . .

Teacher: Beg your pardon.

Ernie: No sir.

Teacher: So that when the soap is finally made he has a little bit of extra base left over plus a little bit of . . . plus the glycerine which has been produced. So the first thing which he does is to remove the glycerine . . . and the extra water--the glycerine and water are removed--by the process known as salting down. (He writes the phrase on the board.) And this is simply the addition of some common salt to the mixture; and it causes the soap to kind of harden into a mass; and the glycerine and water are excluded from the mass. The second step is to use litmus or some other indicator, and add just enough weak acid to neutralize any excess base that is present. The leftover base then, is neutralized. Now the remaining steps in

Episode 6. LL.8-42 (p.A36): IMPRESSION. In this episode the teacher describes the commercial production of soap. Initially there is an implicit relationship between the commercial process and the students' experimental work. There is a reference to a flow chart in the students' textbooks, which is described by the teacher. The flow chart is not included in the present transcription, for it does not advance the analysis.

LL.18-21: Group 3. (It could be that Ernie is not attending to the lesson.)

This episode is characterized by the lack of evidence to support the teacher's assertions, and by the use of the textbook as an authoritative source.

L.33: The process of "salting down" has been described in L.3 p.A29. But at that point the process was not named. Thus there is no special provision for the students to relate the commercial process to their laboratory work. The provision of such a relation would enable the students to make some judgments concerning the viability of the commercial production, apart from being obliged to rely exclusively upon the assertions of the teacher and the textbook.

Presumably, the terms "acid" and "neutralization" have been introduced previously.

the process--the commercial process--are shown by means of what is called a flow chart, on page one sixty of the text. Just turn to that now and we'll go over it quickly. (Pause) In the upper right hand, or in the upper left hand corner of the diagram, we see the big tanks where the soap is stored from the hydrolyzer . . . and it is slightly basic. Now, it is run in liquid form--or semi-liquid form--down into the mixing tanks, which are called the metering and mixing unit, and the stabilizer, which they talk about, is the acid which is used for neutralization; and the preservative is a mixture of chemicals which keep the soap from drying out. Now a few years ago, if you tried to store soap for months, it would probably get quite hard, and, er, would be difficult to use; but they now put in synthetics--usually stearates--which help preserve the moisture and keep the soap in good condition for a long period. So this is the preservative. Now still in the very warm, liquid state, it is elevated up to a hopper above a big roller which is kept cool by circulating water. And the liquid soap runs over the surface of this roller and it hardens, as it cools; so that it forms a thin layer of soap on the roller. Then, as you can see, as the roller rotates . . . the roller rotates, the soap is scraped off in the form of flakes, and is elevated up into the drier, where it passes over a series of conveyor belts and warm air is blown across it so that the flakes are dried out. The dried flakes then

LL.2-7: The students are not provided with any means for determining the appropriateness of the flow chart in representing states-of-affairs.

LL.21-32: In this portion the teacher points out the usefulness of the preservative by referring to the drying out of soap. The phenomenon referred to is not visible to the students; and, since it was "a few years ago" (L.24), it may not have been within their experience.

L.29: Stearates are generally understood to be major components of soap. (In a previous lesson the teacher described soap as "sodium stearate.") There is no explication of how the teacher defines some stearates as "synthetics," and sodium stearate to be soap.

are put into these buggies--which are really just big troughs on wheels—and they're stored for sometimes a week or two until the . . . through the aging process the soap becomes uniform, it has a moisture content and condition--this is known as storage conditioning, and it's very much like tobacco. From there, the final process starts, and it only takes a matter of minutes: It's dumped into a big mixer, called an amalgamator, and it's at this point that the additives are put in--the perfume, any coloring, if it's mechanic's soap this is where they add the abrasive, the grit, and then it goes through a series of plodders, and these plodders are just like compacting machines; and, er, the soap is compacted and rolled between rollers and then compacted again; and finally is extruded in the form of a big sheet which is just the right thickness for bars of soap. Then, on the conveyer belt, a Van Buren cutter cuts it into slabs, which would be maybe, the size of ten bars; and from there it goes into the stamping machine where it is actually stamped into the shape of the soap cake, with the trademark and manufacturer's name and any design on it; and from there it is automatically wrapped and packed in cartons, and is ready to go to the warehouse. The final step, as I say, takes only a matter of minutes, right from the time it's mixed until it

L.11: Presumably this means that the process is similar to the storage conditioning of tobacco. In this lesson there are no means for the students to determine the appropriateness of this analogy. It could be that the storage conditioning of tobacco has been discussed in a previous lesson.

The description of this process contains several terms which are not explained, although they may have been introduced previously. Other examples are:

"Salting down" L.33 (p.A33)
"Neutralize" L.46 (p.A33)
"Hydrolyzer" L.12 (p.A34)
"Synthetics" L.29 (p.A34)
"Stearates" L.29 (p.A34)
"Extruded" L.31 (p.A35)
"Van Buren cutter" L.35 (p.A35)

The above terms are presented without explicit reference to the laboratory work of the students, nor to any experience with which they might be familiar. Thus the students are merely being informed of this commercial production of soap. There is no provision for them to acquire personal knowledge of it. Consequently this episode is found to exemplify IMPRESSION model teaching.

is shipped out in the shipping containers. And, of course, there is a tremendous variety of soap products available. Now, for laundry soap--this is cosmetic type soap that we're talking about here, toilet soap and bath soap--laundry soaps are usually left in the form of flakes, or in little granules. Sunlight soap comes right from the stabilizer. How many of you are familiar with the yellow cake soap called Sunlight soap?

Student: Oh yes, my mother always has it.

Teacher: Usually people have some in the laundry for rubbing across shirt collars and cuffs, things like that--soil spots--and it does seem to help. This is about as close as you can get to the old-fashioned lye soap that used to be made in the home. It does not have any air whipped into it, it doesn't have any preservatives added, it will dry out and become almost as hard as bone if it's left for a few months. And, er, it is oddly enough one of the purest forms of soap. It is pure soap and nothing else. So that you really get your money's worth; it doesn't smell as pretty or it doesn't look as pretty as some of the other cakes of soap, but it is high quality soap. Yes?

LL.19-42: The example of Sunlight soap provides the students with an empirical referent. If they are familiar with this soap they are partly enable to relate the drying out of soap with the lack of preservative. However, it does not seem feasible that being familiar with both Sunlight soap and cosmetic soap will result in the realization that a preservative is present in the latter. The only information which is deducible from such a familiarity is that the two soaps are somehow different. This would not indicate in which respect their constituents are different. Thus, the teacher's assertion concerning the presence of preservatives in cosmetic soap remains unsubstantiated. This section is identified as IMPRESSION.

Lynne: Isn't that the soap that's supposed to lighten your hair?

Episode 7. LL.43-26 (p.A37): IMPRESSION. Lynne introduces a problem from her experiences.

Student: Yes, it is If you wash your hair and go out into the sun.

L.46: This statement apparently is intended to confirm what the soap is supposed to do.

Lynne: What would be in it to do that?

Student: What, the Sunlight?

Student: Cleans better, that's all.

Teacher: I don't think there's any, er, there's no bleach in it; but just the fact that it removes the, er, hair oil and any coating on the hair, and then you go out in the sun and it dries, it dries lighter. And then as your scalp, er, you know your skin is constantly producing skin oils, your scalp is producing this oil, your hair gradually darkens up again. And then when you wash it again, remove that, and dry it in the sun, it looks lighter again. So, it doesn't really bleach the hair, just takes the oil out of the hair, and leaves it lighter in color. (Pause) Now, I was talking over our future with some of the people in the class and the other class, and we felt that just a brief study of our water resources, and what's involved in purifying and keeping it pure--what we mean by pure water. And what all the fuss is about, why is it in the papers all the time? Why are they so worried about the boats on the lake when the city of Detroit puts as much sewage into the Great Lakes system in a day as all the boats--this is, all the small boats, put in in ten years? Why do they pick on the fellow who owns a little motor boat? (A student says something.)

LL.6-26: The teacher offers a tentative explanation. This makes provision for the consideration of alternative explanations. The teacher substantiates his claim by reference to common phenomena. But the evidence is asserted by the teacher; thus, this section is identified as IMPRESSION.

Episode 8. LL.27-30 (p.A39): IMPRESSION.

LL.27-36: This portion serves the purpose of Group 2 statements. In addition, several questions are asked which, presumably, will be answered during the course of the teaching of the next topic.

Although the data may be forthcoming in a following lesson, there is no immediate provision of means for the students to determine the accuracy of the estimated quantity of sewage put into the Great Lakes by Detroit.

Well, I think there's a very good answer to that; I think that they want people to get concerned, and there are something like fifty thousand cruising boats in Ontario waters, and they get fifty thousand people talking about this, and get it on the top of their mind, this could be tremendous political pressure. Every fellow that has a boat is going to be mad when he has to spend three hundred dollars for a holding tank, and he sees some factory just pouring waste out into the lake, and he's going to get after his Member of Parliament, and he's going to raise some fuss and it can't do anything but good.

LL.1-22: The teacher prefaces his explanation by the words "I think." This identifies the explanation to be his own; and, since there is no indication that the students are to explain the phenomena similarly, the teacher is making provision for the consideration of alternative explanations. However, the teacher substantiates his explanation by reputed reports of states-of-affairs. The assertions in this portion similarly represent states-of-affairs and inferences concerning those states-of-affairs. Also, the students are not provided with the sources of the information used, thus they must rely upon the teacher for accuracy. For instance, it is questionable that all fifty thousand boat owners will pay the stated amount for a holding tank, see factories pouring out waste, and contact their Members of Parliament. Since these assertions are made without distinctions between states-of-affairs and inferences, the portion is identified as IMPRESSION.

Student: But this isn't Detroit. (Some students comment.)

Teacher: The water conservation authorities are bringing pressure to bear on the people on the American side, and they are starting to do some work; but they aren't . . . haven't so far been nearly as effective as the Ontario Water Resources Commission. We'll be getting some material from them in the way of, er . . .

LL.30-33: The teacher presents an unsubstantiated judgment as if it were a report of states-of-affairs. The judgment is qualitative. There is no provision of evidence nor of the logical procedures which are used in the formulation of this judgment.

Student: Water! (Some laughter.)

Teacher: Well we get material from them through our taps, but, we'll be getting some printed material which will tell their side of the story about what the people in Ontario are trying to do. And, believe me, we better do something because, right now, Lake Erie is considered to be a dead lake. It has passed the point of no return.

L.47: There is no reference to the authority which finds that the lake is "dead"; nor is there mention of

The . . . it is calculated that the only way in which that section of the waterway can ever be made natural again is simply to dig a channel through the center of the lake and make it into a river. Now they already have a ship channel, which is dredged through the center of the lake, but the rest of the lake will simply become reclaimed land. And, er, because as far as the lake is concerned, it's had it. The reason for this is that there has been so much industrial waste, so much silt from run-off, so much fertilizer that's been swept into the lake from the surrounding farmlands, that the only organisms which live there are the kinds of organisms which we find in, er, sewage, and in stagnant water, which has a high organic content. There is no fishing industry in Lake Erie. There is . . . there are still a few fish in some of the tributaries, but not in the lake itself. (A bell sounds.) All right, dismissed.

(The lesson ends.)

logical procedures and the type of phenomena which are used to arrive at the decision that the lake is dead.

The retrieval of the natural waterway (L.4) is mentioned as the only practical solution. This excludes the consideration of alternatives.

The lesson continues with more unsubstantiated assertions. It is clear that the role of the student is to be informed. There is no opportunity for a student to examine the evidence which is supplied for there is no explicit reference to its source. Neither can a student examine the judgments which are reported for the logical procedures used in formulating these judgments are not explicated. Therefore the episode is judged as exemplifying IMPRESSION model teaching.